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Systematic review

Systematic Review on Static and Dynamic Stabilizers of the Trapeziometacarpal Joint: Biomechanical Evidence and Implications for Physical Therapy

Víctor Margüenda Fernández[1] 0009-0003-9778-0962

Andrea Beguiristain de Miguel[1] 0009-0005-1165-8929

[1] Hand Clinic Madrid, 28020 Madrid, Spain.

ABSTRACT

Background and objectives: The contribution of ligaments and muscles to containing dorsoradial subluxation related to rhizarthrosis remains debated. Anatomical, cadaveric, in vivo, and clinical evidence on trapeziometacarpal joint (TMC) stabilizers and their implications for physiotherapy were synthesized.

Methods: Systematic review (PRISMA 2020; retrospective registration in PROSPERO) of cadaveric, in vivo, and clinical studies on human TMC, with searches in four databases (May 2025; updated September 2026). Quality with QUACS, PEDro, and JBI. Synthesis without meta-analysis (SWiM) and certainty assessment using GRADE domains, expressed as exploratory confidence in biomechanical experiments.

Results: We included 60 studies: 38 cadaveric, 18 in vivo, three mixed, and one physical model. The dorsoradial ligament (DRL) restricted dorsoradial subluxation according to position and load (moderate exploratory confidence); the role of the anterior oblique was variable (low). The opponens pollicis (OP), alone or with the first dorsal interosseous (FDI), reduced subluxation in experiments. In vivo, FDI-directed activation reduced radial displacement of the base of the first metacarpal in healthy subjects, without excluding coactivation, but did not reduce dorsal displacement in advanced osteoarthritis (very low certainty). No trials isolated FDI/OP (non-gradable) training, and the programs evaluated did not outperform the comparator.

Discussion: The findings give mechanistic plausibility to the contribution of these structures to joint stability, with limited clinical extrapolation; invasive techniques lack direct evaluation.

Conclusions: In experimental models, DRL is a relevant passive restrictor. No direct clinical evidence supports selective FDI/OP training or percutaneous techniques for DRL.

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Keywords: Carpometacarpal Joints; Ligaments, Articular; Muscle, Skeletal; Biomechanical Phenomena; Joint Instability; Physical Therapy Modalities; Osteoarthritis.

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Correspondence: victormargu@gmail.com

1. Introduction

The trapeziometacarpal joint (TMC), or first carpometacarpal joint (CMC), of the thumb sacrifices much bone containment for ample three-dimensional mobility, necessary for pinch and functional grasp[1,2,3]. It is a saddle or reciprocal socket joint, with two concave-convex surfaces perpendicular to each other that allow flexion-extension, abduction-adduction arcs and coupled passive axial rotation (pronation-supination)[1,2,4,5,6].

The shallow depth of its articular facets makes articular congruence vulnerable to the continuous axial compression and shear forces generated during object manipulation[4,7,8,9]. The loss of integrity or progressive degeneration of its stabilizing elements causes dorsoradial subluxation of the base of the first metacarpal with respect to the trapezium[7,10,11,12]. This translational vector alters normal kinematic patterns and concentrates harmful contact loads on the anteromedial and dorsoradial slopes of the cartilage, and has been proposed as a relevant mechanism in the origin and progression of rhizarthrosis[7,13,14,15,16].

In passive containment, up to 16 ligaments and periarticular capsular thickenings have been described[4,17,18]. For more than three decades, Eaton and Littler's surgical theses have identified the anterior oblique ligament (AOL), called the beak ligament, as the primary stabilizer against dislocation[1,19,20]. However, modern biomechanical research and quantitative material characterization have qualified this approach[8,10,21,22,23]. Several studies describe the dorsoradial ligament (DRL) as a relevant passive restrictor against dorsoradial subluxation, with greater thickness and stiffness than AOL in comparative models[8,10,21,22,23,24,25]. Histological and arthroscopic studies also show that the DRL is made up of dense collagen and contains a high density of mechanoreceptors[18,22,26,27]. The AOL differs in thickness, tension, and function by anatomical definition and position; several studies describe it as a thin or probably lax structure, but others report relevant directional restriction. Studies do not consistently distinguish its superficial and deep fascicles[18,23,24,25,28,29]. Other elements, such as the intermetacarpal ligament (IML), the posterior oblique ligament (POL), and the posteromedial complex, contribute to secondary containment at the ends of the joint path[2,4,17,22,30,31].

It has been proposed that the pair formed by the opponens pollicis (OP) and the first dorsal interosseous (FDI) helps stabilize the TMC[32]. In FDI, the neural impulse adjusts to its mechanical advantage, which changes with thumb position[33], and in TMC itself, neurohistological[26] and ligament-muscular reflex studies[34] provide a basis for neuromuscular control. In cadaveric models, OP reduced subluxation in a dose-dependent manner, while isolated FDI had protocol-dependent effects; the FDI+OP combination was not statistically superior to isolated OP[35,36]. Associations between muscle characteristics and osteoarthritis provide indirect evidence and do not demonstrate a therapeutic effect of strengthening[37]. Isolated linear loading of the abductor pollicis longus (APL) increased dorsoradial misalignment in a cadaveric model, without determining its net function during physiological activity[36,38]. In healthy volunteers, resisted contraction targeting FDI reduced induced radial subluxation, although coactivation of OP or other muscles was not excluded[39].

The previous systematic review closest in scope, published by Lin, Karl, and Strauch in 2014, analyzed 52 studies identified in two databases up to November 2012 and concluded that the dorsal ligaments, particularly the DRL, are the primary stabilizers of TMC[40]. That review was limited to English-language publications, focused its clinical analysis on ligamentous reconstruction and metacarpal osteotomy, did not include muscle stabilizers or exercise trials, and did not apply, beyond classification by level of evidence, a quality assessment by design or a grading of certainty. Since then, studies of multidirectional ligamentous section[24], simulated muscle loading[35,36], ligament-muscle reflexes[34], and randomized trials of dynamic stability programs have been published[41].

Despite these advances, clinical physiotherapy protocols still vary in how they involve each structure and whether they use therapeutic exercise or invasive techniques[41,42,43,44]. This systematic review aims to synthesize and critically evaluate the available biomechanical and clinical evidence on static and dynamic stabilizers of TMC. Unlike the previous review, it systematically incorporates musculature (especially FDI, OP and APL) and exercise trials, assesses quality by design, grades certainty by outcome, and updates the evidence through 2026. It also examines its implications for active stability programs and conservative rehabilitation and, as an external hypothesis to the corpus included, for invasive physiotherapy. The review addressed four questions: what function passive stabilizers have against TMC subluxation, what function active stabilizers have, how these structures behave in vivo in healthy subjects and with osteoarthritis, and the efficacy of clinical interventions aimed at joint stability.

2. Methods

This systematic review was reported following the guidelines of the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement[45], including its recommendations for updated reviews (checklist completed in File S8), and the PERSiST guide for its application in musculoskeletal rehabilitation[46] (checklist completed in File S7). The protocol was registered in PROSPERO (CRD420261330988; https://www.crd.york.ac.uk/PROSPERO/view/CRD420261330988). For the initial review, the registry was retrospective: version 1.0 was published on 31 August 2026, when the search (5 May 2025), screening, data extraction, quality assessment, and synthesis were already complete. The update phase was prospective with respect to that version: the search on 21 September 2026 and the screening, extraction, and quality assessment of the eight new studies and the report retrieved during the review were performed after registration, with the recorded methods and deviations listed below. The differences between the registry and this report (languages, eligible designs, implant and orthosis objective, quality tools, and dates) have been corrected by an amendment to the registry (version 2.0, submitted on 8 October 2026) and are detailed in Table S6. The subsequent minor amendment (version 2.1, sent on October 21, 2026) declares the time of registration.

2.1 Eligibility Criteria

The selection criteria are presented under the PICOS framework. During the documentary review, the scope of the physical models, clinical outcomes, and indirect mechanistic evidence was made explicit to reflect the included designs.

- **Population/specimens (P):** Human TMC joints studied in cadaveric specimens or in living subjects, and physical or computational models of their anatomy. Non-human animal models and studies of other joints with no functional relationship to TMC were excluded. Index-focused FDI experiments were considered only indirect mechanistic evidence and were identified separately.
- **Interventions/factors evaluated (I):** Mechanical, kinematic, histological, or kinetic assays focused on passive (DRL, AOL, IML, POL, ulnar collateral ligament (UCL), and periarticular capsule) or active (intrinsic and extrinsic muscles, with emphasis on FDI, OP, and APL) structures of the TMC joint. Exercise programs aimed at TMC stability and its clinical outcomes were also included.
- **Comparisons (C):** Tissue integrity states (intact capsule vs. sequential ligamentous transsections), tendon loading vectors (isolated muscle loading vs. coactivation), or relative material properties between ligamentous structures. For clinical interventions, comparisons were general exercise or standard conservative therapy; uncontrolled series were used as descriptive support.
- **Outcome variables (O):** Direct or indirect quantitative variables of joint stability. Variables that directly quantify joint restraint or the ability of a structure to restrict movement were considered to be primary outcomes: spatial translation of the base of the first metacarpal (mm), joint subluxation ratio (%), kinematic arcs of mobility (degrees), and material tensile properties (structural stiffness in N/mm, maximum failure load in N, and elastic modulus or ultimate stress, differentiated even though both are expressed in MPa). Variables that report the mechanism without measuring displacement restriction were considered secondary: quantitative electromyographic activity (EMG, as a percentage of maximum voluntary contraction, %MVC), intra-articular contact areas and pressures, moment arms, neurohistological characterization of mechanoreceptors, and morphology or muscle properties by imaging. For clinical programs, pain and function (numerical pain scale, NRS; Disabilities of the Arm, Shoulder and Hand, DASH, or its short version, QuickDASH), were analyzed, along with the comparator and follow-up. Qualitative anatomical data, EMG activity, muscle morphology, and histological findings were interpreted as indirect evidence when TMC shift was not measured.
- **Study design (S):** Ex vivo cadaveric biomechanical assays, in vivo dynamic kinematic and imaging analyses, physical or computational simulation models, anatomical-histological studies, controlled clinical trials, and uncontrolled intervention studies. Narrative reviews, letters to the editor, expert opinions, clinical cases, and conference proceedings without complete primary data were excluded.
- **Time and language limits:** Publications indexed with no lower date limit until May 5, 2025 (initial search) and until September 21, 2026 (update), written in English, Spanish, French or German.

2.2 Sources of information and search strategy

We searched PubMed/MEDLINE, Scopus, EuropePMC, and Dimensions.ai on 5 May 2025 and updated on 21 September 2026 with the same strings, restricted to records incorporated since the closing date (PubMed and EuropePMC by publication or incorporation date; Scopus and Dimensions.ai by publication year 2025–2026, with manual date verification). The strategy com-

bined controlled descriptors (MeSH) and truncated free-text terms, adapted to the syntax of each database. The PubMed strategy is shown; the four complete strategies, with the date filters and the number of records for each search, are listed in Table S5, according to PRISMA-S[47]:

- **PubMed / MEDLINE:** ("Carpometacarpal Joints"[Mesh] OR "trapeziometacarpal"[Title/Abstract] OR "first carpometacarpal"[Title/Abstract]) AND ("ligament"[Title/Abstract] OR "ligaments"[Title/Abstract] OR "muscle"[Title/Abstract] OR "muscles"[Title/Abstract] OR "anterior oblique ligament"[Title/Abstract] OR "AOL"[Title/Abstract] OR "dorsoradial ligament"[Title/Abstract] OR "DRL"[Title/Abstract] OR "first dorsal interosseous"[Title/Abstract] OR "FDI"[Title/Abstract] OR " opponens pollicis"[Title/Abstract] OR "abductor pollicis longus"[Title/Abstract]) AND ("stability"[Title/Abstract] OR "biomechanics"[Title/Abstract] OR "kinematics"[Title/Abstract] OR "laxity"[Title/Abstract] OR "subluxation"[Title/Abstract])

Checking the reference lists of the included studies identified two additional studies: McGee et al. (2015)[39] in the initial search and, in the update, a study cited by one of the newly included studies (section 3.1). Both predated the search cut-off date, so it did not need to be extended, and the same eligibility criteria, extraction form and quality assessment (Joanna Briggs Institute [JBI] checklist) were applied to them as to the other studies.

2.3 Study selection

The identified records were imported into the Rayyan QCRI platform, and duplicates were resolved. Two reviewers (VMF and ABM) independently and masked (Rayyan's blind mode) evaluated the titles and abstracts. Potentially eligible articles were obtained in full text, and both reviewers examined them in parallel. Discrepancies were resolved by consensus. The concordance of screening by title and abstract was calculated with Cohen's kappa coefficient from the first vote of each reviewer in Rayyan's decision history, prior to consensus, dichotomizing decisions in exclusion versus full-text step-through (inclusion or "maybe")[48]. Update records were screened with the same procedure in an independent Rayyan review; a screening proposal was generated with AI assistance and decisions were recorded independently by both reviewers. A study of the update has the first author of this review as its first author[49]; its extraction and quality assessment were carried out by the second reviewer, and the discrepancies were resolved without the participation of the author involved.

2.4 Data extraction

The two review authors (VMF and ABM) extracted data in duplicate and independently with a pre-designed form, which was also applied to the update studies, and resolved the discrepancies by consensus. For the update study whose first author is V.M.F.[49], A.B.M. performed extraction only. The following were extracted: bibliographic data (authors, year), design, sample characteristics (number, mean age of subjects/donors, cadaveric preservation method), instrumental methodology (MTS servohydraulics, 3D scanning, 4D tomography, EMG), evaluated structures, and quantitative stability outcomes. Initial and analyzed samples, hands and donors, and observed values against eligibility criteria were distinguished. Internal discrepancies of the sources were preserved as notes, without combining incompatible values. The magnitudes in centimeters were converted to millimeters by a tenfold increase. The authors of the primary studies were not contacted.

2.5 Assessment of methodological quality and risk of bias

Methodological quality was assessed with tools according to the design. The 41 cadaveric or mixed studies were assessed with the Quality Appraisal for Cadaveric Studies (QUACS; 13 items) [50]; in the mixed studies, the QUACS score was applied to the entire study and does not replace a specific assessment of the in vivo component. The two randomized controlled trials (RCTs) were assessed using the Physiotherapy Evidence Database (PEDro)[51] and the 16 non-randomized in vivo studies with JBI checklists: thirteen analytical cross-sectional, two quasi-experimental, and one case series(52,53,54). The Comtet physical model[55] was critically described without a QUACS score or numerical risk category. The high/moderate/low quality operational thresholds were maintained: QUACS ≥10/7–9/≤6, PEDro 8–10/6–7/≤5, and JBI ≥70%/50–69%/<50% of applicable items. These thresholds are not validated risk of bias categories and were not equated to the domains of the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system. The prescore for each list was generated with Claude (Anthropic; Claude Opus 4.8 and Claude Opus 5.5) and ChatGPT (OpenAI; GPT-5.5) between June and October 2026; The identifiers and period of use of each version are detailed in the statement on the use of artificial intelligence. The tools received the full text of each study and the corresponding criteria list, with instructions to score each item and cite the page or fragment that justified it. Both reviewers (VMF and ABM) contrasted each item with the original article, and the textual evidence is documented in S2 and S3. The final scores were set by consensus on that prescore, without prior individual scores, so the final assessment was not independent in duplicate and interrater agreement could only be calculated for screening (section 2.3). For the V.M.F. study[49], A.B.M. carried out the evaluation alone (section 2.3). Eligibility decisions, final scores, grading of certainty, and interpretation were not delegated to these tools.

2.6 Synthesis of results and grading of evidence

The synthesis without meta-analysis was structured according to the Synthesis Without Meta-analysis (SWiM) guideline[56]. The results were grouped by question: passive ligamentous restriction, response to simulated muscle load, in vivo kinematics, indirect neuromuscular activity, and clinical efficacy; the update studies were integrated into the same groups. Within each group, structure, load vector, posture, presence of osteoarthritis, comparator, and follow-up were distinguished. The units of each outcome were conserved and, where appropriate, they were converted cm to mm and ratios to percentages. A lower subluxation was interpreted as greater congruence only in the direction measured; pain and function were interpreted separately. Comparisons that directly measured the outcome were prioritized, taking into account their specific limitations, without weighting by total score or counting of statistically significant results. Estimates were not combined because protocols, populations, and outcomes varied, and comparable data were insufficient. Discordant outcomes were examined by direction, position, and disease, without inferring causality from associations. No missing data were imputed, and no subgroup, statistical sensitivity, or meta-regression analyses were performed.

Certainty was examined by outcome using the GRADE domains[57]: risk of bias, inconsistency, indirect evidence, imprecision, and publication bias. RCTs started with high certainty and non-randomized in vivo studies with low certainty. For controlled biomechanical contrasts within the specimen, a high starting point was maintained as an exploratory adaptation of its own, not

validated, and not equivalent to clinical GRADE, the result of which is expressed as exploratory confidence and not as certainty; anatomical and observational studies provided only corroboration. This confidence is limited to response under the experimental protocol. Limitations of sequential section, loss, measurement, and analysis were assessed; imprecision was judged by effective samples, dispersion, and available intervals, without equating agreement to accuracy. Extrapolation to clinical benefit was examined separately, and clinical outcomes without direct evidence were considered non-gradable. No upgrading or formal publication bias tests were applied. Table 6 documents all domains and the justification for each downgrade.

3. Results

3.1 Selection of studies

The initial search identified 845 records (PubMed/MEDLINE: 219; Scopus: 374; EuropePMC: 206; Dimensions.ai: 46). The Rayyan detection tool identified 594 records grouped into 219 duplication clusters. In each cluster, a single record was retained, the one with the most complete metadata (abstract, full authorship, journal of origin, DOI, and date), so 375 records (594 − 219) were deleted, and 470 titles and abstracts were screened. Concordance between review authors in screening by title and abstract was $\kappa = 0.53$ (95% CI: 0.43–0.63), with a raw agreement of 84.3% (470 records). 399 records were discarded, and the full text of 71 reports was searched, of which 6 could not be retrieved (one of the seven reports that had not been obtained at first was obtained during the review of the manuscript and was evaluated with the same criteria). A total of 65 articles were evaluated in full text, and 15 were excluded for explicit reasons: 8 narrative reviews or expert opinions or without verifiable primary data, 2 studies without focus on the TMC articulation, 1 protocol with no results, 1 qualitative study, 1 letter to the editor, 1 technical proposal without primary data, and 1 non-indexed doctoral thesis (individual relationship of the excluded studies with their reason in Table S4). The last exclusion[6], a classic anatomical description with no verifiable primary data, had passed the full-text screening and was detected by rereading the article during the quality assessment; it was then reclassified as a full-text exclusion, did not receive a score or enter the synthesis, and the PRISMA counts it in that step. We included 51 unique studies: 50 from this selection process and one from the comparison of references.

The update search identified 248 records (PubMed/MEDLINE: 25; Scopus: 65; EuropePMC: 141; Dimensions.ai: 17). After removing 65 duplicates (64 in previous deduplication by DOI, PMID and normalized title and one detected in Rayyan), 183 titles and abstracts were screened ($\kappa = 0.52$; 95% CI: 0.34–0.71; raw agreement of 88.0%) and 157 were excluded. The full text of the 26 reports searched was obtained. Of the 26 evaluated, 18 were excluded: nine with no outcome on stabilizers or stability, two with interventions not directed at active stabilization, two surgical without data on native stabilizers, one survey, one narrative review, one letter to the editor, one study of another joint and species, and one already included in the previous version[37]. Eight new studies were added[49,58,59,60,61,62,63,64], and checking the reference lists of the update studies identified a cross-sectional shear wave elastography study of the thenar muscles[65] that met

the eligibility criteria and had not been retrieved by the electronic search, so the updated review includes 60 studies (Figure 1; individual exclusions in Table S4).

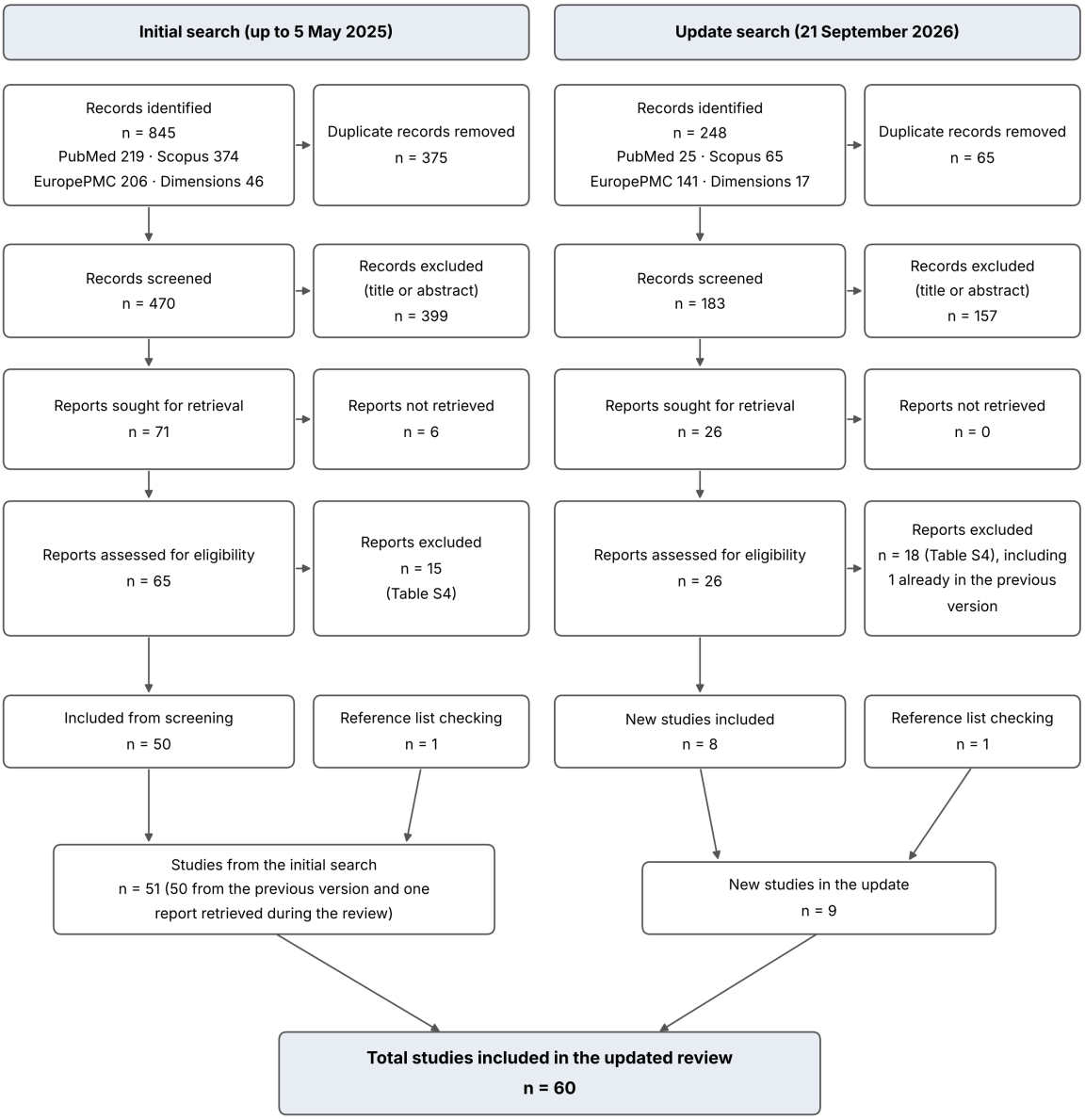


Figure 1. PRISMA 2020 flowchart of the updated review: studies from the initial search (those included in the previous version and a report retrieved during the review) and new studies identified in the update search and through citation searching.

3.2 Study characteristics

3.2.1 Characteristics of the sample and methodological typology

We included 38 cadaveric studies (63.3%), 18 in vivo studies (30.0%), three mixed imaging designs (5.0%), and one artificial physical model (1.7%; Comtet[55]). The categories correspond to the main component of each study; Bojsen-Møller[3] also includes complementary in vivo observations. Table 1 summarizes the designs and Table S1 details the initial and analyzed samples, the donors, and the limitations of each source.

Table 1. Distribution of sample characteristics and type of studies included (N = 60).

Type of methodological design	Proportion (%)	No. of studies	Pooled sample	Methods of analysis and main technology
Mainly cadaveric studies	63.3%	38	Detail in S1	Tests of materials, ligamentous section and reconstruction, kinematics, simulated muscle load, pathological anatomy and immunohistochemistry.
In vivo research	30.0%	18	Detail in S1	Imaging, fluoroscopy, EMG, elastography, inertial sensors, physiology, and exercise programs.
Mixed imaging designs	5.0%	3	Chiavaras: 4 hands + 40 volunteers; Gondim Teixeira: 10 hands + 10 thumbs from 5 volunteers; Margüenda-Fernández: 5 cadavers + 52 thumbs from 26 volunteers	Ultrasound with cadaveric anatomical confirmation.
Artificial physical model	1.7%	1	Comtet: enlarged model based on one healthy subject	Polystyrene and rubber bands; no cadaveric tissue.

3.2.2 Interventions and experimental configurations

Ex vivo studies included ligament material properties assays[8,23], anatomical measurements[2,4], kinematics after ligamentous section[7,10,21,24,30,66], simulated lateral pinch radiographic subluxation after capsule opening and AOL sectioning[67], length changes during movement[68,69], and simulated tendon loading[35,36]. In vivo, computed tomography (CT) and ligamentous modeling[25,70], dynamic CT after DRL reconstruction[71], magnetic resonance imaging (MRI), and ultrasound were used to study TMC position or displacement[13,72], and fluoroscopy during resisted FDI contraction[39]. EMG studies characterized functional tasks or reflexes[34,73,74]. Hudson studied FDI during index finger flexion, with indirect TMC relevance[33]; Normand examined muscle characteristics and their association with osteoarthritis in cadavers, without EMG[37]. Nataraj analyzed finger mechanics and CMC moments during precision gripping, as complementary functional evidence[75]. The update added a study of section and reconstruction of the dorsal ligaments[64], a multimodal study of ligamentous properties, joint topography and kinematics according to the stage of osteoarthritis[58], an anatomopathological study of capsuloligamentous integrity and cartilage wear[61], an anatomical and immunohistochemical study of APL insertions[59], a cadaveric and ultrasonographic validation of the DRL[49] and three in vivo studies in osteoarthritis with MRI[62], shear wave elastography[63] and inertial sensors during pinch[60]; citation searching added another shear wave elastography study of the thenar muscles[65].

3.2.3 Biomechanical results

Static stabilizers (capsuloligamentous complex)

Anatomical descriptions vary between models of 5 cardinal ligaments[2,5] and systems of 16 independent ligamentous structures[4,17,18] (Table 2).

Table 2. Static and dynamic stabilizers of TMC: anatomical nomenclature, insertions, and major biomechanical function. Only studies included in the review are cited.

Anatomical structure	Nature	Proximal and distal insertions	Main mechanical function in joint stability	Support Studies
Dorsoradial ligament (DRL)	Ligament	Dorsoradial tubercle of the trapezium at the postero-radial margin of the 1st metacarpal.	Important passive restrictor against dorsoradial translation; protocol-dependent contribution. Greater stiffness than AOL in comparative trials of isolated ligaments; in a staged study, its properties only deteriorated in advanced osteoarthritis[58].	[2,4,7,8,10,18,21,22,23,24,25,30,49,58,64,71,76]

Anatomical structure	Nature	Proximal and distal insertions	Main mechanical function in joint stability	Support Studies
Anterior Oblique Ligament (AOL)	Ligament	Volar tubercle of the trapezium to the volar beak of the base of the 1st metacarpal.	Restriction dependent on direction and anatomical definition; some models describe it as lax. Not all of them distinguish superficial and deep fascicles. Disinsertion of the deep component (beak ligament) was associated with eburnation in primary osteoarthritis, and the volar complex was attenuated in the initial phases[58,61].	[2,4,8,18,21,22,23,24,25,28,29,55,58,61,67]
Intermetacarpal Ligament (IML)	Ligament	Dorsoradial base of the 2nd metacarpal to the palmar-ulnar tubercle of the 1st metacarpal.	Mechanical restriction against divergence and radial translation; secondary passive stabilizer next to the DRL.	[2,4,13,17,22,30,66]
Posterior Oblique Ligament (POL)	Ligament	Posteroulnar slope of the trapezium to the ulnar tubercle of the 1st metacarpal.	Secondary restraint against dorsal shear in abduction and extreme opposition; posteromedial reinforcement.	[2,4,8,17,25,31,68]
First dorsal interosseous (FDI)	Muscle	Origin in diaphysis of 1st and 2nd metacarpals; insertion at the proximal phalangeal base of the index.	In simulated loading, less misalignment in a protocol; immediate radial reduction during FDI-directed activation in healthy subjects, without excluding synergists. No changes in elasticity at rest in osteoarthritis[63].	Direct data:[35,36,39,72]. Indirect context:[33,34,37,43,63,77].
Opponens pollicis (OP)	Muscle	Tubercle of the trapezium and flexor retinaculum to the radial aspect of the 1st metacarpal.	Dose-dependent reduction of induced subluxation. The combination with FDI was not statistically superior to OP alone. In osteoarthritis, fatty infiltration of its deep belly and less pronation during pinch[60,62]; slightly lower elastographic stiffness[65].	Simulated load:[35]. Functional context:[37,60,62,65,74].
Abductor pollicis longus (APL)	Muscle	Posterior surfaces of the radius and ulna to the radial base of the 1st metacarpal and the trapezium.	Abduction of the thumb; under isolated linear isometric load induces a destabilizing vector with dorsoradial shear. Accessory fascicles with capsular and thenar insertion, and innervation in the trapezial insertion[59].	Isolated load:[36]. Moment and movement arms:[38,78,79]. Anatomy and innervation:[59].

Comparisons of material properties showed that DRL is more rigid than AOL in the Bettinger and D'Agostino protocols[8,23]. These properties alone are not equivalent to joint directional restriction, examined by ligamentous section[24]. D'Agostino did not distinguish superficial and deep fascicles from AOL; their values are attributed to unsubdivided AOL (Table 3). In contrast, Gordon et al., who tested the complete volar complex in the hands of women, found greater stiffness, toughness, and modulus of the volar complex in healthy joints than in DRL and POL; in the staging analysis, the volar complex was attenuated in the periarthritic phase and the DRL only in advanced osteoarthritis[58]. The different anatomical definition (volar complex vs. isolated AOL) and the exclusively female sample may explain the discrepancy.

Table 3. Mechanical properties and restrictor functions of DRL and AOL according to the primary studies included.

Study	Parameter	DRL	AOL	Observations
Bettinger et al., 2000[8]	Maximum breaking load (N)	205.5 ± 60.2	64.5 ± 27.8	The DRL was the most resistant and tenacious ligament of the seven evaluated; the AOL, the most accommodating and with the greatest hysteresis
Bettinger et al., 2000[8]	Stiffness (N/mm) and ultimate stress (MPa)	78.3 ± 21.9; 8.1 ± 1.7 MPa	24.1 ± 13.3; 5.8 ± 1.9 MPa	The stiffness of AOL was significantly lower than that of DRL
D'Agostino et al., 2014[23]	Stiffness (N/mm) and morphology	89 ± 21; thickness 1.1 ± 0.2 mm; shorter	65 ± 30; thickness 0.6 ± 0.1 mm; poorly defined	The distinction between superficial and deep fascicles of the AOL was not reproduced
Kalshoven et al., 2024[24]	Directional restriction after selective section	Restricts flexion and internal rotation; dorsal and radial translation	Restricts extension and volar translation	Complementary and direction-specific stabilizing functions
Gordon et al., 2026[58]	Stiffness, ultimate load and toughness per stage (46 women's hands)	Decline only in the advanced osteoarthritis cluster	Volar complex: values higher than DRL and POL in healthy joints; decrease in the periarthritic cluster	Volar complex = deep and superficial AOL with capsule; absolute figures in supplementary source material

In selective ligamentous section assays, DRL transection caused greater dorsoradial translational displacement of the metacarpal: 1.4 mm vs. 0.06–0.2 mm following isolated section of AOL, IML, or POL[7], and 1.3 mm with a 4.1° increase in lateral pinch pronation, vs. 0.6 mm af-

ter deep AOL section[10], with concordant results in other sequential section models[21,24]. In ten specimens, joint section of the dorsal and ulnar ligaments increased dorsoradial displacement of the first metacarpal under 0.5 kg load from 3.6 ± 1.9 to 6.4 ± 2.4 mm; bifascicular reconstruction of the DRL and central dorsal ligament returned it to values similar to those of the intact state, whereas monofascicular reconstruction of the DRL did not[64]. The contribution of AOL depended on posture, vector, and anatomical definition; Kalshoven described restriction of extension and volar translation[24], while other models attributed a relevant contribution to the anterior complex[66,80]. In contrast, in 11 specimens with osteoarthritis subjected to simulated lateral pinch, neither partial capsule opening nor AOL section significantly modified radiographic dorsal subluxation (32%, 35%, and 34%; p = 0.29)[67]. In vivo modeling from multi-position CT indicated that AOL probably remains lax over most of the range of motion, while DRL could be under tension in adduction and flexion positions[25]; shortening of deep AOL during flexion, abduction, and opposition was also observed in healthy volunteers[70]. Halilaj presents a discrepancy between the abstract (abduction) and the detailed results (adduction); here the description of results follows and the discrepancy in S1 is recorded. In 71 donor joints, disinsertion of the beak ligament was associated with eburnation in 21 of 23 joints with wear and tear, without degeneration of the dorsal complex at any stage (0 of 36)[61]; this cross-sectional association does not measure restriction. Ultrasonography also identified the central fasciculus of the DRL in 52 healthy thumbs with cadaveric validation, without measuring stability[49].

Dynamic stabilizers (muscular stabilizers)

Applying an isolated linear isometric load to the APL tendon was the main destabilizing vector and increased dorsoradial misalignment of the metacarpal base, while isolated FDI loading produced the least dorsoradial translation and the greatest distal migration of the base[36]. In 20 hands with osteoarthritis, the APL presented accessory fascicles in 18, with insertions in the deep capsule (16 out of 20) and in the OP or short abductor (19 out of 20), and nerve endings in its trapezial insertion in 13 out of 20[59].

In Adams[35], 11 preparations were initiated and only seven provided complete data, following OP breakdown in four. OP reduced subluxation in a dose-dependent manner; isolated FDI had little effect. FDI+OP gave the lowest ratio only at 25% load; at 50–100% load, OP alone left less residual subluxation, and the difference was not significant. These results do not demonstrate a specific advantage of coactivation versus OP (Table 4).

In 17 healthy adults (32 thumbs), manual stress-induced radial subluxation decreased from 5.3 ± 2.4 to 1.1 ± 2.0 mm during FDI-directed resisted contraction (difference 4.2 ± 2.2 mm; p<0.001); the subluxation/joint width ratio decreased from 0.42 to 0.09[39]. Manual force was not quantified, and no coactivation was ruled out by EMG; nor was the analysis adjusted for bilateral dependence. In another study, ultrasonography showed dorsal reduction in six out of ten healthy thumbs; in advanced osteoarthritis there was no change in four out of ten and an increase in six out of ten[72]. Protocols and directions differ; none compared FDI+OP in a controlled manner with isolated OP in vivo.

In osteoarthritis, MRI showed fat infiltration of the deep belly of the OP in 43% of 307 patients, compared with none of 440 without osteoarthritis, with a gradient by stage (Eaton 3–4 vs. 1–2:

OR 10.1)[62]. During pinch, the thumb with osteoarthritis showed less pronation than controls (median 2.6° vs. 3.7°; p = 0.014) and more frequently showed a supination pattern (25% vs. 8.8%), with an inverse correlation with stage[60]. Elastography did not detect changes in FDI, but increased stiffness of the adductor pollicis on the dominant side[63]. In another study, with nine thumbs from five patients and nine controls, shear wave stiffness of the abductor pollicis brevis, flexor pollicis brevis and opponens pollicis was lower in osteoarthritis, with differences the authors describe as marginal and no numerical values reported[65]. None of these studies measured subluxation.

Table 4. Metacarpal base responses to isolated muscle load and coactivation in cadaveric models of simulated loading[35,36].

Muscle activation pattern	Resulting Traction Vector	Shifting of the metacarpal base	Joint congruence and stability
Isolated APL	Linear tendon load	Greater dorsoradial misalignment in the protocol evaluated.	In vitro results do not demonstrate impairment of physiological activation[36].
FDI Isolated	Simulated tendon loading	Less dorsoradial translation and greater distal migration(36); little reduction of induced subluxation[35].	Protocol-dependent response[35,36].
Isolated OP	Simulated tendon loading	Dose-dependent radiographic reduction; no pronation vector was directly measured.	Main reductive contribution in Adams[35].
FDI + OP	Simulated simultaneous loading	Lowest ratio only at 25% load; at 50–100%, OP alone left less residual subluxation. Seven complete series.	No significant difference compared to isolated OP. There is no equivalent comparison in vivo[35].

3.3 Methodological quality and risk of bias

Of the 60 included studies, 59 were assessed with the selected checklists: 45 achieved high quality (76.3%), 12 moderate (20.3%), and two low (3.4%). Comtet was evaluated narratively because it was a physical model. The 41 QUACS studies obtained a mean of 11.5/13, median 12/13, and range 6–13: 35 of high quality, five moderate[3,5,14,15,80], and one low[17]. The most frequent non-accredited items were statistical analysis (14/41; 34%), instrument or accuracy (11/41; 27%), demography (10/41; 24%), and discussion of limitations (10/41; 24%). Storage was described as fresh or frozen fresh in 32 studies, fully or partially embalmed in eight, and unspecified in one. The scores did not fully capture bilateral dependence, loss of preparations, confusion by sequential section, or conflicts of interest; these aspects were considered by outcome. The 16 JBI studies had ten high, five moderate, and one low rating, with a median of 80.4% (range 30–100%). RCTs scored 6/10[41] and 7/10[44] in PEDro, both of moderate quality. McVeigh analyzed 67/84 participants and did not reach the expected 120. Davenport was a pilot with no prior calculation: 22/39 completed six months; the 41% losses reported by the authors plus a subsequent exclusion explain why 17/39 (44%) are missing from the final assessment.

Table 5. Methodological quality by design: 59 scored studies and one narratively assessed physical model (60 included). The categories are operational thresholds, not a validated classification of risk of bias. The breakdown by item is provided in S2 and S3.

Design	N	Tool	Quality by thresholds	Scoring	Scope	Main limitations
Cadaveric and mixed	41	**QUACS**[50]	35 High / 5 Moderate / 1 Low	**Mean 11.5; Median 12; Range 6–13**	**Full Study**	Statistics: 14/41; instrument: 11/41; demographics: 10/41; limitations: 10/41. Losses, bilateral dependence, and protocols are also assessed by outcome.
Randomized trials	2	**PEDro**[51]	**2 moderate**	**6/10**[41]**; 7/10**[44]	**Clinical Trials**	No therapist blinding. McVeigh: 67/84, goal 120. Davenport: pilot with no prior calculation; 22/39 at six months.

Design	N	Tool	Quality by thresholds	Scoring	Scope	Main limitations
In vivo not randomized	16	**JBI**[52,53,54]	10 High / 5 Moderate / 1 Low	Median 80.4%; range 30–100%	**Specific design**	McGee: JBI score 4/7 (17 subjects, 32 thumbs); unadjusted bilateral samples and unquantified manual strength. Others: small samples, confusion, and statistics.
Physical model	1	Narrative	Uncategorized	Not applicable	Comtet[55]	Geometric fidelity, inserts and properties of rubber limit extrapolation; QUACS not applicable.

3.4 Synthesis of results and neuromuscular coactivation

Sectional experiments support an important contribution of DRL to dorsoradial, position- and load-dependent restriction. The FDI/OP combination reduced subluxation under simulated load, with no significant superiority over isolated OP[35]. In vivo, immediate radial reduction was observed during FDI-directed resisted activation in healthy subjects[39], with no muscle isolation or demonstration of compensation of a DRL injury. The hypothesis of ligamentous compensation by coactivation lacks direct clinical evidence. In osteoarthritis, the update studies described structural alterations of the OP and less pronation during pinch, without directly measuring subluxation[60,62].

Regarding clinical efficacy, two randomized trials evaluated dynamic stability programs. In the pilot trial (39 randomized; 38 after subsequent exclusion; 22 evaluated at six months), APL-targeted exercises were not superior to general exercise in reducing DASH at three or six months; only the general exercise group improved significantly from baseline at three months (13 points)[44]. In the second trial (84 randomized; 67 analyzed), adding a home-based dynamic stabilization program to standard conservative therapy did not result in any difference in pain (NRS) or QuickDASH at six weeks or six months, although both groups improved from baseline[41]. A retrospective, single-arm study described a 19.3% improvement in QuickDASH with dynamic stability therapy, without a control group[43], and in patients with advanced osteoarthritis pain and lateral pinch strength improved after one month of orthosis and FDI exercise, regardless of the kinematic behavior observed[72].

3.5 Certainty of the evidence

Table 6 summarizes, at three levels (biomechanical function of passive structures, muscle behavior, and clinical efficacy), the exploratory confidence of biomechanical findings and the certainty of in vivo and clinical findings, and identifies the studies that support each.

Table 6. Outcome assessment using GRADE domains. In biomechanical experiments (1a, 1b, and 2a), the rating reflects exploratory confidence based on the authors' own non-validated adaptation, limited to the experimental context, and does not equate to certainty about clinical efficacy. Each cell specifies the judgment and, in parentheses, the downgrade applied.

Finding	Main evidence	Magnitude/Scope	Initial	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Final
1a. Dorsoradial restriction by DRL	Section[7,10,21,24,30,64]; contrasts[66,80]. Anatomy and materials as support[4,8,18,22,23,25,49,69,70].	Higher translation after DRL section in several protocols: 1.4 mm[7] and 1.3 mm[10]; 2.8 mm mean after dorsal and ulnar joint section[64]. Experimental scope.	High*	Serious (−1): sectioning, measurement, and analysis protocols; not all data is straightforward.	No downgrade: differences in vector and posture delimit the finding.	No downgrade for the model; clinical extrapolation not established.	No downgrade (0): six independent section studies with 76 specimens and intraspecimen contrasts; four with significant differences and none in the opposite direction; no combinable intervals. With stricter criteria, confidence would be low.	Uncertain (0)	MODERATE
1b. AOL Directional Function	Comparisons[7,10,16,24,30,66,67,80]; support[8,18,23,25,28,29,58,61,70].	Variable functions: volar restriction/extension and, in some models, dorsoradial. AOL not always subdivided. Volar complex more rigid in healthy joints and attenuated early; degeneration of the beak ligament is associated with eburnation.	High*	Limitations present; no additional independent downgrade.	Serious (−1): definitions and functions that are not concordant between models.	No downgrade for the delimited biomechanics question.	Serious (−1): small samples and non-combinable estimates.	Uncertain (0)	LOW
2a. Simulated muscle load	Adams[35]: 7 complete sets of 11. Mobargha[36]: 10 hands.	OP and OP+FDI reduce subluxation; no significant combination superiority. Isolated APL increases misalignment.	High*	Serious (−1): loss 4/11 preparations and incomplete quantitative reporting in[36].	No downgrade: results linked to the protocol; there is no replication of the OP contrast versus combination.	No downgrade for simulated load; does not measure exercise efficacy.	Serious (−1): a small study by main contrast.	Uncertain (0)	LOW
2b. In vivo FDI targeted activation	McGee[39]: 17 subjects/32 healthy thumbs. Ooishi[72]: 10 healthy and 10 with advanced OA.	Radial: 5.3±1.1 mm and ratio 0.42±0.09[39]. Dorsal: reduction 6/10 healthy; increase 6/10 OA[72].	Low	Serious (−1): manual force, unmeasured coactivation, bilaterality and confusion.	No downgrade: different directions, protocols, and populations; it is not a direct replica.	Serious (−1): attributing the effect to isolated FDI or to clinical benefit is not possible.	Serious: few independent people and heterogeneous protocols.	Uncertain (0)	VERY LOW
2c. Neuromuscular Activity and Stability	EMG/reflexes[34,73,74]; index physiology[33] as an indirect context; APL innervation[59].	Patterns of activation are observed; not a direct measure of TMC subluxation restriction.	Low	Limitations of selection, measurement, and analysis; no quantification of a stabilizing effect.	Not assessable for a common effect on subluxation.	Serious (−1): EMG activity does not equate to stability;[33] focuses on the index.	Serious: small samples; there is no direct estimate of the effect on stability.	Uncertain (0)	VERY LOW
2d. Muscular and kinematic alterations in osteoarthritis	El Hor[62]: 747 MRI. Tsukamoto[60]: 36 hands with osteoarthritis and 19 controls. Karademir[63]: 29 and 26 thumbs. Nwawka[65]: 9 and 9 thumbs.	Fat infiltration of the OP in 43% with osteoarthritis and 0% without; pronation during pinch 2.6° vs. 3.7°; no elastic changes in the FDI; slightly lower thenar stiffness, with marginal differences.	Low	Serious (−1): unblinded single reader, unadjusted bilateral hands, controls without x-ray and controls not age-matched.	No downgrade: distinct and consistent outcomes with OP dysfunction.	Serious (−1): structure and kinematics do not equate to stability; indeterminate causal direction.	No further downgrade: wide sample in MRI; non-combinable estimates.	Uncertain (0)	VERY LOW
3a. Clinical benefit attributable to training FDI/OP	RCT[41,44]; series[43,72] for descriptive support only.	No superiority in DASH[44] or NRS/QuickDASH[41]. No RCTs isolate training from the FDI/OP pair.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	NOT GRADABLE
3b. Percutaneous interventions on DRL	No direct trials; anatomy/reflexes[18,26,34]; DRL ultrasound[49].	It does not allow estimating efficacy or clinical safety.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	NOT GRADABLE

* Experimental starting point of the authors' own non-validated adaptation; the rating expresses exploratory confidence, not GRADE certainty, and is limited to the model. Anatomical and observational sources corroborate, but do not inherit high certainty. In 2b, 2c, and 2d, additional downgrades cannot reduce the category below very low. No upgrading was applied. Publication: uncertain (0) indicates that bias is not ruled out and no additional downgrade is applied due to lack of specific evidence. In 3a and 3b, the absence of direct evidence makes the outcome non-gradable.

Table 6 assigns moderate exploratory confidence to dorsoradial restriction by DRL and low to AOL directional function and simulated muscle loading. Certainty is very low for in vivo FDI-directed activation and for muscle and kinematic alterations observed in osteoarthritis, and the clinical benefit of specific FDI/OP training is not gradable because direct evidence is lacking. The judgment on DRL is downgraded one level because of limitations in the sectioning, measurement, and analysis protocols. It was not downgraded for imprecision because the six independent section studies total 76 specimens, all contrasts are intraspecimen, and four showed statistically significant differences[10,21,30,64], with none in the opposite direction. The absence of overlapping intervals prevents joint estimation, and a stricter criterion would reduce the sample size; confidence would be low. The increased thickness, stiffness, and breaking load of the DRL[8,23] and its mechanoreceptor density[18,22,26] are consistent with this function, but were taken only as corroboration and did not elevate the rating. The updated studies did not modify the rating of any outcome: the properties of the volar complex and its degeneration in osteoarthritis[58,61] did not measure restriction after section and were considered indirect support for 1b. Biomechanical grading is exploratory and does not authorize clinical recommendations based on the model alone.

4. Discussion

The results of the 60 studies analyzed support a review of the classic model of trapeziometacarpal joint stability. In cadaveric models, passive containment against dorsoradial subluxation falls predominantly on the DRL[7,10,21,22,23,24], while simulated loading studies attribute to the OP, alone or together with the FDI, a possible recentering role[35]. For more than three decades, the surgical model of Eaton and Littler placed the AOL as the primary passive restrictor against dislocation[1,19,20]. One possible explanation is that the palmar approach directly exposes the AOL, which is also usually observed to degenerate in advanced arthritic stages[1,7,19], although this interpretation is speculative. Materials tests[8,23] and in vivo modeling[25] describe an AOL of lower stiffness or probably lax in several positions, and in a lateral pinch model with arthritic parts, its section did not modify the dorsal subluxation[67]. D'Agostino measured a thickness of 0.6 ± 0.1 mm in an unsubdivided AOL[23]; it is not valid to attribute it exclusively to the superficial fasciculus or to deduce its function in all directions. The evidence, however, is not unanimous: a cadaveric assay attributed to AOL a relevant mechanical contribution to dorsoradial subluxation[80], and classical kinematic studies of ligamentous section identified the anterior complex (AOL and ulnar collateral ligament) as the main restrictor during circumduction[66], divergences attributable to the load vector and joint position evaluated in each model. DRL, on the other hand, has greater thickness (1.1 ± 0.2 mm[23]), rigidity (78.3 ± 21.9 N/mm[8]; 89 ± 21 N/mm[23]) and breaking load (205.5 ± 60.2 N[8]) than AOL, and its section produced greater dorsoradial translation in sequential section models[7,10,21,24]. These data identify it as an important dorsoradial restrictor, dependent on position and load vector, but do not allow us to establish that its incompetence is a necessary condition for subluxation or to determine the causal direction between laxity, subluxation and osteoarthritis.

These results are consistent with the review by Lin et al., who, from 24 of their 52 studies, anatomical, biomechanical, or histopathological studies published up to 2012, concluded that the

dorsal ligaments are the primary stabilizers of TMC[40]. The present review confirms this conclusion with subsequent studies, such as Kalshoven's multidirectional robotic analysis[24] and a model of section and reconstruction of the dorsal complex[64], but with nuances. The restriction depends on the direction: AOL contributes to slowing down extension and volar translation[24]. Nor is the structure that degenerates in primary osteoarthritis necessarily the most restrictive in the healthy joint: disinsertion of the beak ligament was associated with eburnation in 21 of 23 joints, without degeneration of the dorsal complex at any stage[61], and the volar complex showed greater stiffness in healthy joints and was attenuated earlier than DRL in a staged study conducted only in women[58]. Both findings are cross-sectional associations that do not measure restriction after section; they do not contradict the role of DRL against dorsoradial subluxation, but suggest that the relationship between mechanical stabilizers and degenerative injury is more complex than section models imply. Unlike Lin et al., who focused clinical analysis on ligamentous reconstruction and osteotomy with level IV studies, this review incorporates muscle stabilizers, two exercise RCTs, a quality assessment by design, and a grade of certainty by outcome.

In dynamic containment, outcomes depend on the protocol and population. In cadaveric bench testing, the isolated isometric load of the APL increased dorsoradial displacement of the metacarpal base[36]. This finding alone does not justify contraindicating its activation, since the models dispense with basal tone and living-hand synergies: electromyographic recordings show that APL remains continuously active during forceful pinch and in functional tasks, along with the rest of the thenar musculature[73,74]. APL also presents accessory fascicles in most hands that are inserted into the capsule and thenar musculature, with nerve endings in their trapezial insertion[59], an anatomy compatible with a coupling with the OP and with a possible proprioceptive function that has not been evaluated. Its net contribution to stability during physiological coactivation therefore remains uncertain.

In vivo studies of the update partially shift attention from FDI to OP. In osteoarthritis, fat infiltration of the deep belly of the OP was observed in 43% of patients, compared to none without osteoarthritis, with a gradient according to stage[62], and less thumb pronation during pinch that correlated with radiographic stage[60]; elastography showed no changes in the FDI[63], and another study described slightly lower stiffness of the thenar muscles, including the OP, with marginal differences[65]. These data are cross-sectional, do not measure subluxation, and do not allow us to establish whether muscle alteration is a cause or consequence of osteoarthritis. Even so, they are consistent with the greater reducing contribution of OP in simulated load[35] and justify including OP as a target in future trials.

Most studies included cadaveric tissue: 38 were primarily cadaveric, and three combined cadaver and in vivo imaging. Donor age, tissue preservation, and loading conditions limit extrapolation to live hand. A high QUACS score does not eliminate inter-hand dependence within the same donor, statistical limitations, or loss of preparations. For example, Adams obtained only seven complete sets[35], and Shin noted funding and relationships with the manufacturer of the system evaluated[76]. Funding does not demonstrate bias by itself, but should be considered when interpreting the results.

No formal tests for publication bias were performed due to the small number of comparable studies in each contrast. Searches in four databases and agreement of results do not allow us to rule it out. Table 6 records uncertainty without an additional downgrade due to insufficient specific evidence. Excluding abstracts without complete data and the lack of accessible protocols in some studies limit the evaluation of selective reporting.

Invasive physiotherapy: hypotheses and research gaps

Proposals for invasive physiotherapy on the dorsoradial region, such as periarticular dry needling or percutaneous neuromodulation, derive from indirect mechanistic inferences from the density of DRL mechanoreceptors and ligament-muscular reflexes evoked from this ligament[18,22,26,34], and not from clinical trials analysed in this review. No included studies evaluated an invasive technique, so the following paragraphs raise hypotheses supported by evidence from other joints, not recommendations.

The most direct rationale comes from TMC itself. Stimulation of the DRL triggers reflex patterns in the APL, FDI, and other thumb muscles that vary with pinch type[34], and cutaneous and periarticular anesthetic blockade of the TMC attenuated these patterns in healthy subjects[81]. Therefore, a needle procedure in the periarticular region may modify neuromuscular control and, for the same reason, caution is warranted with anesthetic infiltrations and denervation, which may reduce reflex protection. In patients with osteoarthritis, the distribution of mechanoreceptors in the DRL and AOL is altered[82], so that the response to stimulation may differ from that described in healthy subjects.

On dynamic stabilizers, evidence in TMC is scarce: ischemic compression of FDI trigger points in patients with rhizarthrosis only improved the pressure pain threshold of the muscle itself[83], and a series of nine cases treated with periosteal, muscle, and periarticular dry needling described improvements in pain and function without a control group[84]. In joints with stability deficits, dry needling of the peroneals increased electromyographic preactivation and reduced centre of pressure displacement in players with chronic ankle instability[85], and its combination with proprioceptive exercise improved function more than isolated exercise[86]; in the lumbar spine, greater multifidus contraction was described after dry needling in patients who responded to treatment[87]. In contrast, a meta-analysis found no consistent effects of needling on force production outside the cervical region[88]. By analogy, in TMC it would be more plausible to expect improved motor control of OP and FDI when puncture is combined with stabilization exercise than an increase in strength; ultrasound-guided percutaneous neuromodulation of the thenar motor branch of the median nerve would be another exploratory line[89].

Regarding static stabilizers, the only injectable intervention with trials in TMC is dextrose prolotherapy, which improved pain and function in the medium term versus corticosteroids[90] or versus anesthetic only in finger and thumb joints[91], without measuring stability. In an animal model of ligamentous injury, dextrose increased ligament cross-sectional area without reducing laxity[92], so its potential benefit should not be attributed to DRL tightening. Ultrasound-guided percutaneous electrolysis reduces pain in different tendinopathies[93], but it has not been studied for stabilizing hand ligaments. The ultrasound protocol of the central fasciculus of the DRL allows the ligament to be located[49], and the proximity of the superficial radial nerve branches

to the dorsoradial approaches[94], together with the multiple innervation of the joint[95], makes ultrasound guidance necessary in any study exploring a DRL approach.

Limitations

This review has limitations of its own and those of the primary literature. The protocol was registered after data extraction from the initial review, so outcome selection bias is possible: the choice and definition of reported outcomes may have been influenced by already known results. The update aligned with the registered protocol, but this risk persists for the studies in the initial search, which make up the majority of the corpus. Clarifying the scope of the eligibility criteria during full-text review may also have been influenced by these results. The score thresholds and the biomechanical adaptation of GRADE are not validated. Screening agreement was moderate ($\kappa = 0.53$ in the initial search and 0.52 in the update), although all discrepancies were resolved by consensus, and the quality assessment was based on a consensus-reviewed AI-assisted prescore, with no independent duplicate assessment or calculable agreement. Six reports could not be retrieved from the initial search, which may introduce selection bias, and two studies were added through citation searching, suggesting that the electronic search did not capture all eligible studies; one of them, a muscle elastography study, did not contain any term from the stability block of the search strategy in its title or abstract. Some studies provide indirect evidence, and the three mixed designs only have QUACS scores applied to the entire study, without a specific assessment of their in vivo component. In the update, one of the included studies belongs to the first author, so its evaluation was assigned to the second reviewer. The heterogeneity of protocols, populations, and comparable data justified synthesis without meta-analysis[56], not just the difference in units.

Implications for clinical practice and research

The findings provide a mechanistic basis for clinical practice, but do not demonstrate efficacy. The available trials did not isolate the effect of training the FDI/OP pair: the APL-targeted exercise program did not outperform general exercise[44] and the home-based dynamic stabilization program added no benefit to standard conservative therapy[41]. Ultrasound or radiological responses to FDI contraction differed between healthy and thumbs with advanced osteoarthritis[39,72], and the difference cannot be attributed to stage alone. Therefore, there is no basis for systematically inhibiting APL or for recommending selective OP and FDI programs outside of stratified trials. Slight metacarpophalangeal flexion during grasping is supported by biomechanical reasoning that has not been clinically evaluated[42,43]. Invasive techniques on TMC stabilizers should be considered experimental.

Future research requires concurrent EMG and dynamic imaging studies, and trials of programs targeting OP and FDI with a comparator, stratification by stage, and sufficient follow-up. Trials of invasive techniques should compare them with a sham procedure, combine them with stabilization exercise, measure stability (ultrasound or fluoroscopic displacement of the base of the first metacarpal and EMG activity of OP and FDI) as well as pain and function, stratify by stage, and record adverse effects.

5. Conclusions

In cadaveric models, the DRL is an important passive restrictor to dorsoradial subluxation, dependent on position and load vector (moderate exploratory confidence). AOL function varies by model, direction, and anatomical definition; it cannot be generally reduced to a loose structure or attributed to the superficial fasciculus results of an unsubdivided AOL.

The isolated loading of the APL increased dorsoradial misalignment in a cadaveric model, while the OP, alone or together with the FDI, reduced the induced subluxation (low exploratory confidence). In healthy subjects, immediate radial reduction has been observed during resisted contraction directed to the FDI, without excluding coactivation of other muscles; in another protocol, no dorsal reduction was observed in advanced osteoarthritis (very low certainty). In osteoarthritis, fat infiltration of the OP and less pronation during pinch have been described (very low certainty); the OP therefore deserves to be studied as a research target. The net contribution of each muscle during physiological tasks remains uncertain.

The available trials did not demonstrate superiority of the specific programs evaluated compared to general exercise or standard therapy; none isolated selective FDI/OP training, for which there is no direct clinical evidence, so this outcome is not gradable. The corpus contains no direct clinical evidence on the efficacy or safety of percutaneous interventions in the DRL region, and their application should be considered experimental until evaluation in controlled trials.

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✉ Correspondence
victormargu@gmail.com

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Ethics Statement

Not applicable. Because this is a systematic review of previously published studies, no ethics committee approval was required.

Study Registration

PROSPERO, CRD420261330988. Registration was retrospective for the initial review: version 1.0 was published on 31 August 2026, when the search (5 May 2025), screening, data extraction, quality assessment, and synthesis had already been completed. It was prospective for the update phase: the search on 21 September 2026 and the screening, extraction and evaluation of new studies were performed after registration. Both circumstances are stated in Methods, and the risk of outcome selection bias, among the limitations of the manuscript. Link: https://www.crd.york.ac.uk/PROSPERO/view/CRD420261330988. The differences between the registration and the review were corrected by an amendment (version 2.0, submitted on October 8, 2026) and are detailed in Table S6. The subsequent minor amendment (version 2.1, submitted on October 21, 2026) states the timing of registration.

Informed Consent Statement

Not applicable.

Data Availability Statement

The characteristics of the 60 included studies, item-by-item methodological quality assessments with their textual evidence, the list of excluded full-text studies, and the criteria of the lists used are provided in the supplementary material (Tables S1–S4), along with the complete search strategies (Table S5) and the differences with the PROSPERO registry (Table S6). The screening records (Rayyan) and extraction forms are available upon reasonable request to the corresponding author. The completed PRISMA 2020 checklist is provided as an additional file (S8). The completed PERSiST checklist is provided as File S7. Regarding the use of artificial intelligence, Tables S2 and S3 present the final score for each item with the fragment of the article that justifies it, and the pre-scores generated with the AI tools and records of their verification by both authors are available upon reasonable request.

Statement on the use of artificial intelligence

During the preparation of the work, Claude (Anthropic; Claude Opus 4.8, identifier claude-opus-4-8, used between June and September 2026, and Claude Opus 5.5, identifier claude-opus-5-5, used between September and October 2026) and ChatGPT (OpenAI; GPT-5.5, identifier GPT-5.5, used between June and October 2026) were used as support for the pre-scoring of quality lists, data extraction and verification, the proposal of synthesis and certainty judgments, and the review of text, references, tables and figures. In the update, these tools were also used to unify and deduplicate the exports of the databases and to propose a pre-screening that the reviewers independently verified; the searches were executed by the authors. The authors are responsible for selection decisions, verification of extractions and scores, comparison of originals, validation of grading, and final interpretation. Additions and changes made during the comparison were reviewed and validated by both authors and are documented in the supplement. The tools do not meet authorship criteria.

Conflicts of Interest

V.M.F. is the first author of one of the included studies (Margüenda-Fernández et al., Eur J Radiol 2025); A.B.M. performed data extraction and quality assessment for that study, and resolved discrepancies without V.M.F.'s participation. A.B.M. declares no conflicts of interest.

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Supplementary Material

Methodology

Cadaveric study scale	QUACS, 13 items, applied to 41 cadaveric or mixed studies (36 from the initial search and 5 from the update). Comtet is a physical model and is appraised narratively; it does not receive QUACS.
Operational thresholds	High/moderate/low quality: QUACS ≥10 / 7–9 / ≤6; PEDro 8–10 / 6–7 / ≤5; JBI ≥70% / 50–69% / <50% of applicable items. They are not equivalent to a validated risk of bias.
Scoring sources	Extraction and appraisal are based on a full reading of the original articles. Final checking and validation of the extractions and scores were carried out by both authors.
Criteria and interpretation	The item-level justifications preserve the decisions of the original matrix, including borderline cases. The scores summarise reporting/quality; they do not neutralise losses, confounding, bilateral dependence, statistical errors or conflicts of interest, which were additionally assessed by outcome.
Procedure and traceability	Sixty unique studies were included: 50 from the initial screening (one of them retrieved during the revision of the manuscript), one from reference list checking in the initial search, 8 from the update and one from reference list checking in the update. Search dates: 5 May 2025 (initial) and 21 September 2026 (update). Agreement in title and abstract screening (Cohen's kappa): initial search $\kappa = 0.53$ (95% CI: 0.43–0.63); update $\kappa = 0.52$ (95% CI: 0.34–0.71) (first vote of each reviewer in the Rayyan history; exclusion versus advancing to full text).
QUACS distribution	41 studies: 35 high quality, 5 moderate and 1 low. Mean 11.5/13; median 12; range 6–13. Items not met: statistics 14/41; instrumentation 11/41; demographics 10/41; limitations 10/41.
In vivo studies	16 JBI: 13 cross-sectional, 2 quasi-experimental and 1 case series. Quality: 10 high, 5 moderate and 1 low; median 80.4% (30–100%). Two RCTs with PEDro: 6/10 and 7/10, both moderate.
Overall distribution	60 included; 59 scored (41 QUACS + 16 JBI + 2 PEDro): 45 high, 12 moderate and 2 low; 76.3%, 20.3% and 3.4% of 59. One physical model without a category.
Certainty and synthesis	Synthesis structured by outcome and protocol, reported following SWiM. GRADE domains; own biomechanical adaptation, not validated. Table 6 of the manuscript: risk of bias, inconsistency, indirectness, imprecision and publication bias. Certainty judgements reviewed and validated by the authors.
Original exclusions	Fifteen studies were excluded at full text in the initial search and eighteen in the update (one of them, Normand 2025, already included in the previous version); individual reasons in S4. Letters to the editor are distinguished from original studies.
Sources of extraction	Data and quality justifications are extracted from the full texts, including their tables and figures. The location of the sources and the discrepancies are documented in S1–S3.
Search strategies and registration	Full strategies and record counts per database in S5; differences between the PROSPERO registration and the final report in S6.

Table S1. Characteristics of the 60 included studies (rows 51–58: studies from the search update, 21 September 2026; row 59: report from the initial search retrieved during the revision; row 60: study identified in the update through citation searching)

No.	Study (title)	Reference no. in the manuscript	Reference (audited bibliography of the manuscript)	DOI	Design	Sample / Population	Structures / Stabilisers assessed	Measurement method	Main stability results	Quality tool	Score	Quality (operational threshold)	Extraction notes (limitations reported)	Eligibility note
1	A Biomechanical Assessment of Ligaments Preventing Dorsoradial Subluxation of the Trapeziometacarpal Joint	7	Van Brenk B, Richards RR, Mackay MB, Boynton EL. A biomechanical assessment of ligaments preventing dorsoradial subluxation of the trapeziometacarpal joint. J Hand Surg Am. 1998; 23(4):607-611. doi: 10.1016/S0363-5023(98)80045-2	10.1016/S0363-5023(98)80045-2	Experimental biomechanical cadaveric study	Six fresh cadaveric hands (2 right, 4 left), age not reported, no signs of degenerative arthritis	Ligaments of the trapeziometacarpal joint: intermetacarpal, anterior oblique, palmar (posterior) oblique and dorsoradial collateral (called RCL in the source; equivalent to the DRL of the manuscript)	Dorsoradial displacement of the first metacarpal relative to the trapezium, measured with a linear variable displacement transformer under a 150 g load	Sectioning of the dorsoradial collateral ligament (RCL in the nomenclature of the source; DRL in the manuscript) produced the greatest dorsoradial displacement (mean 1.4 mm), much greater than the other ligaments (IML 0.08 mm, AOL 0.06 mm, POL 0.2 mm)	QUACS (13 items)	10/13	High	Limited by the use of cadavers, the removal of non-ligamentous soft tissue and the use of an artificial load; the full functional conditions of the thumb were not replicated	The source reports six final specimens after excluding one with OA; the individual table presents only five columns. The declared n=6 is kept and the reporting omission is recorded.
2	An Anatomic Study of the Stabilizing Ligaments of the Trapezium and Trapeziometacarpal Joint	4	Bettinger PC, Linscheid RL, Berger RA, Cooney WP 3rd, An KN. An anatomic study of the stabilizing ligaments of the trapezium and trapeziometacarpal joint. J Hand Surg Am. 1999;24(4):786-798. doi: 10.1053/jhsu.1999.0786	10.1053/jhsu.1999.0786	Cadaveric anatomical study (descriptive)	n=37 hands from 24 fresh-frozen cadavers; 17 men (6 pairs) and 20 women (7 pairs); mean age 73 years; Eaton I (n=27) and II (n=10) TMC joints; no advanced baseline osteoarthritis on radiographs	Stabilising ligaments of the trapezium and the trapeziometacarpal (TMC) joint: SAOL, dAOL (beak), DRL, POL, UCL, IML, DIML, DTT, VTT, DT-II MC, VT-II MC, T-III MC, TCL, T-C, VST, RST	Pre-dissection radiographs for Eaton staging; anatomical dissection; length/width/thickness measurements with a precision caliper (0.05 mm); documentation of prevalence (%); subjective manual assessment of tension/laxity by position	Sixteen ligaments were identified (14 insert on the trapezium and 2 on the first metacarpal: IML and DIML). Prevalence and dimensions (mean±SD): SAOL 100%, 9.45±1.61 mm (L) / 8.59±2.61 (W) / 1.34±0.25 (T); dAOL 70%, 8.37±1.68 / 5.45±0.45 / 1.17±0.15; UCL 100%, 8.05±2.02 / 3.35±0.33 / 0.83±0.12; DRL 100%, 7.12±1.67 / 11.39±1.92 / 2.25±0.33; POL 100%, 10.08±1.41 / 4.97±0.89 / 1.35±0.28; IML 100%, 9.67±2.26 / 3.47±1.26 / 1.03±0.18; DIML 43%, 10.67±1.65 / 3.70±0.83 / 1.10±0.08; DTT 100%, 3.55±0.93 / 6.86±1.41 / 1.72±0.15; VTT 100%, 3.64±0.69 / 6.71±1.34 / 1.30±0.23; DT-II MC 100%, 3.10±1.27 / 7.89±1.27 / 1.88±0.31; VT-II MC 78%, 4.75±1.43 / 6.81±1.57 / 1.89±0.45; T-III MC 92%, 13.67±1.40 / 5.53±0.77 / 1.23±0.19; T-C 100%, 8.17±1.59 / 7.27±1.16 / 1.40±0.24. Functional findings (subjective): the DRL and dAOL play a substantial role in TMC stabilisation; the dAOL may act as a pivot for pronation during palmar abduction; DT-II MC, VT-II MC and T-III MC act as tension bands to prevent instability from cantilever flexion forces on the trapezium; the DRL tightens with dorsal/dorsoradial subluxation forces in almost all positions except full extension.	QUACS (13 items)	12/13	High	Descriptive cadaveric study with subjective functional assessment (no objective biomechanical measurements), selection of specimens without advanced osteoarthritis (Eaton I–II) and ex vivo measurements that may differ from in vivo conditions	
3	Anatomy of trapeziometacarpal ligaments	2	Imaeda T, An KN, Cooney WP 3rd, Linscheid RL. Anatomy of trapeziometacarpal ligaments. J Hand Surg Am. 1993;18(2):226-231. doi: 10.1016/0363-5023(93)90352-4	10.1016/0363-5023(93)90352-4	Anatomical/descriptive cadaveric study	30 hand specimens (men and women, fresh and embalmed cadavers, mean ages 69–75 years)	Ligaments	Microscope-assisted anatomical observation and dissection, manual ligament tension tests	Five main ligaments were identified: the anterior oblique ligament (main stabiliser), the ulnar collateral ligament, the first intermetacarpal ligament, the posterior oblique ligament and the dorsoradial ligament. The anterior oblique ligament is the main stabiliser of the thumb in extension, abduction and pronation. The other ligaments are secondary stabilisers. Degenerative changes typically attenuate the anterior oblique ligament; the dorsoradial ligament was neither a primary nor a secondary stabiliser.	QUACS (13 items)	10/13	High	No additional extraction notes; item-level evidence in Table S2	

No.	Study (title)	Reference no. in the manuscript	Reference (audited bibliography of the manuscript)	DOI	Design	Sample / Population	Structures / Stabilisers assessed	Measurement method	Main stability results	Quality tool	Score	Quality (operational threshold)	Extraction notes (limitations reported)	Eligibility note
4	Comparison of the Anatomical Dimensions and Mechanical Properties of the Dorsoradial and Anterior Oblique Ligaments of the Trapeziometacarpal Joint	23	D'Agostino P, Kerkhof FD, Shahabpour M, Moermans JP, Stockmans F, Vereecke EE. Comparison of the anatomical dimensions and mechanical properties of the dorsoradial and anterior oblique ligaments of the trapeziometacarpal joint. J Hand Surg Am. 2014; 39(6):1098-1107. doi: 10.1016/j.jhsa.2014.02.025	10.1016/j.jhsa.2014.02.025	Experimental anatomical cadaveric study	13 fresh-frozen hands from 9 human specimens (adults, men and women, mean age: 74 years, without advanced osteoarthritis)	Ligaments: dorsoradial ligament (DRL) and anterior oblique ligament (AOL)	Magnetic resonance imaging (3T), anatomical dissection, digital caliper, and mechanical tests with a material testing rig (cyclic loading, force-displacement curves)	The DRL is significantly shorter, thicker and stiffer than the AOL. The DRL shows greater stiffness (89 N/mm vs 65 N/mm) and greater hysteresis (25% vs 21%) than the AOL. The AOL is thin, fragile and ill-defined, whereas the DRL is a robust structure. The authors did not find the AOL as two distinct structures (superficial and deep); the DRL is the main mechanical stabiliser of the TMC.	QUACS (13 items)	13/13	High	Small sample of advanced age; potential selection bias because advanced osteoarthritis was not included; limitation of the measurement method (differences between MRI and dissection)	Undivided AOL: the authors did not reproduce superficial/deep fascicles. Stiffness: DRL 89 ± 21 and AOL 65 ± 30 N/mm according to the text; the tables label MPa inconsistently. Do not attribute these data to the superficial AOL.
5	Complex, Multidimensional Thumb Movements Generated by Individual Extrinsic Muscles	79	Li ZM, Tang J, Chakan M, Kaz R. Complex, multidimensional thumb movements generated by individual extrinsic muscles. J Orthop Res. 2008; 26(9):1289-1295. doi: 10.1002/jor.20641	10.1002/jor.20641	Laboratory experimental study with cadaveric specimens	Ten fresh cadaveric arms (4 men, 6 women; mean age 52.8 years)	Extrinsic thumb tendons: abductor pollicis longus (APL), extensor pollicis brevis (EPB), extensor pollicis longus (EPL) and flexor pollicis longus (FPL)	Three-dimensional analysis with markers and a motion capture system to record the angular movement of the thumb CMC, MCP and IP joints during loading of each muscle	Each extrinsic muscle generated unique joint trajectories in multiple directions. FPL, APL, EPB and EPL generated 2, 2, 3 and 6 movements respectively, adding up to 8 different movements across the thumb joints. High interjoint coordination was observed between MCP–IP flexion by FPL and MCP–IP extension by EPL, as well as intra-articular extension–supination coordination at the CMC by APL, EPL and EPB.	QUACS (13 items)	13/13	High	No additional extraction notes; item-level evidence in Table S2	
6	Contact patterns in the trapeziometacarpal joint: The role of the palmar beak ligament	16	Pellegrini VD Jr, Olcott CW, Hollenberg G. Contact patterns in the trapeziometacarpal joint: The role of the palmar beak ligament. J Hand Surg Am. 1993;18(2):238-244. doi: 10.1016/0363-5023(93)90354-6	10.1016/0363-5023(93)90354-6	Experimental cadaveric study	23 forearm specimens from cadavers with no history of connective tissue disease	Palmar beak ligament	Pressure-sensitive film (Fuji) to record joint contact patterns in different functional positions	The main contact area in the trapeziometacarpal joint during flexion-adduction in lateral pinch is the palmar compartment. Sectioning the beak ligament resulted in a dorsal translation of the contact zone, similar to the pattern observed in osteoarthritic degeneration. Specimens with end-stage osteoarthritis showed a pathological, diffuse pattern, with no change after further manipulation of the ligament.	QUACS (13 items)	11/13	High	No additional extraction notes; item-level evidence in Table S2	
7	Coupling between mechanical and neural behaviour in the human first dorsal interosseous muscle	33	Hudson AL, Taylor JL, Gandevia SC, Butler JE. Coupling between mechanical and neural behaviour in the human first dorsal interosseous muscle. J Physiol. 2009;587(Pt 4):917-925. doi: 10.1113/jphysiol.2008.165043	10.1113/jphysiol.2008.165043	Experimental physiological study in healthy volunteers, within-subject crossover (comparison of thumb postures), with and without radial nerve block in a subgroup	15 healthy adults; 32 ± 10 years; 7 women. Radial block in 5 subjects; ultrasound in 6. Right hand.	First dorsal interosseous (FDI) and long finger flexors/extensors; effect of thumb position (carpometacarpal angle) on the FDI moment arm	Flexion force measured with a load cell; flexion twitch evoked by supramaximal ulnar nerve stimulation; ultrasonography to estimate the change in moment arm (FDI tendon displacement); surface EMG of FDI normalised to the maximal M wave (Mmax) and EMG of the long flexors; EMG monitoring of the extensors	- With 'thumb down' versus 'thumb up', the flexion twitch force was ≈60% greater and the flexion moment arm ≈50% greater. - Changing the carpometacarpal angle had a minimal effect on twitch force in both postures. - In voluntary contractions of ≈5 N, normalised FDI EMG was ≈28% greater with 'thumb down'; there was no consistent change in the EMG of the long flexors. - The size of the M wave was similar between postures; the radial block did not modify the findings.	JBI analytical cross-sectional	6/7	High	Small sample (n=15), no masking; within-subject design and random order of postures reduce confounding; possible EMG 'cross-talk'; generalisation limited to healthy volunteers.	Indirect relevance: mechanics/neural drive of the FDI in index finger flexion, not direct TMC stability

No.	Study (title)	Reference no. in the manuscript	Reference (audited bibliography of the manuscript)	DOI	Design	Sample / Population	Structures / Stabilisers assessed	Measurement method	Main stability results	Quality tool	Score	Quality (operational threshold)	Extraction notes (limitations reported)	Eligibility note
8	Digit mechanics in relation to endpoint compliance during precision pinch	75	Nataraj R, Audu ML, Li ZM. Digit mechanics in relation to endpoint compliance during precision pinch. J Biomech. 2015; 48(4):672-680. doi: 10.1016/j.jbiomech.2014.12.040	10.1016/j.jbiomech.2014.12.040	Experimental study	Thirteen healthy, right-handed subjects, all men, mean age 31.2±6.3 years	Not applicable	3D kinematics (markers and optical motion capture) and forces in 6 degrees of freedom (load cells in a custom pinch apparatus / bands); inverse modelling to calculate joint angles and joint moments normalised by force	The index finger showed greater dependence on compliance for angular position, whereas the thumb did so for normalised joint moments; forces were modulated according to resistance; the index finger was more efficient in applying normal force; coordination in the angle of forces between fingers increased with lower compliance; the changes in joint postures and moments were mainly in the index MCP and thumb CMC joints.	JBI analytical cross-sectional	7/7	High	No additional extraction notes; item-level evidence in Table S3	Indirect relevance: pinch mechanics, no direct outcome of TMC stability
9	Distribution of strength potential of the thumb muscles and their relationship to trapeziometacarpal osteoarthritis: An exploratory cadaveric study	37	Normand M, Effatparvar MR, Lavoie FA, Brismée JM, Sobczak S. Distribution of strength potential of the thumb muscles and their relationship to trapeziometacarpal osteoarthritis: An exploratory cadaveric study. Clin Biomech (Bristol). 2025;124:106489. doi: 10.1016/j.clinbiomech.2025.106489	10.1016/j.clinbiomech.2025.106489	Exploratory correlational cadaveric study	19 hands from 10 fresh cadavers (60% men, mean age 79.2 years, standard deviation 7.1)	Dynamic stabilising muscles of the thumb (abductor pollicis longus, opponens pollicis, etc.)	Estimation of muscle mass normalised to body weight, PCSA calculated by anatomical dissection, radiographic and direct visual assessment of TMC osteoarthritis and its mapping in nine joint zones	Moderate negative correlations were found between the normalised mass of the abductor pollicis longus and the opponens pollicis and the Eaton-Glickel grade (r⍰ = -0.60 and -0.59, p<0.01) and the TMC index (r⍰ = -0.51 and -0.63, p<0.05/p<0.01). There was no correlation between PCSA and the osteoarthritis indices. Moderate negative correlations between normalised muscle mass and wear in specific joint zones. The sample size decreased for topographic mapping because of complete eburnation in some specimens.	QUACS (13 items)	13/13	High	Limited by small sample size, advanced age of the specimens and sample reduction for topographic mapping because of articular eburnation.	
10	Dynamic stabilization home exercise program for treatment of thumb carpometacarpal osteoarthritis: A prospective randomized control trial	41	McVeigh KH, Kannas SN, Ivy CC, Garner HW, Barnes CS, Heckman MG, Brushaber DE, Murray PM. Dynamic stabilization home exercise program for treatment of thumb carpometacarpal osteoarthritis: A prospective randomized control trial. J Hand Ther. 2022;35(3):435-446. doi: 10.1016/j.jht.2021.06.002	10.1016/j.jht.2021.06.002	Prospective randomised clinical trial	84 initial participants; 17 without follow-up excluded and 67 analysed (SCT 34; SCT+HE 33). Age: SCT 63.9 years (46–86), SCT+HE 66.5 (48–86). The 18–86 year range corresponds to eligibility, not to the ages observed.	Hand-based thumb spica orthosis; several brands and styles	Numerical rating scale (NRS), QuickDASH (Disabilities of the Arm, Shoulder and Hand), range of motion (ROM), grip and pinch strength, Kapandji opposition scale, Eaton radiographic stage; assessed at baseline, 6 weeks and 6 months.	There were no statistically significant differences between SCT and SCT+HE in pain reduction (NRS) and in QuickDASH at 6 weeks (P = .28 and .36, respectively) or at 6 months (P = .52 and .97, respectively). Both groups showed statistically significant improvements in NRS and QuickDASH relative to baseline.	PEDro	6/10	Moderate	Sample size smaller than planned. Therapists not blinded. Computer-generated random allocation with concealment. Adherence and reporting with limitations. 17/84 patients lost to follow-up.	
11	Effects of a dynamic stability approach in conservative intervention of the carpometacarpal joint of the thumb: A retrospective study	43	O'Brien VH, Giveans MR. Effects of a dynamic stability approach in conservative intervention of the carpometacarpal joint of the thumb: A retrospective study. J Hand Ther. 2013;26(1):44-52. doi: 10.1016/j.jht.2012.10.005	10.1016/j.jht.2012.10.005	Retrospective (retrospective cohort)	35 adults (31 women, 4 men; age range: 30–82 years; mean: 58 years) with thumb carpometacarpal joint pain or a diagnosis of CMC osteoarthritis; patients with other pathologies excluded.	CMC orthosis (type not specified; customised according to the patient's functional needs; specific design not controlled, but all stabilised the CMC)	QuickDASH (Disabilities of the Arm, Shoulder and Hand), short version: pain domain (question 9) and overall disability (total score of 11 items), recorded at baseline and at discharge/final intervention.	Significant reduction in mean pain (QuickDASH, question 9) from 3.34 to 2.74 (−17.9%, p<0.01); improvement in mean disability score from 37.0 to 29.9 (−19.3%, p<0.01). The mean individual improvement was 15.7%, exceeding the MCID (15%).	JBI quasi-experimental	4/7	Moderate	Retrospective design, no control group, possible variability between therapists and unmonitored adherence, mix of 7 centres and 16 therapists, potential baseline diagnostic imprecision and no clear specification of the type of orthosis	

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12	Effects of the Deep Anterior Oblique and Dorsoradial Ligaments on Trapeziometacarpal Joint Stability	10	Colman M, Mass DP, Draganich LF. Effects of the deep anterior oblique and dorsoradial ligaments on trapeziometacarpal joint stability. J Hand Surg Am. 2007;32(3):310-317. doi: 10.1016/j.jhsa.2006.12.002	10.1016/j.jhsa.2006.12.002	Experimental cadaveric study	18 initial hands from different donors (6 men and 12 women); one excluded for poor bone quality, 17 tested. The distribution by sex corresponds to the initial sample; the sex of the excluded specimen is not specified.	Deep ligaments of the thumb: dorsoradial ligament (DRL) and deep anterior oblique ligament (dAOL)	Three-dimensional magnetic tracking system (Polhemus 3Space Fastrak), digitisation of anatomical bony landmarks and recording of displacements and rotations	In lateral pinch, sectioning of the DRL produced a mean three-dimensional translation of 1.3 mm and increased pronation by 4.1°, whereas sectioning of the dAOL produced a mean translation of 0.6 mm and increased pronation by 2.4°. Radial translation (1.0 mm, p<0.05) was significant after sectioning of the DRL and ulnar translation (0.3 mm; p<0.05) after sectioning of the dAOL. In thumb opposition, sectioning of the DRL increased translation by 1.0 mm and of the dAOL by 0.5 mm.	QUACS (13 items)	13/13	High	No additional extraction notes; item-level evidence in Table S2	
13	Importance du complexe ligamentaire postéromédial trapézométacarpien	17	Kuhlmann JN. Importance du complexe ligamentaire postéromédial trapézométacarpien. Chir Main. 2001;20(1):31-47. doi: 10.1016/s1297-3203(01)00012-9	10.1016/s1297-3203(01)00012-9	Experimental anatomical and biomechanical cadaveric study	40 thumbs from fresh cadavers	Posteromedial ligamentous complex (posterior oblique, anterior oblique, intermetacarpal and retinaculometacarpal ligaments)	Direct anatomical observation and biomechanical analysis of mobility and stability after selective sectioning of the ligaments; use of Kirschner wires and angular reference on a table	The posteromedial ligamentous complex is essential for the stability and pronosupination of the thumb. Sectioning of these ligaments produces different degrees of instability. The anterolateral ligament only reinforces the action of the posteromedial complex in extreme positions. Practical implications for diagnosis and surgical reconstruction.	QUACS (13 items)	6/13	Low	No additional extraction notes; item-level evidence in Table S2	
14	In Vivo Length and Changes of Ligaments Stabilizing the Thumb Carpometacarpal Joint	70	Tan J, Xu J, Xie RG, Deng AD, Tang JB. In vivo length and changes of ligaments stabilizing the thumb carpometacarpal joint. J Hand Surg Am. 2011;36(3):420-427. doi: 10.1016/j.jhsa.2010.11.007	10.1016/j.jhsa.2010.11.007	Prospective observational study in healthy volunteers	6 healthy volunteers (3 men and 3 women), aged 20–32 years (mean 25 years), without systemic disease or symptoms in the right hand	Main ligaments of the thumb carpometacarpal joint (deep anterior oblique/beak ligament, dorsoradial ligament, posterior oblique ligament, intermetacarpal ligament and dorsal intermetacarpal ligament)	Serial computed tomography (CT), 3D bone reconstruction and modelling of ligament paths with specialised software; measurement of distances between origin and insertion in the positions of interest; statistical analysis of the changes	The estimated ligament lengths changed significantly during thumb movements. Flexion caused the greatest changes: all ligaments lengthened significantly except the beak, which shortened significantly. In abduction and opposition, the beak also shortened significantly, while the other ligaments lengthened. The beak showed marked shortening in all three movements, whereas the others lengthened to varying degrees.	JBI analytical cross-sectional	5/7	High	Possible selection bias because of the small number of volunteers and the limitation to the healthy right hand of young adults	
15	In vivo recruitment patterns in the anterior oblique and dorsoradial ligaments of the first carpometacarpal joint	25	Halilaj E, Rainbow MJ, Moore DC, Laidlaw DH, Weiss AC, Ladd AL, Crisco JJ. In vivo recruitment patterns in the anterior oblique and dorsoradial ligaments of the first carpometacarpal joint. J Biomech. 2015;48(10):1893-1898. doi: 10.1016/j.jbiomech.2015.04.028	10.1016/j.jbiomech.2015.04.028	Observational cross-sectional in vivo study	44 healthy subjects (10 young men, 11 young women, 10 older men, 13 older women), ages: young ≈ 22–24 years, older ≈ 55–57 years	Ligaments: anterior oblique (AOL) and dorsoradial (DRL) of the thumb carpometacarpal joint	Clinical computed tomography (CT) with three-dimensional modelling of bones and ligaments; analysis of fibre length and percentage of recruitment relative to the maximum length observed for each ligament in the scanned positions	AOL: mean recruitment <91% in the positions studied. DRL: greatest recruitment in adduction and flexion according to the detailed results; the abstract says abduction and flexion (internal discrepancy). Real resting length and direct tension were not measured. Radial fibres of the DRL longer than ulnar fibres; DRL longer in men.	JBI analytical cross-sectional	6/7	High	Potential bias due to the impossibility of measuring the real resting length of the ligaments and to dependence on manual identification of ligament insertion sites based on previous studies; no method reported to minimise selection bias	
16	Influence of the trapeziometacarpal joint fusion on thumb muscles and thumb-tip movement: A cadaveric study	77	Kawano Y, Nakamura T, Tada M, Nagura T, Matsumoto M, Nakamura M, Sato K. Influence of the trapeziometacarpal joint fusion on thumb muscles and thumb-tip movement: A cadaveric study. Clin Biomech (Bristol, Avon). 2019;67:8-14. doi: 10.1016/j.clinbiomech.2019.04.013	10.1016/j.clinbiomech.2019.04.013	Experimental cadaveric biomechanical (ex vivo) study with before/after comparison in the same specimen.	6 left upper limbs from fresh-frozen cadavers (3 men, 3 women), mean age 88 years (range 82–95).	TMC arthrodesis with two 1.8 mm Kirschner wires.	Optical motion capture system (OptiTrack Flex 13) with markers on bones; 3D reconstruction with CT; calculation of the length and area of the thumb tip trajectory under different traction/loading combinations; statistical analysis with paired t test or Wilcoxon (α=0.05).	The area of the thumb tip trajectory decreased on average to 32.8% of the intact state after arthrodesis (P=0.03, power 0.99). The length of the trajectory decreased significantly when pulling the APL (−54%, P<0.01, power 0.87), with no significant changes for FPL, EPL and EPB. With loads on the intrinsics: APB and FPB decreased to ~30% (−70%, P<0.01, power 0.99), OP to ~15% (−85%, P<0.01, power 0.99) and ADP to ~70% (−30%, P<0.01, power 0.99).	QUACS (13 items)	12/13	High	No additional extraction notes; item-level evidence in Table S2	

No.	Study (title)	Reference no. in the manuscript	Reference (audited bibliography of the manuscript)	DOI	Design	Sample / Population	Structures / Stabilisers assessed	Measurement method	Main stability results	Quality tool	Score	Quality (operational threshold)	Extraction notes (limitations reported)	Eligibility note
17	Internal brace augmentation improves the biomechanical properties of trapeziometacarpal joint dorsoradial ligament repair	76	Shin SH, Shin SS, McGarry MH, Lee TQ. Internal brace augmentation improves the biomechanical properties of trapeziometacarpal joint dorsoradial ligament repair. Hand Surg Rehabil. 2024;43(2):101643. doi: 10.1016/j.hansur.2024.101643	10.1016/j.hansur.2024.101643	Biomechanical study with a cadaveric model, comparison of paired groups	14 fresh-frozen hands from 7 donors (7 pairs); mean age 61.9 ± 7.4 years; 4 men and 3 women.	Internal brace (internal reinforcement) using Labral Tape and SwiveLock anchors (Arthrex)	Custom biomechanical testing system: range of motion tests (flexion/extension, abduction/adduction), measurement of dorsal/volar translation, load-to-failure test; analysis with a 3D digitiser	Repair with internal brace significantly improved load resistance at both 2 mm displacement (18.0±1.8 N vs 10.8±1.3 N; p=0.009) and 3 mm displacement (35.3±3.7 N vs 23.1±2.9 N; p=0.006) and at maximum load (83.7±4.3 N vs 50.0±4.7 N; p=0.001). Range of motion was not compromised relative to the intact state, whereas isolated repair showed hypermobility in flexion-extension.	QUACS (13 items)	13/13	High	Seven pairs; immediate postoperative model. Funding and conflicts with Arthrex declared; consider them by outcome, without assuming that they demonstrate bias. Failure loads expressed as mean ± standard error in the source.	
18	Kinematics of the Trapeziometacarpal Joint After Sectioning of Ligaments	66	Imaeda T, Niebur G, An KN, Cooney WP 3rd. Kinematics of the trapeziometacarpal joint after sectioning of ligaments. J Orthop Res. 1994;12(2):205-210. doi: 10.1002/jor.1100120209	10.1002/jor.1100120209	Experimental in vitro biomechanical study	12 fresh human cadaveric hands, free of osteoarthritis	Ligaments of the trapeziometacarpal joint (anterior oblique, ulnar collateral, first intermetacarpal, ulnar capsule)	Three-dimensional magnetic tracking system and kinematic analysis of the movement of the base of the first metacarpal; measurement of laxity and of the displacement of the borders and centroid of the base	Sectioning of the anterior oblique and ulnar collateral ligaments resulted in significant dorsal-ulnar displacement and increased dorsopalmar laxity; sectioning of the intermetacarpal ligament and ulnar capsule did not modify the movement pattern. The anterior oblique and ulnar collateral ligaments were the main stabilisers during circumduction of the thumb.	QUACS (13 items)	11/13	High	Limited by in vitro experimental design and exclusive use of cadaveric specimens without simulation of full active loading	
19	Kinematics of Trapeziometacarpal Joint During First Dorsal Interosseous Maneuver in Osteoarthritic Patients: An Imaging Study Using Real-Time Magnetic Resonance Imaging and Ultrasonography	72	Ooishi D, Ueba H, Aso K, Izumi M, Ikeuchi M. Kinematics of trapeziometacarpal joint during first dorsal interosseous maneuver in osteoarthritic patients: An imaging study using real-time magnetic resonance imaging and ultrasonography. J Hand Surg Am. 2025;50(11):1408.e1-1408.e9. doi: 10.1016/j.jhsa.2024.12.018	10.1016/j.jhsa.2024.12.018	Level IV therapeutic study; prospective observational study with healthy comparator; real-time imaging assessment and 1-month clinical follow-up with orthosis + FDI exercise	10 female patients with TMC osteoarthritis in advanced stages (Eaton II=1, III=8, IV=1), mean age 64 years (52–83); baseline VAS pain ~74.5 mm; mean lateral pinch strength 1.7 kg. Controls: 10 thumbs from 5 healthy women, mean age 49.4 years (40–57)	Dynamic stabiliser: first dorsal interosseous (FDI); static stabiliser: TMC immobilisation orthosis	Real-time 3T MRI (GE SIGNA Architect, TRICKS sequence, 30 fps) with measurement of translation and tilt of the MC1 in sagittal and coronal planes; volumetric segmentation of the FDI muscle on T1 MRI (volume normalised by BMI); dynamic ultrasound (18 MHz linear probe) to classify metacarpal displacement (improved/unchanged/worse); pain VAS (0–100 mm) and lateral pinch strength (kg)	- During the FDI manoeuvre, thumbs with OA showed greater radial translation of the MC1 and greater ulnar and dorsal tilt than healthy thumbs; there were no differences in palmar translation, but palmar tilt differed significantly between groups. - FDI volume significantly lower in OA (median [IQR] 28 [26–32] cm3/BMI) than in healthy thumbs (39 [38–41] cm3/BMI). - On ultrasound, 6/10 OA thumbs showed increased dorsal subluxation (worse), 4 no change; in healthy thumbs, 6 improved and 4 no change. - Maximum radial translation was lower (better) in the group with ultrasound improvement than in the groups with no change or worsening. - After 1 month of therapy, patients improved pain (VAS 74.5 ⁇ 30.3 mm) and pinch strength (1.7 ⁇ 2.6 kg), with no direct correlation with kinematic changes.	JBI analytical cross-sectional	5/8	Moderate	Small sample and women only; non-randomised; healthy comparator not age-matched; non-functional posture in MRI; exercise adherence not verified; advanced-stage OA only; short follow-up; possible uncontrolled confounders. Imaging assessors blinded and reliability of measures adequate (intra-rater ICC 0.81–0.88; inter-rater 0.69–0.83)	FDI-targeted manoeuvre; does not compare controlled FDI+OP coactivation or OP in isolation. Distinguish radial translation on MRI from dorsal subluxation on ultrasound and the clinical results of the uncontrolled programme.

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20	Ligament length during circumduction of the trapeziometacarpal joint	68	Imaeda T, Niebur G, Cooney WP, Linscheid RL, An KN. Ligament length during circumduction of the trapeziometacarpal joint. J Orthop Sci. 1997;2:319-327. doi: 10.1007/BF02488916	10.1007/BF02488916	Experimental in vitro biomechanical study in cadaveric hands.	12 fresh cadaveric hands (63–78 years), without deformity or osteoarthritis on radiography.	Native ligaments of the trapeziometacarpal joint (AOL, UCL, IML, POL, DRL).	3Space electromagnetic tracking system (Polhemus) with a sensor on the 1st metacarpal and a digitizing stylus for ligament origins/insertions; calculation of the 3D origin-insertion distance as a proxy for ligament length (normalized to the maximum during circumduction). Measurement error ~0.18 mm.	- The 1st metacarpal described an ellipse during circumduction. - Maximum lengths: AOL and UCL in extension-abduction; IML and POL in flexion-abduction (radial-palmar); DRL in adduction (ulnar-palmar). - Minimum lengths occurred in opposite positions. - Total length variation during circumduction: 5%–9% of the maximum (AOL 5.45%, UCL 4.96%, IML 5.46%, POL 8.80%, DRL 5.93%). - Mean maximum distances (mm): AOL 12.54; UCL 13.15; IML 12.99; POL 12.93; DRL 12.21. - At least one ligament is functionally taut throughout the circumduction arc; within the ellipse all are <99% of the maximum.	QUACS (13 items)	11/13	High	In vitro cadaveric study, small sample, indirect length measurement (origin-insertion distance), simplified and constant muscle loads, no blinding or randomization.	
21	Ligamento-Muscular Reflex Patterns Following Stimulation of a Thumb Carpometacarpal Ligament: An Electromyographic Study	34	Mobargha N, Rein S, Hagert E. Ligamento-muscular reflex patterns following stimulation of a thumb carpometacarpal ligament: An electromyographic study. J Hand Surg Am. 2019;44(3):248.e1-248.e9. doi: 10.1016/j.jhsa.2018.06.011	10.1016/j.jhsa.2018.06.011	Laboratory experimental study, electromyography in healthy volunteers.	10 healthy subjects (5 women and 5 men), mean age 28 years (range 24-37 years), with no history of hand or wrist trauma or dysfunction.	Dorsoradial ligament (DRL) of the trapeziometacarpal joint.	Electromyography (EMG) of 4 stabilizing muscles of the CMC1 (extensor pollicis longus, abductor pollicis longus, abductor pollicis brevis, first dorsal interosseous) using needle electrodes and fine-wire electrodes in the DRL, with ultrasound guidance for placement.	Patterns of massive inhibition were observed in all muscles during tip pinch, rapid co-contraction in lateral (key) pinch, and rapid inhibition of antagonists in palmar pinch. The APL was the only muscle to react in <20 ms after stimulation.	JBI analytical cross-sectional	6/7	High	Limited by small sample size, possible bias due to the invasive nature of the study, and limited muscle selection; pain minimized with subthreshold stimulation.	
22	Ligamentous constraint of the first carpometacarpal joint	30	Rusli WMR, Mirza E, Tolerton S, Yong S, Johnson R, Horwitz MD, et al. Ligamentous constraint of the first carpometacarpal joint. J Biomech. 2021;128:110789. doi: 10.1016/j.jbiomech.2021.110789	10.1016/j.jbiomech.2021.110789	In vitro experimental study with sequential ligament sectioning in cadaveric specimens	16 specimens of complete forearms/phalanges from fresh cadavers (8 men, 8 women; mean age 52.4 ± 11.7 years; 9 right hands, 7 left; 10 bilateral, 6 unilateral), with no osteoarthritis or observed lesions	Ligaments of the first carpometacarpal joint: anterior oblique ligament (AOL), ulnar collateral ligament (UCL), intermetacarpal ligament (IML), dorsal radial ligament (DRL)	Joint translation (first metacarpal relative to the trapezium) measured with linear variable differential transformers (LVDT) in the dorsal-volar and radial-ulnar axes under load applied with a materials testing machine and a custom ball-table system	Sectioning of the IML and DRL significantly increased translation of the first CMC in response to external loads, especially in the dorsal, volar and radial directions ($p<0.05$). The DRL and IML are important in restraining joint translation; sectioning of the AOL and UCL did not produce significant increases. No significant ligamentous restraint was found under ulnar load.	QUACS (13 items)	13/13	High	Limited; possible variability due to specimen morphology and fixed sequence of ligament sectioning, but standardized and controlled procedures; muscle contribution not assessed	
23	Ligamentous Stability of the Base of the Thumb	5	Pagalidis T, Kuczynski K, Lamb DW. Ligamentous stability of the base of the thumb. Hand. 1981; 13(1):29-35. doi: 10.1016/s0072-968x(81)80026-5	10.1016/s0072-968x(81)80026-5	Anatomical cadaveric dissection study	17 embalmed adult hand specimens	Ligaments (intermetacarpal ligament, anterior and posterior oblique ligaments, dorsoradial ligament, volar/ulnar collateral ligament)	Anatomical observations, laxity and displacement tests after ligament sectioning, direct inspection and photographic documentation	Only sectioning of the first intermetacarpal ligament produced major displacement (radial/dorsal) of the base of the first metacarpal. The volar ligament and other ligaments did not produce significant instability by themselves. In cases of advanced osteoarthritis, spontaneous elongation or destruction of the intermetacarpal ligament was observed.	QUACS (13 items)	7/13	Moderate	Not explicitly reported; limitations related to the anatomical design and small sample size	
24	L'articulation trapézométacarpienne : l'allongement des ligaments en fonction de la position du pouce. Étude sur modèle agrandi	55	Comtet JJ, Rumelhart C, Chèze L, Fickry T. L'articulation trapézométacarpienne : l'allongement des ligaments en fonction de la position du pouce. Étude sur modèle agrandi [The trapezio-metacarpal joint: the strain of the ligaments as a function of the thumb position. Study on an enlarged model]. Chir Main. 2006; 25(5):185-192. doi: 10.1016/j.main.2006.09.002	10.1016/j.main.2006.09.002	Experimental study in an enlarged anatomical model	Polystyrene anatomical model of the first two rays of the hand based on a scan of a healthy male subject	Ligaments simulated with rubber bands of known mechanical properties	Direct measurement of ligament elongation with a millimetre ruler, percentage elongation calculation; statistical comparison using Wilcoxon test	The greatest elongations (26-39%) were observed in the intermetacarpal ligament and the anterior oblique ligament in the postero-medial (J) and postero-lateral (L) directions. The dorsoradial and posterior oblique ligaments showed elongations ≤12% in the other directions.	Narrative assessment of a physical model; QUACS not applicable	Not applicable	No category	Physical model made of polystyrene and rubber bands, without cadaveric tissue. Artificial geometry, insertions and properties limit external validity; measurement error described as 5–10%. Not included in the QUACS denominator.	

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25	Macroscopic and Microscopic Analysis of the Thumb Carpometacarpal Ligaments: A Cadaveric Study of Ligament Anatomy and Histology	18	Ladd AL, Lee J, Hagert E. Macroscopic and microscopic analysis of the thumb carpometacarpal ligaments: A cadaveric study of ligament anatomy and histology. J Bone Joint Surg Am. 2012; 94(16):1468-1477. doi: 10.2106/JBJS.K.00329	10.2106/JBJS.K.00329	Anatomical and descriptive cadaveric study	30 cadaveric hands (10 fresh, 20 embalmed) from 19 adult cadavers (8 women, 11 men; mean age at death: 76 years)	Ligaments of the first carpometacarpal (CMC) joint of the thumb	Digital caliper measurements for morphometry; histological stains and triple immunofluorescence to analyze tissue organization, cellularity and sensory innervation; semi-quantitative analysis and linear mixed regression to compare parameters between ligaments	Seven main ligaments were identified: three dorsal (dorsal radial, dorsal central, posterior oblique), two volar (anterior oblique, ulnar collateral) and two ulnar (dorsal trapeziometacarpal and intermetacarpal). The dorsal ligaments are significantly thicker, with greater cellularity and sensory innervation than the volar ones ($p < 0.001$). The anterior oblique ligament is a thin, hypocellular structure, resembling a capsule rather than a true ligament.	QUACS (13 items)	13/13	High	No additional extraction notes; item-level evidence in Table S2	
26	Material Properties of the Trapezial and Trapeziometacarpal Ligaments	8	Bettinger PC, Smutz WP, Linscheid RL, Cooney WP 3rd, An KN. Material properties of the trapezial and trapeziometacarpal ligaments. J Hand Surg Am. 2000;25(6):1085-1095. doi: 10.1053/jhsu.2000.18487	10.1053/jhsu.2000.18487	Experimental biomechanical study in cadavers	20 hands from 19 cadavers: 10 hands from male donors and 10 from female donors. Age by sex: men 75 ± 7.4 years; women 67 ± 11.6. These figures by sex describe hands, not 20 independent donors.	Ligaments of the trapeziometacarpal joint and of the trapezium: dorsal and volar trapeziotrapezoid, dorsal and volar trapezium-second metacarpal, anterior oblique, dorsoradial, and trapezium-third metacarpal	Peak load, peak stress, maximum elongation, stiffness, toughness (energy to failure) and hysteresis, using a servohydraulic machine (MTS) at different controlled strain rates	The dorsoradial ligament was the strongest and most resistant (peak load and toughness); the trapezium-third metacarpal ligament showed the highest peak stress and stiffness; the anterior oblique was the weakest and most compliant, with the greatest hysteresis. There were sex differences for some parameters.	QUACS (13 items)	12/13	High	No additional extraction notes; item-level evidence in Table S2	
27	Mechanical advantage of the thumb muscles	38	Smutz WP, Kongsayreepong A, Hughes RE, Niebur G, Cooney WP, An KN. Mechanical advantage of the thumb muscles. J Biomech. 1998;31(6):565-570. doi: 10.1016/S0021-9290(98)00043-8	10.1016/S0021-9290(98)00043-8	In vitro biomechanical study in cadavers (technical note)	Seven fresh-frozen cadaveric hands (4 left, 3 right) from 6 donors (4 men, 2 women); mean age 77 years (range 72–84)	Dynamic muscular stabilizers of the thumb (extrinsic and intrinsic muscles)	Tendon excursion measured with potentiometers (linearity ±0.5%) and joint angles with a 3-Space electromagnetic tracker (accuracy 0.5 mm/0.5°); moment arm calculated as the slope of the excursion-angle relationship using polynomial regression (up to 6th order) and differentiation; three repetitions per condition; system validation with known pulleys/cams (error ~0.1 mm). Moment potentials calculated using published PCSA and a specific tension of 35.3 N/cm².	Specific functions: FPL, pure flexor; FPB, flexor and adductor; EPL, extensor and adductor; EPB, extensor and weak abductor; APL, extensor and abductor; APB, mainly abductor; adductor pollicis (ADP: transverse and oblique heads), strong flexor and adductor; OPP, flexor and abductor. Notable magnitudes: IP: FPL 9.0 mm (20° hyperext), EPL −5.2 mm (20° flex); MP: FPL 13.6 mm (neutral), EPL up to −11.5 mm (50° flex); CMC: ADPt ~36.9 mm (flexion in neutral position), ADPt adduction up to ~26.7 mm; EPL, EPB and APL main extensors at the CMC; APB/APL/FPB main abductors at the CMC.	QUACS (13 items)	13/13	High	Small sample size; anatomical variation between specimens (large SDs); in vitro conditions that may differ from in vivo; moment arms averaged for muscles that may have portions with different functions; possible error from numerical differentiation.	
28	Osteoarthritis of the carpometacarpal joint of the thumb: a new MR imaging technique for the standardized detection of relevant ligamental lesions	13	Dumont C, Lerzer S, Vafa MA, Tezval M, Dechent P, Stürmer KM, Lotz J. Osteoarthritis of the carpometacarpal joint of the thumb: A new MR imaging technique for the standardized detection of relevant ligamental lesions. Skeletal Radiol. 2014;43(10):1411-1420. doi: 10.1007/s00256-014-1955-x	10.1007/s00256-014-1955-x	Prospective comparative study	20 CMC I joints from 14 asymptomatic volunteers and 28 CMC I joints from 22 symptomatic patients with a radiological diagnosis of CMC I osteoarthritis	Ligaments of the CMC I (AOL, IML, POL and DRL)	3T MRI in two standardized planes (paracoronal and parasagittal), multiplanar image analysis, ligament assessment for integrity/rupture and measurement of joint translations and angles	Isolated AOL rupture in 21% and combined AOL+IML rupture in 18% of symptomatic joints. Dorsal translation of the MC I was significantly greater in patients (median 6.4 mm) vs. volunteers (median 5.4 mm, $p<0.05$). Palmar tilt angle was greater in patients (mean 15.3°) than in volunteers (mean 8.5°, $p<0.0001$).	JBI analytical cross-sectional	6/8	High	No additional extraction notes; item-level evidence in Table S3	

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29	Osteoligamentous Guidance of the Movements of the Human Thumb	3	Bojsen-Møller F. Osteoligamentous guidance of the movements of the human thumb. Am J Anat. 1976; 147(1):71-80. doi: 10.1002/aja.1001470106	10.1002/aja.1001470106	Descriptive anatomical study (cadaveric dissection + observational in living subjects)	20 dissected hands (2 fresh, 18 fixed), 10 normal adult dry skeletons, observations in an unspecified number of living adult and child hands, and frequency of use in a class of 43 students (sex not specified for the dissections)	Static (ligaments ▯ Y-shaped intermetacarpal [IMC], dorsal oblique, palmar oblique, ulnar collateral ligament); dynamic (muscle assessment mentioned but not experimentally tested)	Gross anatomical observation of dissected specimens, functional movement analysis in living hands, observation in a real-life situation (writing). No quantitative imaging methods or clinical scales are used.	The Y-shaped intermetacarpal ligament is tensed during abduction, establishing a center of stability for circumduction. The ulnar collateral ligament and the radial prominence of the head of the first metacarpal 'lock' in MP flexion, preventing rotation and lateral abduction. In writing, apposition is mainly used (21/23 women, 12/20 men in the observed sample). No quantitative results are reported.	QUACS (13 items)	7/13	Moderate	Not reported (no formal tool used, although it is a descriptive anatomical study without comparison of interventions or health outcomes)	
30	Pilot randomized controlled trial comparing specific dynamic stability exercises with general exercises for thumb carpometacarpal joint osteoarthritis	44	Davenport BJ, Jansen V, Yeandle N. Pilot randomized controlled trial comparing specific dynamic stability exercises with general exercises for thumb carpometacarpal joint osteoarthritis. Hand Ther. 2012;17(3):60-67. doi: 10.1258/ht.2012.012010	10.1258/ht.2012.012010	Pilot randomized controlled trial (RCT)	39 participants randomized; one subsequently excluded because of bilateral allocation error. Baseline table: 38 (17 specific, 21 general); 22 completed six months. Clinical and radiographic CMC OA; all grades.	Dynamic CMC stabilizing exercises targeting abductor pollicis longus (APL) vs. general exercises	Primary: DASH questionnaire (Disabilities of the Arm, Shoulder and Hand) at 3 and 6 months. Secondary: pinch and grip strength (Jamar), pain at rest and during pinch (Visual Analogue Scale, VAS), APL moment (measured with an ad hoc device, without formal validation)	No significant between-group differences in DASH improvement at 3 or 6 months. Within-group analysis: only the general exercise group improved significantly from baseline at 3 months (13-point reduction; P=0.001), not at 6 months; only this group improved pain at rest and during pinch from baseline. APL moment was higher in the general group at baseline and was associated with better functional outcome, but there were no significant between-group changes in pinch strength or APL moment.	PEDro	7/10	Moderate	Pilot without prior sample size calculation, intended to inform a subsequent trial. The source reports 16 dropouts (41%) and one later exclusion; 22/39 remain at six months (17/39 without final data; 44%). APL device without formal validation and therapist not blinded.	
31	Radiographic Analysis of Simulated First Dorsal Interosseous and Opponens Pollicis Loading Upon Thumb CMC Joint Subluxation: A Cadaver Study	35	Adams JE, O'Brien V, Magnusson E, Rosenstein B, Nuckley DJ. Radiographic analysis of simulated first dorsal interosseous and opponens pollicis loading upon thumb CMC joint subluxation: A cadaver study. Hand (N Y). 2018; 13(1):40-44. doi: 10.1177/1558944717691132	10.1177/1558944717691132	Experimental cadaveric study	11 fresh-frozen hands from 8 donors (7 men, 1 woman), mean age 68 years (45–87). Four preparations lost due to OP rupture; only 7 complete series for the results.	Muscular stabilizers (first dorsal interosseous and opponens pollicis) simulated by muscle loading	Radiographic measurement of subluxation of the first metacarpal on the trapezium (radial subluxation/articular width ratio - RS/AW) using fluoroscopy and ImageJ	The OP reduced subluxation in a dose-dependent manner; the FDI alone had little effect. FDI+OP gave the lowest ratio only at 25% load; at 50–100% load, the OP alone left less residual subluxation, with no significant difference between them. Results correspond to 7 complete series.	QUACS (13 items)	13/13	High	Loss of 4/11 preparations due to OP rupture; effective n = 7. Acute subluxation induced by capsulotomy and loading, without neuromuscular control. Does not demonstrate superiority of the combination over the OP nor clinical efficacy of exercise.	
32	Sonography of the Anterior Oblique Ligament of the Trapeziometacarpal Joint: A Study of Cadavers and Asymptomatic Volunteers	28	Chiavaras MM, Harish S, Oomen G, Popowich T, Wainman B, Bain JR. Sonography of the anterior oblique ligament of the trapeziometacarpal joint: A study of cadavers and asymptomatic volunteers. AJR Am J Roentgenol. 2010;195(6):W428-W434. doi: 10.2214/AJR.10.4403	10.2214/AJR.10.4403	Descriptive cross-sectional study, based on cadaver analysis and asymptomatic volunteers	4 adult cadaveric hands and 40 asymptomatic adult volunteers (21 women, 19 men; mean age: 36 years, range 19–63)	Anterior oblique ligament (superficial and deep) of the trapeziometacarpal joint of the thumb	High-resolution ultrasound (5-13 MHz linear transducer for cadavers and ML6-15 MHz array for volunteers), with anatomical confirmation by methylene blue injection in cadavers	Cadaveric dissection confirmed correct identification and localization of the anterior oblique ligament by ultrasound. In volunteers, mean ligament thickness was 0.7 mm (metacarpal insertion), 0.98 mm (mid portion) and 0.65 mm (trapezial insertion); mean length was 10.6 mm in the dominant hand and 9.6 mm in the non-dominant hand. Volar translation of the metacarpal under stress was ≤ 0.8 mm. There were no significant differences in thickness by sex, side or dominance.	QUACS (13 items)	12/13	High	Not blinded, only asymptomatic volunteers, no comparison with pathological patients or with other techniques	

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33	Subject-specific thumb muscle activity during functional tasks of daily life	73	Kerkhof FD, Deleu G, D'Agostino P, Vereecke EE. Subject-specific thumb muscle activity during functional tasks of daily life. J Electromyogr Kinesiol. 2016;30:131-136. doi: 10.1016/j.jelekin.2016.06.009	10.1016/j.jelekin.2016.06.009	Experimental cross-sectional study	10 healthy adult women (mean age: 22.88 years ± 4.75); exclusion: previous musculoskeletal problems, trauma, surgery or neurological conditions in the forearm/hand area	Muscular stabilization (intrinsic and extrinsic of the thumb)	Intramuscular electromyography with fine-wire electrodes (fEMG) in 8 thumb muscles; force measurement with a load cell during functional tasks; statistical analysis using ANOVA and Mann-Whitney/Wilcoxon tests	No task-specific muscle activation patterns were observed, but subject-specific patterns that remained constant across tasks. Extrinsic muscles had significantly greater activity than intrinsic muscles in all tasks. Electrode insertion reduced force production by 11% to 18%. Only the adductor pollicis showed lower activation when going from power grasp to jar twist.	JBI analytical cross-sectional	6/7	High	Small sample (n=10), only young women, possible effect of discomfort/invasiveness during measurement, recording excluded some muscles and tasks only at 80% effort	
34	The effect of individual isometric muscle loading on the alignment of the base of the thumb metacarpal: a cadaveric study	36	Mobargha N, Esplugas M, Garcia-Elias M, Lluch A, Megerle K, Hagert E. The effect of individual isometric muscle loading on the alignment of the base of the thumb metacarpal: A cadaveric study. J Hand Surg Eur Vol. 2016;41(4):374-379. doi: 10.1177/1753193415597114	10.1177/1753193415597114	Experimental cadaveric study (laboratory cadaveric study)	Ten fresh-frozen human cadaveric hands and forearms (six men and four women, mean age 73 years, range 67–80), with no signs of thumb CMC osteoarthritis	Stabilizing muscles of the carpometacarpal (CMC) joint of the thumb	Fastrak® three-dimensional motion tracking system; sensors on the base of the first metacarpal, third metacarpal and distal radius	The first dorsal interosseous (FDI) caused the least dorsoradial translation and the greatest distal migration of the base of the first metacarpal. The abductor pollicis longus (APL) was the main destabilizer, increasing dorsoradial misalignment.	QUACS (13 items)	12/13	High	Limitations due to cadaveric design, non-dynamic and non-isotonic, possible anatomical variability of the APL not considered, not directly extrapolable to living patients.	
35	The multidirectional roles of the anterior oblique ligament and dorsoradial ligament of the thumb carpometacarpal joint	24	Kalshoven JM, Badida R, Morton AM, Molino J, Weiss AC, Ladd AL, Crisco JJ. The multidirectional roles of the anterior oblique ligament and dorsoradial ligament of the thumb carpometacarpal joint. J Orthop Res. 2024;42(11):2390-2399. doi: 10.1002/jor.25922	10.1002/jor.25922	Controlled experimental cadaveric study	16 fresh-frozen right forearms (7 male, 9 female). Methods: 27–74 years; Table 1 includes a minimum of 20 years. Internal discrepancy in the source; not corrected by assumption.	Ligaments: anterior oblique ligament (AOL) and dorsoradial ligament (DRL) of the carpometacarpal joint of the thumb	Robotic musculoskeletal simulation with testing of rotational range of motion (ROM) and translation in 6 degrees of freedom, with dynamometry and computed tomography (CT) imaging; quantitative biomechanical analysis of changes in ROM and joint stiffness	Sectioning of the DRL markedly increased rotational ROM and decreased stiffness in flexion and internal rotation directions; sectioning of the AOL increased ROM in extension. Translational ROM increased mainly in the dorsal and radial directions after DRL sectioning, and in the volar direction after AOL sectioning. Both ligaments have complementary stabilizing roles, restraining specific translations and rotations.	QUACS (13 items)	13/13	High	Low risk for in vitro biomechanical inference, but without reference to selection bias or clinical representativeness; limited by the number of samples and cadaveric nature	
36	The role of the carpometacarpal ligaments of the thumb in stability and the development of osteoarthritis lesions: an anatomical study	15	Lamas Gómez C, Mustafa Gondolbeu A, Morro Martí R, Proubasta Renart I, Llusà Pérez M. The role of the carpometacarpal ligaments of the thumb in stability and the development of osteoarthritis lesions: An anatomical study. Acta Orthop Belg. 2017;83(3):449-457. PMID: 30423648	PMID: 30423648)	Experimental anatomical cadaveric study	25 fresh-frozen hands (14 female and 11 male). Internal discrepancy: abstract, mean 65 years (51–92); methods, mean 67 (51–94). Both descriptions are retained without combining them.	Main carpometacarpal ligaments of the thumb: dorsoradial (DRL), anterior oblique (AOL), posterior oblique (POL), intermetacarpal (IML), and others	Anatomical measurements with a digital caliper in cadavers, visual and macroscopic assessment, joint OA classification, measurement of metacarpal displacement, articular surfaces and contact area according to the Momose method	Isolated or combined rupture of the DRL produces a significant increase in dorsal translation of the metacarpal (mean 1.6-1.7 mm; P=0.006). There is a relationship between DRL rupture and the presence of OA in the radial quadrants (P=0.032). Cartilage degradation begins in the radial quadrants. The DRL is shorter and thicker than the AOL and its rupture correlates with instability and osteoarthritic lesions.	QUACS (13 items)	9/13	Moderate	No additional extraction notes; item-level evidence in Table S2	
37	The Stabilising Effect of the Anterior Oblique Ligament to Prevent Directional Subluxation at the Trapeziometacarpal Joint of the Thumb: A Biomechanical Cadaveric Study	80	McCann MR, Rust PA, Wallace R. The stabilising effect of the anterior oblique ligament to prevent directional subluxation at the trapeziometacarpal joint of the thumb: A biomechanical cadaveric study. Arch Bone Jt Surg. 2018;6(2):105-111. PMID: 29600262	PMID: 29600262)	Laboratory cadaveric biomechanical study (Level of evidence III)	3 fresh-frozen cadaveric hands without radiographic osteoarthritis; mean age 81.3 years (SD 10.6).	Anterior oblique ligament (AOL) of the TMCJ (ligamentous stabilizer)	Zwick/Roell z005 machine; controlled displacement of the trapezium 5 mm at 5 mm/min; force required to reach 5 mm in radial, dorsal and dorsoradial planes; 5 cycles (first cycle discarded), average of 4 measurements; non-parametric analysis (Mann-Whitney).	Dorsoradial: significant decrease in mean force from 6.68 N to 1.15 N (P<0.001) after AOL sectioning. Radial: significant increase from 2.89 N to 4.04 N (P<0.001). Dorsal: no significant changes (2.74 N to 2.62 N; P=0.98). Some dorsoradial resistance persisted after sectioning, attributable to other ligaments (e.g., DRL, IMC).	QUACS (13 items)	9/13	Moderate	No additional extraction notes; item-level evidence in Table S2	

No.	Study (title)	Reference no. in the manuscript	Reference (audited bibliography of the manuscript)	DOI	Design	Sample / Population	Structures / Stabilisers assessed	Measurement method	Main stability results	Quality tool	Score	Quality (operational threshold)	Extraction notes (limitations reported)	Eligibility note
38	The trapeziometacarpal screw home torque mechanism as a clinical indicator of the posterior joint ligament complex integrity: A cadaveric investigation	31	Normand M, Ibrahim M, Morsy M, Brismée JM, Sobczak S. The trapeziometacarpal screw home torque mechanism as a clinical indicator of the posterior joint ligament complex integrity: A cadaveric investigation. J Hand Ther. 2024;37(3):388-396. doi: 10.1016/j.jht.2023.08.007	10.1016/j.jht.2023.08.007	Cross-sectional laboratory study (radiological and cadaveric).	20 fresh cadaveric hands of older adults (mean age 79.2 years, range 70–89; 60% men).	"Screw home" torque mechanism (SHTM) of the TMC as a passive joint stabilizer.	PA hand radiographs, Robert view (AP of the thumb) and lateral thumb view; Eaton-Glickel OA grading and calculation of the ThOA index; measurement of radial and palmar abduction with the TROM technique and a digital goniometer; radial subluxation quantified as the distance between lines parallel to the radial diaphyseal border of the first metacarpal and of the trapezium; torque application with a digital screwdriver and inclinometer; macroscopic assessment by dissection of the posterior ligamentous complex (DRL, DCL, POL). Analysis with ICC, Student's t, Pearson and Kendall correlations.	- Significant reduction of radial subluxation with SHTM versus rest: rest M=5.2 mm (SD 1.9) vs 21 Nm M=4.4 (SD 2.4), t(19)=3.2, p=0.01; 34 Nm M=4.3 (SD 2.6), t(19)=2.6, p=0.02. - No significant correlation between the SHTM subluxation reduction ratio and the combined status of the posterior ligamentous complex; there was a moderate negative correlation with DCL injury at 21 Nm (τb=−0.46, p<0.05) and 34 Nm (τb=−0.45, p<0.05). - Moderate negative correlation between the ThOA index and the subluxation reduction ratio at 21 Nm (r=−0.50, p<0.05) and 34 Nm (r=−0.47, p<0.05); and between Eaton-Glickel grade and the reduction ratio at 21 Nm (τb=−0.44, p<0.05) and 34 Nm (τb=−0.41, p<0.05). - Radial abduction correlated negatively with OA (Eaton-Glickel τb=−0.49, p<0.001; ThOA r=−0.72, p<0.001); palmar abduction showed no correlation. - Stabilizing effect in 100% of non-osteoarthritic joints (Eaton 0–1); lower efficacy with advanced OA.	QUACS (13 items)	13/13	High	Not reported.	
39	Three-dimensional dynamic motion analysis of the first carpometacarpal ligaments	69	Nanno M, Kodera N, Tomori Y, Hagiwara Y, Takai S. Three-dimensional dynamic motion analysis of the first carpometacarpal ligaments. J Orthop Surg (Hong Kong). 2017;25(1):2309499016684752. doi: 10.1177/2309499016684752	10.1177/2309499016684752	Experimental biomechanical cadaveric study	Six fresh-frozen cadaveric upper limbs (three men, three pairs; mean age 64.3 years; range 62-69 years)	Ligaments of the first carpometacarpal joint: dorsoradial ligament (DRL), posterior oblique ligament (POL), superficial anterior oblique ligament (SAOL), deep anterior oblique ligament (dAOL)	Manual digitization of ligament insertion sites on 3D reconstructed models of the metacarpal and trapezium obtained by CT, using a MicroScribe-3DX digitizer and surface reconstruction software	The lengths of the four ligaments changed significantly during CMC joint motion. The DRL and POL lengthened during flexion, the SAOL and dAOL during extension. The DRL and SAOL lengthened during adduction, whereas the POL and dAOL did so during abduction. The DRL was the only one to show significant lengthening in flexion and adduction (dorsoradial dislocation). The dAOL was the shortest and appears to act as a pivot. There were no significant differences between the different paths (radial, central, ulnar) of each ligament.	QUACS (13 items)	13/13	High	Small sample and advanced age of the cadavers; limitations in generalization due to the use of cadaveric models	
40	Thumb Carpometacarpal Ligaments Inside and Out: A Comparative Study of Arthroscopic and Gross Anatomy from the Robert A. Chase Hand and Upper Limb Center at Stanford University	22	Zhang AY, Van Nortwick S, Hagert E, Ladd AL. Thumb carpometacarpal ligaments inside and out: A comparative study of arthroscopic and gross anatomy from the Robert A. Chase Hand and Upper Limb Center at Stanford University. J Wrist Surg. 2013;2(1):55-62. doi: 10.1055/s-0033-1333683	10.1055/s-0033-1333683	Comparative anatomical study in cadavers	Five cadaveric upper limbs and hands (4 Caucasian men and 1 woman, all right-handed, ages 50-93 years, mean 69.2)	Stabilizing ligaments of the carpometacarpal joint of the thumb (CMC-I): superficial and deep anterior oblique, ulnar collateral, dorsal trapeziometacarpal, posterior oblique, dorsal central, dorsal radial	Arthroscopic identification and dissection with ligament referencing using Kirschner wires and standard hand techniques; division of the articular surface into quadrants to assess wear, using a modified Outerbridge scale	The volar ligaments (sAOL, dAOL, UCL) showed high variability in appearance and in arthroscopic and anatomical location, usually as a diffuse membranous structure not always identifiable as separate entities. The dorsal ligaments (DTM-I, POL, DCL, DRL) were consistent across all specimens. Cartilage wear patterns recorded arthroscopically and anatomically were concordant.	QUACS (13 items)	11/13	High	Small sample; male predominance; only older specimens with osteoarthritis; possible incomplete visualization of some articular quadrants	

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41	Trapeziometacarpal Joint Instability Affects the Moment Arms of Thumb Motor Tendons	78	Omokawa S, Ryu J, Tang JB, Han JS, Kish VL. Trapeziometacarpal joint instability affects the moment arms of thumb motor tendons. Clin Orthop Relat Res. 2000;(372):262-271. doi: 10.1097/00003086-200003000-00029	10.1097/00003086-200003000-00029	Experimental study in cadavers (biomechanical, in vitro)	10 fresh cadaveric upper limbs (4 left, 6 right), age 45-85 years (mean 68.2), 6 men, 4 women	Eaton and Littler ligament reconstruction	Simultaneous measurement of excursion of the thumb motor tendons (moment arm length) and joint angulation with electrogoniometry and displacement transducers; computerized data analysis	The moment arm of the abductor pollicis longus and extensor pollicis brevis tendons increased significantly after palmar sectioning of the capsuloligamentous components during flexion-extension movement; the moment arm of the extensor pollicis longus increased significantly during abduction-adduction after ulnopalmar cuts. After ligament reconstruction, values returned to normal levels. Ligamentous instability alters the mechanics of the thumb motor tendons.	QUACS (13 items)	13/13	High	Not reported. Inherent bias due to the use of cadaveric tissue and in vitro experimental simulation.	
42	Trapeziometacarpal Ligaments Biomechanical Study: Implications in Arthroscopy	21	Esplugas M, Lluch-Bergada A, Mobargha N, Llusa-Perez M, Hagert E, Garcia-Elias M. Trapeziometacarpal ligaments biomechanical study: Implications in arthroscopy. J Wrist Surg. 2016;5(4):277-283. doi: 10.1055/s-0036-1581052	10.1055/s-0036-1581052	Experimental biomechanical cadaveric study	11 fresh-frozen human cadaveric specimens, mean age 73 years (67–80 years), 5 women and 2 men, 6 right hands and 5 left.	Ligaments of the trapeziometacarpal joint (dorsal, volar, ulnar)	Three-dimensional motion tracking device (FasTrak); measurement of translation of the base of the first metacarpal before and after sectioning of each ligament	Sectioning of the dorsal ligaments caused the greatest dorsoradial translation of the base of the first metacarpal (mean 0.523 mm; SD 0.0512; p=0.004) compared with sectioning of the volar (mean 0.150 mm; SD 0.072) and ulnar ligaments (mean 0.064 mm; SD 0.301).	QUACS (13 items)	13/13	High	No additional extraction notes; item-level evidence in Table S2	
43	Trapeziometacarpal Stabilization Through Dorsoradial Ligament Reconstruction: An Early Post-Surgery In vivo Biomechanical Analyses	71	Kerkhof FD, Vereecke EE, Vanovermeire O, Vanhaecke J, Vanneste M, Stockmans F. Trapeziometacarpal stabilization through dorsoradial ligament reconstruction: An early post-surgery in vivo biomechanical analysis. J Orthop Res. 2018;36(11):2851-2864. doi: 10.1002/jor.24103	10.1002/jor.24103	Case series with healthy control group (comparative study, level of evidence III)	4 patients with pain and laxity in the trapeziometacarpal (TMC) joint without radiographic signs of osteoarthritis, compared with healthy controls matched by age and sex (characteristics: women, ages 50-56 years)	Imbrication of the dorsoradial ligament (DRL) with bone anchor in the trapezium	Dynamic computed tomography (dynamic 3D CT) quantifying bone motion, contact area and joint congruence during functional movements and tasks	No overall decrease in first metacarpal (MC1) motion or increase in postoperative joint congruence was observed in three of the four patients. Pre- and postoperative differences were small and patient-dependent. Significant variability in biomechanical results, even with the same procedure and surgeon. All patients reported clinical satisfaction.	JBI case series	3/10	Low	Very small number of patients; partially objective but clinically subjective measurement; no blinding; possible selection bias	
44	Contact areas in the thumb carpometacarpal joint	9	Ateshian GA, Ark JW, Rosenwasser MP, Pawluk RJ, Soslowsky LJ, Mow VC. Contact areas in the thumb carpometacarpal joint. J Orthop Res. 1995; 13(3):450-458. doi: 10.1002/jor.1100130320	10.1002/jor.1100130320	Ex vivo biomechanical	13 fresh-frozen cadaveric hands (8 women, 55–71 years, mean 66; 5 men, 61–80 years, mean 70); radiographic osteoarthritis Eaton I–III, no stage IV	Articular surfaces / congruence	Contact stereophotogrammetry	Trapezium-metacarpal contact areas shift with joint position under simulated muscle load; larger areas in men than in women (p<0.02). Contact maps by stereophotogrammetry (uncertainty 25 µm; proximity criterion 0.25 mm)	QUACS (13 items)	13/13	High	No young normal controls; friction in the pulley system; full abduction not measurable; 4 specimens excluded from thickness analysis because of high error (limitations discussed by the authors)	
45	Sequential wear patterns of the articular cartilage of the thumb carpometacarpal joint in osteoarthritis	12	Koff MF, Ugwonali OF, Strauch RJ, Rosenwasser MP, Ateshian GA, Mow VC. Sequential wear patterns of the articular cartilage of the thumb carpometacarpal joint in osteoarthritis. J Hand Surg Am. 2003;28(4):597-604. doi: 10.1016/S0363-5023(03)00145-X	10.1016/S0363-5023(03)00145-X	Ex vivo anatomical-histological	104 fresh-frozen TMC joints (63 men/41 women; 18–97 years, mean 52.3 ± 17.8)	Cartilage / wear pattern (indirect indicator of instability)	Chondral wear mapping	Sequential progression of chondral wear by stage and quadrant in the trapezium and first metacarpal (means ± SD per stage; stereophotogrammetry with 25 µm precision, ~275 mesh points; repeated-measures ANOVA)	QUACS (13 items)	12/13	High	The Discussion does not include an explicit limitations section for the study itself	
46	Osteoarthritis of the trapeziometacarpal joint: I. Anatomy and pathology of the aging joint	14	Pellegrini VD Jr. Osteoarthritis of the trapeziometacarpal joint: The pathophysiology of articular cartilage degeneration. I. Anatomy and pathology of the aging joint. J Hand Surg Am. 1991;16(6):967-974. doi: 10.1016/S0363-5023(10)80054-1	10.1016/S0363-5023(10)80054-1	Ex vivo anatomical-histological	47 cadaveric thumbs (29 women/18 men; mean age 79 years); 12 fresh and 35 embalmed	Beak ligament (deep AOL) / degeneration	Dissection and histological analysis	Description of the patterns of age-related chondral degeneration and their cross-sectional association with the integrity of the anterior oblique ligament/palmar beak; percentages by sex and pattern (gross inspection, no measuring instrument or inferential statistical analysis)	QUACS (13 items)	9/13	Moderate	Unquantified manual loading during serial ligament sectioning; grades of chondromalacia not operationalized; staining abandoned midway through the series; mixture of fresh and embalmed specimens; no discussion of limitations	

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47	Innervation patterns of thumb trapeziometacarpal joint ligaments	26	Hagert E, Lee J, Ladd AL. Innervation patterns of thumb trapeziometacarpal joint ligaments. J Hand Surg Am. 2012; 37(4):706-714.e1. doi: 10.1016/j.jhsa.2011.12.038	10.1016/j.jhsa.2011.12.038	Ex vivo neurohistological	10 fresh-frozen cadaveric hands (3F/5M; mean 65 years) Sex discrepancy in the source: methods indicate 3 women and 5 men, whereas the figure identifies 5 female and 5 male specimens; no unambiguous distribution is attributed to the 10 hands.	DRL, dorsal central ligament, POL, UCL, AOL	Triple immunofluorescence; mechanoreceptor classification	The 3 dorsal ligaments were significantly more innervated than the 2 volar ones; endings close to the metacarpal insertion (p=0.010); AOL with scant or no innervation; predominance of Ruffini endings	QUACS (13 items)	13/13	High	Small sample; mild osteoarthritis in 9/10 specimens	Direct support for the proprioceptive argument of the DRL
48	High-resolution ultrasound evaluation of the trapeziometacarpal joint with emphasis on the anterior oblique ligament (beak ligament)	29	Gondim Teixeira PA, Omoumi P, Trudell DJ, Ward SR, Blum A, Resnick DL. High-resolution ultrasound evaluation of the trapeziometacarpal joint with emphasis on the anterior oblique ligament (beak ligament). Skeletal Radiol. 2011;40(7): 897-904. doi: 10.1007/s00256-010-1068-0	10.1007/s00256-010-1068-0	Ex vivo + in vivo imaging	10 cadaveric hands + 10 thumbs of 5 healthy volunteers	AOL / detectability and thickness	High-resolution ultrasound with guided confirmatory dissection	AOL identified in 90% of specimens and 100% of volunteers; thin hypoechoic structure 1.0-2.0 mm thick	QUACS (13 items)	12/13	High	Consensus of 2 radiologists; small sample	
49	Phasic relationships of the intrinsic and extrinsic thumb musculature	74	Johanson ME, Skinner SR, Lamoreux LW. Phasic relationships of the intrinsic and extrinsic thumb musculature. Clin Orthop Relat Res. 1996;(322):120-130. doi: 10.1097/00003086-199601000-00015	10.1097/00003086-199601000-00015	In vivo EMG	5 healthy right-handed adult volunteers (3 men/2 women; 33–52 years)	Intrinsic and extrinsic thumb musculature	Dynamic EMG with kinematics	Phasic activity patterns of the intrinsic and extrinsic thumb musculature during hand opening-closing and lateral and opposition pinches (fine-wire EMG in 9 muscles and electrogoniometry); FDI and adductor, phasic during closing and pinch; findings compatible with individual motor strategies	JBI analytical cross-sectional	4/7	Moderate	Phasic/continuous/silent classification by visual inspection without inter-rater reliability; goniometer axis estimated; no inferential analysis	EMG of functional tasks; indirect evidence on TMC stability. Original source checked; 5 volunteers, 3 men and 2 women, 33–52 years.
50	First dorsal interosseous muscle contraction results in radiographic reduction of healthy thumb carpometacarpal joint	39	McGee C, O'Brien V, Van Nortwick S, Adams J, Van Heest A. First dorsal interosseous muscle contraction results in radiographic reduction of healthy thumb carpometacarpal joint. J Hand Ther. 2015;28(4):375-380; quiz 381. doi: 10.1016/j.jht.2015.06.002	10.1016/j.jht.2015.06.002	In vivo repeated-measures experiment in one group; conditions in random order; secondary cross-sectional component. The authors label it a case series in the abstract.	17 healthy adults (5 men, 12 women), mean age 25.9 years (21–59). 34 thumbs were assessed; 2 excluded for radiographic OA; 32 analyzed (17 right, 15 left). University convenience sample.	Resisted maximal voluntary contraction directed at the FDI during manual radial stress; no isolation by EMG.	AP fluoroscopy at rest, under stress and under stress with contraction; three blinded raters. Radial subluxation (cm converted to mm), subluxation/joint width ratio, RIHM force and Jamar grip.	32 thumbs: radial subluxation 5.3 ± 2.4 to 1.1 ± 2.0 mm; difference 4.2 ± 2.2 mm (SD), p<0.001. Ratio 0.42 ± 0.18 to 0.09 ± 0.16; difference 0.33 ± 0.18, p<0.001. Table 3 of the source: original figures in cm. It is not a 33% percentage reduction: it is 33 percentage points of the ratio.	JBI quasi-experimental	4/7	Moderate	No parallel group or time series; manual stress not quantified, possible coactivation, bilateral dependence not adjusted for in the pooled analysis. Does not assess clinical efficacy or subjects with OA.	Identified by reference cross-checking; extraction from the full text (methods, results and Tables 1–3).

No.	Study (title)	Reference no. in the manuscript	Reference (audited bibliography of the manuscript)	DOI	Design	Sample / Population	Structures / Stabilisers assessed	Measurement method	Main stability results	Quality tool	Score	Quality (operational threshold)	Extraction notes (limitations reported)	Eligibility note
51	Association of ligament mechanical properties and articular surface topography with trapeziometacarpal kinematics across osteoarthritis stages	58	Gordon D, Sun S, Walker L, Buchweitz N, Zhao J, Mah E, et al. Association of ligament mechanical properties and articular surface topography with trapeziometacarpal kinematics across osteoarthritis stages. Osteoarthritis Cartilage. 2026;34(1):148-159. doi: 10.1016/j.joca.2025.10.019	10.1016/j.joca.2025.10.019	Multimodal ex vivo cross-sectional cadaveric study: CT topography + kinematics under simulated tendon load + ligament mechanical testing; unsupervised classification (PCA + K-means, 3 clusters) versus Age–Eaton-Littler	46 fresh-frozen hands, women only (22 R/24 L; 3 bilateral pairs + 40 donors); healthy young n=16 (38.6±6.8 y), healthy older n=18 (59.6±6.8), OA (EL≥2) n=12 (65.5±14.4). n analyzed per module: topography 43; kinematics 33–34; mechanics 76 ligaments (27 VLC, 24 DRL, 25 POL), 18 of them from Walker 2024	Volar ligament complex (VLC = deep AOL/beak + superficial AOL-capsule), DRL and POL (mechanical testing). ADD, APB, APL, FPL, EPL, EPB tendons only as motion generators (not compared). No IML/UCL; no FDI/OP	CT 0.3 mm (joint space, curvedness, congruence, curvature); 3D optical tracking with markers on MC1/trapezium, Euler and helical angles (°, mm) in flexion, extension, adduction, abduction and lateral pinch; stress-relaxation (5–20% strain) ⇒ instantaneous/relaxed moduli (N/mm²); tensile testing to failure at 10%/s ⇒ stiffness, ultimate load, modulus, toughness (Bose ElectroForce, MTS). GLM + type III ANOVA, Holm-Bonferroni; bootstrap PCA + K-means	Three clusters: C1 healthy; C2 "peri-OA" with excessive ROM (⇑ helical, radial-ulnar, volar-dorsal rotations) and attenuated ligaments; C3 remodeled with loss of ROM and degenerated ligaments. VLC: relaxation moduli ⇑ C1⇑C2 (+5.64 N/mm² [2.05–9.24] relaxed; +6.98 [1.81–12.15] instantaneous) but stiffness, ultimate load, toughness, stress and modulus at failure ⇑ C1⇑C2 and C1⇑C3. DRL: decrease in stiffness/ultimate load/modulus only in C3. In C1 the VLC exceeds the DRL and POL in stiffness, toughness, ultimate stress and modulus. With Age-EL: only kinematic difference = radial-ulnar rotation in abduction, young⇑OA +9.82° [1.94–17.72]. Absolute values per ligament only in supplementary tables (not available in the PDF)	QUACS (13 items)	12/13 (Item 7=0: no precision/reliability of tracking or manual marking)	High	Limitations (authors): cadaver without muscle activation; limited n in advanced OA; women only; PC1+PC2 ≈30% variance; possible marker errors; C3 does not distinguish EL II from III-IV; non-causal associations; post-cluster p values exploratory. Funding NIH/NIGMS P20GM121342 and P20GM103499; no COI; use of ChatGPT declared. Internal discrepancies in the source: (1) Abstract: "minor DRL attenuation" C1⇑C2 and C2⇑C3; Results: DRL attenuation only in C3; Discussion: DRL "relatively stable". (2) Age cut-off <45 (Methods) vs ≤45 (Fig. 4). (3) "46 joints analyzed" vs effective n 43/33–34/76 ligaments. (4) VLC ⇑ relaxation moduli but ⇑ at failure; the abstract summarizes this as "attenuation". (5) Fig. 7 legend labels Q-V as K-means when they are results by EL	Direct evidence for question 1 (VLC/DRL/POL properties by stage) and partial for question 2 (cadaveric kinematics under simulated load, without isolating FDI/OP/APL). Counterpoint to the mechanical primacy of the DRL: in healthy joints the VLC shows superior properties and is the first to attenuate; the DRL deteriorates only in the advanced cluster. Women only; partial sample overlap with Walker 2024. "Instability" = relative ROM pattern, not measured subluxation
52	Proprioceptive role of the abductor pollicis longus in thumb carpometacarpal osteoarthritis: An anatomical and immunohistochemical study	59	Lamas C, Serra J, Fa-Binefa M, Ramirez-Bermejo E, Orellana R, Garcia-Elias M, et al. Proprioceptive role of the abductor pollicis longus in thumb carpometacarpal osteoarthritis: An anatomical and immunohistochemical study. Osteoarthritis Cartilage. 2026;34(8):1221-1230. doi: 10.1016/j.joca.2026.04.007	10.1016/j.joca.2026.04.007	Cross-sectional cadaveric anatomical study: dissection + histology (HE, alcian blue; Mankin, Otte) + immunohistochemistry (PGP 9.5, S-100); no control group; NCT05626192; STROBE	20 fresh-frozen hands (−18 °C, <1 month) from 20 donors (11 R/9 L); 13 F/7 M; 68 y (53–95). Initial n = analyzed n = 20. All with ICRS ≥2 in trapezium and MC1 (moderate-severe morphological OA in 100%)	Main tendon and accessory fascicles of the APL and their insertions (MC1, trapezium, deep capsule, OP/APB belly); first extensor compartment; innervation (S-100, PGP 9.5) of the accessory trapezial insertion; osteophytes; cartilage	Dissection with 3.5x loupe; digital caliper (0.01 mm) for diameters, APL footprint (mm²) and osteophytes (mm², not normalized); ICRS 0–4; histology and IHC by a blinded pathologist; mechanoreceptors according to Freeman-Wyke (announced). Spearman with 95% CI; Mann-Whitney U as effect size r; no adjustment	Accessory APL fascicles in 18/20 (90%); 3–6 fascicles per specimen; ≥1 insertion on the trapezium 19/20; on the deep capsule 16/20 (80%); on OP/APB 19/20 (95%). APL footprint on MC1 median 4.15 mm² (3.3–6.0). S-100+ in 13/20 (65%); PGP 9.5+ 2/20. Correlations: number of fascicles–chondral cellularity r=0.47 [0.04–0.77] (only one with CI excluding 0); S-100+ vs MC1 OA r=−0.52 [−0.78; −0.10]; APL–EPB septum vs MC1 OA r=−0.41 [−0.71; 0.06]; fascicles vs trapezium OA r=−0.24; vs MC1 OA r=0.14. Radial osteophyte 8.39±1.67 mm² > ulnar 3.91±2.37 mm²	QUACS (13 items)	12/13 (Item 7=0: no inter/intra-observer reliability of the macroscopic measurements; caliper precision is declared)	High	Limitations (authors): cross-sectional; cadaver; no clinical history or radiographs; APL only; osteophytes not normalized; convenience sample; no reliability; no adjustment; confounding by age. No funding; no COI. Internal discrepancies in the source: (1) 18/20 (90%) with accessory fascicles in Results/Abstract vs "75% (15 cases)" in Discussion. (2) 47 tendons = sum of insertions on MC1, not of total fascicles (77). (3) Text: ICRS 3–4 in MC1 vs 2–3 in trapezium; Table 1 shows the opposite. (4) Ulnar osteophyte: mean±SD in text, median (IQR) and "mm" in Table 1. (5) Cellularity per mm³ (Methods) vs mm² (Fig. 2). (6) Freeman-Wyke announced, not reported. (7) Errata in CIs of Table 2. (8) Donors without documented degenerative disease but 100% with morphological OA	Indirect evidence (question 2, anatomical basis; tangential to 3 through proprioception). Does not measure ligamentous restraint, load or kinematics. Reinforces the anatomical coupling APL–OP–capsule and provides innervation at the trapezial insertion of the APL. Does not support the hypothesis of overload by accessory fascicles (Zancolli); the APL–EPB septum tended to be associated with less OA. No data on DRL/AOL or FDI

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53	Thumb rotation patterns during pinch in patients with trapeziometacarpal osteoarthritis	60	Tsukamoto K, Fujita K, Kuroiwa T, Norose M, Yoshii T, Nimura A. Thumb rotation patterns during pinch in patients with trapeziometacarpal osteoarthritis. J Hand Surg Eur Vol. 2026;51(3):328-334. doi: 10.1177/17531934251383073	10.1177/17531934251383073	In vivo analytical cross-sectional, cases (TMC OA) vs healthy controls; kinematics with inertial sensor during pinch; level III. Subset of Tsukamoto 2025	OA: 36 hands of 27 consecutive patients (3 M/24 F; 67 y, 54–88; Eaton 1/2/3/4 = 5/8/16/7). Control: 19 hands of 11 volunteers (TKA candidates, no clinical or radiographic TMC OA; 4 M/7 F; 64 y). A priori sample size calculation (52 hands). No losses	Rotation (pronation/supination) of the MC1 during pinch as an indirect expression of the OP (pronator) – FDI (supinator) balance. No muscle or ligament is measured	Triaxial gyroscope + accelerometer (MicroStone MP-M6-02/500C) on the dorsum of the MC1; wrist and MC 2–5 fixed; strong tip pinch, 5 trials (mean of 2–4); Δ pronation (°) from contact; supination pattern if Δ<0. Mann-Whitney, Spearman, Fisher	Δ pronation median OA 2.6° (IQR 0.5–3) vs control 3.7° (2.6–6.0), p=0.014. Correlation with Eaton-Littler r=−0.42 (p=0.0013) and KL r=−0.46 (p=0.00037). Supination pattern in 25% of OA pinches (27/108) vs 8.8% control (5/57), p=0.013. The authors attribute the lower pronation to OP dysfunction with FDI/adductor compensation; they acknowledge structural stiffness as an alternative explanation	JBI analytical cross-sectional (8 items)	7/8 (87.5%) (Item 6=N: no adjustment; bilateral hands and repeated pinches treated as independent)	High	Limitations (authors): skin displacement of the sensor; OP not assessed directly; cross-sectional, no causality. Funding: JA Kyosai, JSPS KAKENHI JP21H03485, JSSH; no COI. Internal discrepancies in the source: (1) Table 1 "mean (range)" but ages with SD and compared with Mann-Whitney. (2) "27/108 pinch times in 36 patients" when 36 are hands. (3) Sample size calculation 52 hands; "three additional patients" were added (excess of 3 hands). (4) Discussion "mean pronation angle" vs Results in medians. (5) Spearman appears to include controls (Fig. 4) without explicit n. (6) Sex 36% M control vs 11% OA, "no difference" (p=0.16)	Indirect evidence for question 3 (in vivo kinematics in OA). Qualifies the FDI-centered narrative: the deficit in OA may be one of pronation (OP); they propose facilitating the OP in addition to the FDI. Contributes nothing on DRL/AOL
54	Revisiting the Critical Pathology of Primary Thumb Trapeziometacarpal Osteoarthritis: Volar Beak Ligament Degeneration	61	Pellegrini VD Jr, Fort MW, Nelton EB, Chiaramonti AM, Wu Y. Revisiting the critical pathology of primary thumb trapeziometacarpal osteoarthritis: Volar beak ligament degeneration. J Hand Surg Am. 2026;51(1):3-11. doi: 10.1016/j.jhsa.2025.10.015	10.1016/j.jhsa.2025.10.015	Observational cross-sectional anatomopathological cadaveric study (association between capsuloligamentous integrity and eburnation by stage); no loading or kinematics	80 thumbs from 40 embalmed donors (both thumbs of the same donor in the same group). Dorsal arthrotomy: 40 (20 M/20 F; 83 y, 72–100). Volar arthrotomy: 40 (24 M/16 F; 90 y, 76–102). 9 excluded (1 dissected, 1 arthrodesis, 7 inflammatory arthritis) ⇒ 71 analyzed (35 dorsal, 36 volar). Stages by eburnation area: none 20, early (<25%) 15, advanced (25–75%) 17, end-stage (>75%) 19	Intracapsular volar beak ligament (≈ deep AOL; separate from the superficial AOL) assessed by dorsal arthrotomy; dorsal ligament complex/DRL assessed by volar arthrotomy (without individualizing DRL/POL/IML). Articular surfaces (eburnation)	En bloc resection; dorsal or volar capsulotomy preserving the opposite capsule; visual inspection by consensus of two authors (normal / in continuity with irregularities / detached); methylene blue to delimit eburnation; standardized photography and ImageJ (mean of two measurements); trapezium/MC eburnated area ratio; heat maps by 6 sectors (intra-observer κ 0.88 [0.85–0.92]). One-tailed Student's t	Complete detachment of the beak from the volar margin of the MC1 in 21/23 (91%) with eburnation: 8/8 end-stage, 7/8 advanced, 6/7 early; denuded osteophyte at the insertion 18/23. Without eburnation: 11/12 normal ligament. Dorsal complex: 0/36 with degeneration at any stage. Dorsal eburnation only in end-stage disease and always with concurrent volar eburnation. TR/MC ratio 1.22 early, 1.07 advanced, 0.98 end-stage (early vs end-stage p=0.03; no dispersion). Stability/laxity not measured	QUACS (13 items)	12/13 (Item 8=0: single test, one-tailed without justification, no analysis of the ligament–stage association or of thumb pairing)	High	Limitations (authors): association, not causality; embalmed; methylene blue stains capsule; 2D images; qualitative ligament assessment by consensus. Not declared: paired thumbs treated as independent; no blinding to stage; DRL/POL/IML not distinguished; age 72–102; groups of different age. COI: none; no funding statement. First author = historical proponent of the beak hypothesis. Internal discrepancies in the source: (1) Age range of volar group 76–100 (Abstract) vs 76–102 (Methods/Table 3). (2) Stage by "fractional area trapezium+MC" (Methods) vs "% trapezial eburnation" (Results). (3) Discussion "0.98 in advanced" when 0.98 = end-stage. (4) "Detachment consistent with any eburnation" vs 21/23. (5) Three grades defined, tables only report "degeneration (%)". (6) p<0.05 vs p=0.03. (7) Consensus vs "independent [assessments] resolved by consensus". (8) They call cadaveric findings "in vivo"	Indirect evidence for question 1 (in situ integrity, not measured restraint). Provides the only in situ pathology data in a large series: near-universal detachment of the beak/deep AOL in OA and complete absence of dorsal degeneration. Key distinction: "biomechanical stabilizer in a healthy joint" (DRL, sectioning studies) ≠ "structure whose degeneration is associated with OA" (beak). Notes that Ladd 2012 assessed the extra-articular superficial AOL, not the beak. Nothing on FDI/OP/APL

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55	Thumb Carpometacarpal Osteoarthritis and Fatty Infiltration of the Opponens Pollicis Muscle, a New Finding	62	El Hor H, Larson D, Grande J, Iida N, Lachman N, Rhodes N, et al. Thumb carpometacarpal osteoarthritis and fatty infiltration of the opponens pollicis muscle, a new finding. J Orthop Res. 2026;44(2): e70149. doi: 10.1002/jor.70149	10.1002/jor.70149	Retrospective cross-sectional imaging study (consecutive 3 T wrist MRI, Nov-2022–Jul-2023), OA vs no OA, with logistic regression; illustrative cadaveric component (2 hands 7 T MRI + dissection; 1 hand H&E histology)	817 MRIs screened − 747 analyzed (1 per patient): 48.8 y (18–87); 57.2% women; BMI 29.7 (missing 16.3%). No TMC OA n=440; with OA n=307 (Eaton 1/2/3/4 = 28/102/147/30), staged with ≥3 radiographic views (≤6 months); 10 staged by MRI. Cadaver: no age/sex	Opponens pollicis (superficial and deep bellies); "other thenar muscles" globally (APB normal in Fig. 2; FPB/AdP not named; FDI and APL not assessed). No ligaments or stability parameters	3 T MRI reading (mainly T1) by a single observer (orthopedic surgeon), without blinding or reliability; binary fatty infiltration (FI) with localization; no semiquantitative scale. Eaton-Littler on radiographs. Prevalence with binomial 95% CI; t/χ^2; univariable and multivariable logistic regression (age, sex, BMI, stage, steroid infiltration)	FI of the deep belly of the OP in 133/747 (17.8%) = 133/307 with OA (43.3%; CI 37.9–48.9); 0/440 without OA. Constant location on the palmar facet of the trapezium/palmar-ulnar aspect of the MC1. No FI in the superficial belly or in other thenar muscles. By stage: Eaton 1 0%, 2 15.7%, 3 59.2%, 4 100% (p<0.001). Multivariable: Eaton 3–4 vs 1–2 OR 10.1 [5.2–19.5]; male sex OR 1.9 [1.1–3.5]; age OR 1.05/year. Histology (1 hand): diffuse FI of the deep belly. Stability not measured	JBI analytical cross-sectional (8 items)	7/8 (87.5%) (Item 7=N: single non-blinded reader, binary FI without reliability)	High	Limitations (authors): retrospective without clinical data; natural history unknown; FI not quantified; incidental wrist MRIs; selection bias. Not declared: single non-blinded reader; BMI missing 16%. Funding Mayo Clinic; no COI. Internal discrepancies in the source: (1) Table 2, Eaton 2 "without FI" = 28 (84.3%) when it should be 86 (the table sums to 249 ≠ 307). (2) Mean age 49 / 48.8 / 47 depending on section. (3) Age OR 1.05 [1.02–1.08] with p=0.030 (CI suggests lower p). (4) Abstract/conclusion speak of stability without measuring it. (5) "Other thenar muscles" not listed	Indirect evidence for question 3 (structural marker of possible OP dysfunction in advanced OA). The keyword and conclusion on "stability" are inference. FDI and APL not assessed; the only degenerated muscle was the OP. Hypothetical causal direction (OA → FI)
56	Shear Wave Elastography for the Assessment of Thenar Muscle Elasticity in Trapeziometacarpal Osteoarthritis: A Cross-Sectional Study	63	Karademir F, Yıldız AE, Hayran KM, Adıgüzel İF, Ülger Ö, Fırat T. Shear wave elastography for the assessment of thenar muscle elasticity in trapeziometacarpal osteoarthritis: A cross-sectional study. J Hand Surg Am. 2026;51(2):153.e1-153.e8. doi: 10.1016/j.jhsa.2025.07.007	10.1016/j.jhsa.2025.07.007	In vivo analytical cross-sectional, cases (TMC OA) vs asymptomatic controls, shear wave elastography (SWE); single center; March 2023–March 2024	Cases: 18 women with TMC OA, 29 affected thumbs (11 bilateral); 57 ± 2.2 y; Eaton I/II/III/IV = 4/12/11/2; VAS 7 ± 1.8; DASH 44 ± 22. Controls: 13 asymptomatic women matched by age (26 thumbs), 53 ± 16.2 y, no radiograph. Separate reliability pilot: 10 young healthy subjects (20 hands). No a priori sample size calculation (post hoc power 81%)	Adductor pollicis (AdP) and first dorsal interosseous (FDI), both sides, at rest. No OP, APB, FPB or APL; no ligaments	ACUSON S3000 SWE, 9L4 probe; single radiologist blinded to group; standardized position, relaxed muscle; ROI without tendon/fascia; 3 measurements averaged. Variables: shear wave velocity (m/s) and elastic modulus (kPa). Test-retest (pilot): ICC 0.81–0.89. Linear mixed model (group, dominance, interaction; random intercept per subject), Bonferroni	AdP stiffer in OA only on the dominant side: SWV 1.9 ± 0.2 vs 1.6 ± 0.4 m/s (diff. −0.27 [−0.51; −0.04], p=0.022); EM 11.6 ± 2.0 vs 8.4 ± 3.7 kPa (p=0.042); non-dominant no difference; overall group effect NS (p=0.13/0.15). FDI no differences on either side (p>0.19). No correlations with pain, DASH, strength or stage. Interpretation: pathological adaptation of the AdP (contracture, closure of the web space, Neumann model); causal direction undetermined	JBI analytical cross-sectional (8 items)	8/8 (100%) (Item 3–4 borderline: controls without radiograph; Item 5 borderline: partial confounders)	High (75% if Items 3–4 are penalized; remains high)	Limitations (authors): no intra/inter-observer agreement (only pilot test-retest); small n, no analysis by stage; controls without radiographs. Not declared: women only; post hoc power; controls = staff/relatives; implausibly small SDs in Table 1 (possible standard error instead of standard deviation); resting SWE does not inform active function. No funding declared; no COI. Internal discrepancies in the source: (1) AdP SWV dominant control 1.6 ± 0.4 (Table 2) vs 1.7 ± 0.4 (text). (2) Abstract "markedly higher" but overall group effect NS. (3) "Age- and sex-matched" (Abstract) vs "age-matched women" (Methods). (4) Limitation "no agreement" vs reported test-retest ICC. (5) Table 2 headed with n by persons although it analyzes thumbs	Direct evidence for question 3 (in vivo imaging of dynamic stabilizers, OA vs healthy); indirect for 4. The FDI shows no alteration of passive stiffness in OA; the altered muscle is the AdP. Together with Nwawka 2020 (ref. 65; APB/OP/FPB slightly less stiff) this draws a thenar imbalance. Nothing on DRL/AOL

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57	The central dorsal component of the dorsoradial ligament of the trapeziometacarpal joint: Cadaveric and sonographic validation	49	Margüenda-Fernández V, Valera-Garrido F, Valderrama-Canales FJ, Minaya-Muñoz F, Herrero P, Lapuente-Hernández D. The central dorsal component of the dorsoradial ligament of the trapeziometacarpal joint: Cadaveric and sonographic validation. Eur J Radiol. 2025;192:112398. doi: 10.1016/j.ejrad.2025.112398	10.1016/j.ejrad.2025.112398	Mixed: cadaveric anatomical study (identification of the DRL and its fascicles; landmarks) + descriptive cross-sectional ultrasound study in healthy volunteers (protocol and normative values by sex, age and side). No pathological group; no reliability	Cadaver: 5 embalmed specimens (UCM, March–May 2023), no age/sex. In vivo: 26 healthy volunteers, 52 thumbs; 14 M/12 F; 48.8 ± 11.2 y (27–68); 92% right-handed; convenience; exclusion <25 y and clinical diagnosis of TMC OA; no radiograph	DRL with its three fascicles (radial, central, posterior oblique, according to Ladd 2012); focus on the central fascicle (dorsal fibers trapezial tubercle ⁄ dorsal base MC1, adhered to the capsule). Landmarks: APL, EPB, EPL, radial artery, sensory branch of the radial nerve. No dynamic stabilizers assessed	Cadaver: dissection by planes and tension maneuvers (flexion, opposition, abduction/adduction, dorsal translation); no quantitative measurements. In vivo: Mindray N8 ultrasound, 16 MHz linear probe, one examiner (>10 years); thumb in flexion + slight opposition; standardized sequence with the trapezial tubercle as reference; ImageJ with rectangle system. Variables (cm): trapezium–skin, MC–skin, trapezium–MC, joint space, fascicle area (cm²). Shapiro-Wilk; t/U (sex); Pearson/Spearman (age); paired t/Wilcoxon (side)	The three fascicles were identified in all cadavers; the central one is the largest and most reproducible on imaging; DRL deep to the APL (the "DRL" image of Gondim Teixeira 2011 would probably correspond to the POL). In vivo (right/left): trapezium–skin 0.39 ± 0.09 / 0.41 ± 0.10; MC–skin 0.26 ± 0.08 / 0.27 ± 0.07; trapezium–MC 1.19 ± 0.15 / 1.14 ± 0.17; joint space 0.42 ± 0.13 / 0.36 ± 0.13; area 0.20 ± 0.06 / 0.20 ± 0.08 cm². Greater in men for trapezium–skin (p=0.018) and trapezium–MC (p=0.010); no effect of age or asymmetry. Thickness not reported. No stability outcome was measured	QUACS (13 items)	10/13 (Item 3=0: donor age and sex not reported; Item 7=0: no instrument or reliability; Item 13=0: conclusion not supported)	High (borderline)	Limitations (authors): 5 cadavers and 26 subjects; different equipment between phases; embalmed; no reliability; measurements only under tension; healthy subjects only; the contribution of the DRL to stability was not quantified. No funding. Internal discrepancies in the source: (1) Abstract: space 0.36 ± 0.13 and area 0.20 ± 0.08 = left hand values, not average. (2) "Average" rows of Table 1 are right+left sums, not means. (3) Mindray N8 (2.3.2) vs M8 (limitations). (4) "High tension" vs "flexion and slight opposition". (5) Conclusion "reliably and accurately assessed… identifying ligamentous insufficiency" without reliability or patients	Study by the first author of the review: extraction and assessment were performed by the second reviewer, without participation of the first author in resolving discrepancies (see Methods and conflict of interest statement). Indirect evidence for question 3 (protocol and morphological normative values of the DRL); no restraint or translation; does not modify DRL vs AOL or FDI/OP/APL. Fits with Chiavaras 2010 and Gondim Teixeira 2011 (mixed)
58	Biomechanical comparison of monofascicular and bifascicular reconstruction of the dorsal ligaments of the trapeziometacarpal joint	64	Domínguez Font E, Del Valle Jou M, Ferreres Claramunt A, Salvà Coll G, Rodríguez Baeza A. Biomechanical comparison of monofascicular and bifascicular reconstruction of the dorsal ligaments of the trapeziometacarpal joint. Hand (N Y). 2026. Epub ahead of print. doi: 10.1177/15589447251406715	10.1177/15589447251406715	Experimental biomechanical cadaveric repeated-measures study: intact state, ligament sectioning, bifascicular reconstruction and monofascicular reconstruction	10 fresh-frozen upper limbs (8 men, 2 women; 5 right, 5 left); mean age 82.1 years (72–100); no TMC osteoarthritis. Hands with osteoarthritis at final dissection would be excluded; no exclusions reported	Dorsal group (DRL, dorsal central ligament and POL) and ulnar group (dorsal trapeziometacarpal ligament and IML), sectioned together; reconstruction of the DRL (monofascicular) or of the DRL and dorsal central ligament (bifascicular) with an APL strip	Mounting in pinch position with locking rotation (screw-home); 3D electromagnetic tracking (Fastrak) with sensors on the bases of the first and second metacarpals; 0.5 kg dorsoradial luxating force via a pulley at 30° to the coronal plane; displacement on the x axis (cm) between neutral and loaded measurement. Shapiro-Wilk; Student's t or Mann-Whitney U	Dorsoradial displacement of the first metacarpal: intact 0.36 ± 0.19 cm; after sectioning 0.64 ± 0.24 cm (p = 0.012); bifascicular reconstruction 0.31 ± 0.16 cm (vs intact p = 0.912; vs sectioning p = 0.001); monofascicular reconstruction 0.57 ± 0.19 cm (vs intact p = 0.023; vs sectioning p = 0.510); bifascicular vs monofascicular p = 0.003. All 10 specimens increased displacement after sectioning (mean difference 2.8 mm; individual data in Table 1 of the source)	QUACS (13 items)	10/13 (Item 7=0: no precision of the tracking system; Item 8=0: tests for independent samples in a repeated-measures design and multiple comparisons without adjustment; Item 13=0: conclusions on complete restoration and the ulnar ligaments were not tested)	High (borderline)	Limitations (authors): a single loading direction; no musculature; the cadaver does not reproduce healing. Not declared: fixed order of reconstructions (bifascicular before monofascicular) without describing the conversion of one into the other; low load (0.5 kg); older donors; joint sectioning of the dorsal and ulnar groups, which does not isolate the DRL; APL graft harvested before the measurements. No funding; no conflicts of interest. Internal discrepancies in the source: the abstract speaks of "dorsoradial and ulnar" ligaments and the methods of "dorsal and ulnar" ligaments; case 2 presents a negative value (−0.102 cm) after bifascicular reconstruction; the monofascicular mean calculated from Table 1 is 0.58 cm (0.57 in the text).	Included for providing data on the native intact vs sectioned state (question 1); the results of the reconstructions are described as surgical context. Retrieved in full text during the update. Direct evidence for finding 1a, without isolating the DRL.
59	The effect of the joint capsule and anterior oblique ligament on dorsal subluxation of the first metacarpal during key pinch	67	Norton NM, Barnds B, McIff TE, Bruce TE, Fischer KJ. The effect of the joint capsule and anterior oblique ligament on dorsal subluxation of the first metacarpal during key pinch. J Biomech Eng. 2020;142(6):064502. doi: 10.1115/1.4046364	10.1115/1.4046364	Experimental biomechanical cadaveric repeated-measures study: intact state, partially opened capsule (between the AOL and the APL) and sectioned AOL	11 fresh-frozen forearms (10 men, 1 woman); mean age 72 years (54–88). All specimens had TMC osteoarthritis at final inspection (ICRS 3–4 in six and 1–2 in five); most had been frozen for at least six months	Joint capsule (partial opening) and AOL (complete sectioning)	Simulated lateral pinch with static loads (EPL 0.8 N; ADP group 4.2 N; APB group 5.0 N; FPL 8.4 N; APL 13.4 N); anteroposterior radiograph with C-arm; dorsal subluxation as a percentage (cantilever of the metacarpal base divided by its articular width); measurement error estimated with ten repeated measurements (SD 2%)	Dorsal subluxation: intact 32 ± 16%; capsule opened 35 ± 17%; AOL sectioned 34 ± 17%; repeated-measures ANOVA F(2,20) = 1.32; p = 0.29. Mean intra-specimen differences: intact vs capsule opened 5.9 ± 7.8%; intact vs AOL sectioned 3.3 ± 2.8%	QUACS (13 items)	12/13 (Item 11=0: the discussion focuses on the methodological implications of opening the capsule and barely addresses clinical relevance)	High	Limitations (authors): measurement by a single investigator; prolonged freezing; only one woman; advanced age and osteoarthritis of the specimens. Not declared: fixed order of conditions (capsule before AOL), two-dimensional measurement in a single projection and absence of power analysis with n = 11	Report from the initial search that could not be retrieved; obtained during the manuscript review (October 2026) and assessed with the same criteria. Support for finding 1b (directional function of the AOL); does not assess the DRL.

No.	Study (title)	Reference no. in the manuscript	Reference (audited bibliography of the manuscript)	DOI	Design	Sample / Population	Structures / Stabilisers assessed	Measurement method	Main stability results	Quality tool	Score	Quality (operational threshold)	Extraction notes (limitations reported)	Eligibility note
60	Association of Clinical Assessments of Hand Function and Quantitative Ultrasound Metrics in First Carpometacarpal Osteoarthritis	65	Nwawka OK, Weinstock-Zlotnick G, Lin B, Ko LM. Association of clinical assessments of hand function and quantitative ultrasound metrics in first carpometacarpal osteoarthritis. HSS J. 2020; 16(Suppl 2):420-424. doi: 10.1007/s11420-020-09795-z	10.1007/s11420-020-09795-z	Analytical cross-sectional in vivo pilot study, patients with first CMC osteoarthritis vs. asymptomatic volunteers, shear wave elastography (SWE); tertiary hospital; March 2016–July 2018	Patients: 5 (9 osteoarthritic thumbs); mean age 62.8 y (51–71); modified Eaton–Littler 1/2/3/4 = 2/2/2/3 thumbs. Controls: 9 asymptomatic volunteers (9 thumbs); mean age 38 y (26–57); no radiographs. Sex and dominance not reported; convenience sample; groups not age-matched	Thenar muscles: abductor pollicis brevis (APB), flexor pollicis brevis (FPB) and opponens pollicis (OP); flexor pollicis longus (FPL) tendon. No FDI, AdP or APL; no ligaments	SWE with LOGIQ E9 (GE), 9 MHz probe; one musculoskeletal radiologist; short axis using the first metacarpal and the FPL as landmarks; hand resting in supination to minimise active tension; mean of 3 measurements per muscle (kPa); no blinding or reliability reported. Function: PSFS, PRWHE, DASH, M-SACRAH and AHFT, by a hand therapist. Statistics: linear mixed-effects model (between-group differences) and Spearman's rho with 95% CI by subject-clustered bootstrap	- Mean stiffness of APB, FPB, OP and FPL lower in osteoarthritis than in controls; the authors describe the differences as «marginal»; values shown only in Figure 2 of the source, without p values (approximate reading, kPa, osteoarthritis vs. controls: APB ≈7.0 vs. ≈10.0; FPB ≈7.0 vs. ≈9.4; OP ≈6.8 vs. ≈9.1; FPL ≈19.0 vs. ≈20.7; overlapping error bars). - APB: rho = 0.8 (95% CI 0.4 to 1.0) with two-point pinch and −0.7 (−1.0 to −0.1) with the button board test; FPB: −0.6 (−0.9 to −0.1) with the PRWHE and 0.6 (0.0 to 0.9) with pinch. - OP: weak correlation with function (no values). - Weak negative correlation of stiffness with radiographic grade (rho −0.1 to −0.7). - No stability or subluxation measures	JBI analytical cross-sectional (8 items)	4/8 (50%) (Items 1–2=N: no criteria for controls and no sex or dominance of the sample; Item 6=N: no adjustment for confounders; Item 7=N: single operator without blinding or reliability)	Moderate (lower borderline)	Limitations (authors): small convenience sample; groups not age-matched (younger controls); no adjustment for age, sex or dominance; function assessor not blinded; adductor pollicis and ligaments not studied. Not reported: group results without numerical values in the text; informed consent waived. No conflicts of interest; funding not reported. Internal discrepancies of the source: (1) «ABP» in Results vs. «APB» in Methods. (2) Results: «marginal» differences; Abstract and Discussion: lower stiffness in osteoarthritis	Identified in the update by checking the reference list of Karademir 2026 (ref. 63); not retrieved by the electronic search (no stability-block terms in title or abstract). Indirect evidence for question 3 (in vivo imaging of muscle properties, osteoarthritis vs. controls), including the OP; does not measure stability. Nothing on DRL/AOL

Sixty included studies (51 from the initial search and 9 from the update phase: 8 from the search and 1 from citation searching); 59 scored and one physical model without category. The categories express quality by operational thresholds, not validated risk of bias. Extractions from the initial search were verified and validated by both authors; those from the update are based on assisted pre-scoring checked against the full text and validated by both authors. Margüenda-Fernández 2025 (row 57) belongs to the first author of the review: its extraction and assessment were performed by the second reviewer. Norton 2020 (row 59) was retrieved during the manuscript review; its extraction and assessment were also validated by both authors. Nwawka 2020 (row 60) was identified in the update by checking the reference list of Karademir 2026; its extraction and assessment were validated by both authors.

Table S2. QUACS

Study	Year	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Item 13	Total	%	Quality (threshold)	Basis of scoring	Justification
Osteoligamentous Guidance of the Movements of the Human Thumb	1976	1	1	0	1	0	1	0	0	0	1	1	0	1	7/13	54%	Moderate	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'It was the aim of the present investigation to describe the structural basis of apoposition and to compare it to the well-known opposition' (p.71). Item 2=1: 20 dissected hands + 10 dry skeletons (+ 'a number of living hands' and 43 students observed) (p.71-2). Item 3=0: 'normal adult humans', no age or sex. Item 4=1: 2 unfixed and 18 formalin-fixed (p.71). Item 5=0: only 'all soft tissues were removed except the joint capsules and the reinforcing ligaments'; movements and restraints were 'observed' without loading protocol or sectioning order. Item 7=0: no measuring instrument; qualitative description (angles of 25-30° estimated). Item 8=0: no statistics. Item 9=0: narrative results; only isolated counts (2/10 skeletons 'flat type'; frequency of apoposition when writing 21/2 and 12/6/2) without data per specimen. Item 11=1: functional implications (writing, muscular economy through ligament guidance) (p.78-9). Item 12=0: no limitations. Item 13=1: descriptive conclusions consistent with what was observed.
Ligamentous Stability of the Base of the Thumb	1981	1	1	0	1	0	1	0	0	0	1	1	0	1	7/13	54%	Moderate	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'to study the anatomy and function of the ligaments… and in particular to determine the role of the ligaments in the control of the base of the first metacarpal' (p.29). Item 2=1: 17 embalmed hands (p.29). Item 3=0: 'adult hands', no age or sex. Item 4=1: embalmed (p.29). Item 5=0: 'cutting one ligament at a time' without specifying order, loading positions or applied force; laxity/tension checked manually. Item 7=0: the radial displacement 'up to six millimetres' after sectioning the IML does not indicate instrument or measurement method (p.32-3). Item 8=0: no statistics. Item 9=0: narrative results by ligament; anatomical variants counted (3 fan-shaped insertions, 4 with fibers to the 2nd MC, 5 with osteoarthritis) but no stability data per specimen. Item 11=1: implications for ligament reconstruction and arthroplasty (p.33-5, Fig. 8). Item 12=0: only one sentence ('It is impossible to know from this study if the arthritic changes precede ligament disruption'), without discussion of limitations. Item 13=1 (borderline item; resolved by consensus): 'clearly demonstrated that the first intermetacarpal ligament… is the main factor' is based on manual tests in 17 specimens, although cautious about causality.
Osteoarthritis of the trapeziometacarpal joint: I. Anatomy and pathology of the	1991	1	1	1	1	0	1	0	0	1	1	1	0	1	9/13	69%	Moderate	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'this study was undertaken to investigate the effects of physiologic aging on the TMC joint…' (p.967-8). Item 2=1: 47 cadaveric thumbs (p.968). Item 3=1: 29 women/18 men, mean 79 y, means by subgroup (p.968). Item 4=1: 12 fresh and 35 embalmed (p.968); no storage details. Item 5=0: dorsal (3/4) or palmar approach described, but the 'serial ligament division' with 'manual loading' is not quantified and the normal/chondromalacia/eburnation grades are not operationalized; Diff-Quik staining was abandoned midway through the series (p.968-9). Item 7=0: gross inspection and photography, no instrument or calibration. Item 8=0: only percentages; 'no significant age difference' without test. Item 9=1: percentages by sex and pattern for the whole series, Fig. 4 (p.971-2); no absolute counts per subgroup. Item 12=0: does not discuss limitations (e.g., fresh/embalmed mixture, absence of blinding). Item 13=1 (borderline item; resolved by consensus): causal relationship ligament–osteoarthritis inferred from a cross-sectional association, although worded as 'suggesting' and 'support' (p.974).
Anatomy of trapeziometacarpal ligaments	1993	1	1	1	1	1	1	0	0	1	1	1	0	1	10/13	77%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'The purpose of this study was to examine the precise orientation of the ligaments… and to record their contributions to joint stability' (p.226). Item 2=1: 30 specimens (p.226). Item 3=1: 11 embalmed from 3 M/8 F, mean 75 y; 19 fresh-frozen from 7 M/12 F, mean 69 y (p.226). Item 4=1: embalmed and fresh-frozen; Eaton staging by radiographs (p.226-7). Item 5=1: step-by-step dissection (APB, OP, FPL, FPB, radial artery, 1st DIO, adductor), microdissection with loupe/microscope, defined test positions (Fig. 1) and intra-articular confirmation (p.227). Item 7=0: 'Tautness or laxity is a qualitative assessment' (p.227); no instrument or quantification. Item 8=0: no statistics. Item 9=1: Table I (origin, insertion, tension by position for the 5 ligaments), state of the AOL in the 7 with osteoarthritis, thin IML in 23/30 (p.227-30). Item 11=1: reconstruction of the AOL in osteoarthritis (p.230-1). Item 12=0: only 'The number of osteoarthritic specimens… was limited… comparison… tentative' (p.230); passing mention, without explicit discussion. Item 13=1 (borderline item; resolved by consensus): 'AOL is the primary stabilizer' is inferred from qualitative assessment and 7 osteoarthritic specimens, but the authors qualify it ('no single ligament provides the sole joint stabilization').
Contact patterns in the trapeziometacarpal joint: The role of the palmar beak li	1993	1	1	0	1	1	1	1	0	1	1	1	1	1	11/13	85%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'the purpose of this study was to develop a suitable cadaver model… and allow investigation of the joint contact areas and the function of the beak ligament' (p.238). Item 2=1: 23 forearm specimens (p.239). Item 3=0: donor age and sex not stated. Item 4=1: 'fresh frozen', no storage/thawing details (p.239). Item 5=1: Plexiglas mounting, K-wires (wrist 30° ext, MCP 20° flex, fingers 90°/30°), loads EPL 85 g/ADD 426 g/APB 511 g/FPL 852 g/APL 1363 g (ratio 1-5-6-10-16, mod. of Cooney and Chao), 6 functional modes, 10 dynamic pinch cycles, ligament sectioning in ~90° arc (p.239-40). Item 7=1: Fuji ultra-low pressure film, densitometer calibrated by loading mode and humidity; 3 film fixations (p.240). Item 8=0: no statistics, acknowledged ('statistical significance… is limited', p.243). Item 9=1: 1656 imprints; peak pressures with range in the normal group (ext 4.6; flex 7.6; pinch 9.8 kg/cm²) and results for the 3 groups (7 normal, 12 moderate, 4 end-stage), although the moderate group is described only in relation to the normal range (p.241-3). Item 12=1: explicit limitations paragraph (film unsuitable for absolute figures, shear increases density, no digitized analysis, sample biased by OA prevalence) (p.243). Item 13=1: conclusions limited to contact patterns and their change after sectioning.
Kinematics of the Trapeziometacarpal Joint After Sectioning of Ligaments	1994	1	1	0	1	1	1	1	1	1	1	1	0	1	11/13	85%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'The purpose of this study was to analyze the contribution of the individual ligaments to stability of the joint' (p.205-6). Item 2=1: 12 hands (6 pairs; group I in the 6 left, group II in the 6 right) (p.206-7). Item 3=0: no age or sex. Item 4=1: fresh-frozen, radiographs to exclude osteoarthritis (p.206). Item 5=1: 3rd MC-capitate fixation with rod, plastic screws in trapezium/trapezoid, methacrylate, IP/MCP transfixed, 6 tendons with 50 g, intrinsic pulleys, two defined sectioning groups (p.206-7). Item 7=1 (borderline item; resolved by consensus): 3Space Tracker (Polhemus) with sensor on M1 and surface digitization; precision is not stated here but by reference to the previous study (14). Item 8=1: paired t α=0.05, power calculation (80% for 1.5 SD) (p.207). Item 9=1: Tables 1-2 with mean±SD of laxity, borders and centroid per group, with p (p.208). Item 11=1: recommends reconstructing the AOL and not the IML (p.209). Item 12=0: only 'the kinematics… under such loading should be the subject of future study'; no discussion of limitations (50 g load, n=6 per group). Item 13=1: conclusions confined to the data, with the surgical recommendation limited 'on the basis of this in vitro biomechanical study'.
Contact areas in the thumb carpometacarpal joint	1995	1	1	1	1	1	1	1	1	1	1	1	1	1	13/13	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Items 2-3: 13 hands (8 women 55-71y, mean 66; 5 men 61-80y, mean 70) (Methods). Item 4: fresh-frozen, 12 h thawing, radiographic OA grading (I-III, no IV). Items 5-7: mounting with Steinmann pins under fluoroscopic guidance, Dacron cables per muscle with sequential loading protocol, stereophotogrammetry with 25 µm uncertainty (95% CI), proximity criterion 0.25 mm. Item 8: statistics where appropriate (areas by sex, p<0.02); the thickness analysis is descriptive and they state so. Item 12=1: limitations discussed in the text (no young normal controls, pulley friction, full abduction not measurable, 4 specimens excluded from thickness because of high error).

Study	Year	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Item 13	Total	%	Quality (threshold)	Basis of scoring	Justification
Ligament length during circumduction of the trapeziometacarpal joint	1997	1	1	0	1	1	1	1	0	1	1	1	1	1	11/13	85%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'The purpose of this study was to determine how the lengths of the constraining ligaments change during circumduction' (p.319). Item 2=1: 12 hands (p.320). Item 3=0: age 63-78 y, no sex ⁉ 0 according to criterion. Item 4=1: fresh-frozen, exclusion radiographs (p.320). Item 5=1: mounting identical to Imaeda 1994, 50 g preload justified (Schuind), defined movements, digitization x5 of each insertion (p.320-2). Item 7=1: 3Space Tracker with own validation: error 0.196-0.201 mm (sensor) and 0.18±0.15 mm (digitizer), 121 points on a 1 mm grid (p.322). Item 8=0: only mean±SD; no inferential analysis or explicit justification for its absence. Item 9=1: Tables 1-2 (maximum length and relative range, mean±SD) and Figs. 5-9 with SD (p.323-4). Item 11=1: relevance discussed although 'not entirely clear' (p.326). Item 12=1 (borderline item; resolved by consensus): the limitation of measuring origin-insertion distance (underestimates length and does not inform tension) is discussed in the Introduction and Discussion (p.319, 325); no formal limitations paragraph. Item 13=1 (borderline item; resolved by consensus): the hypothesis that ligament attenuation is the first event of osteoarthritis is presented as 'we believe/we hypothesize' (p.326).
A Biomechanical Assessment of Ligaments Preventing Dorsoradial Subluxation of th	1998	1	1	0	1	1	1	0	0	1	1	1	1	1	10/13	77%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'The purpose of this study was to determine which of these 4 ligaments is most important in preventing dorsoradial subluxation' (p.607). Item 2=1: 7 hands, 1 discarded for osteoarthritis ⁉ 6 (p.608). Item 3=0: 'The ages of the specimens were unknown', no sex (p.608). Item 4=1: fresh-frozen at -20 °C, 24 h thawing (p.608). Item 5=1: AO screws in wrist, acrylic cement, eyelet screw 1 cm from the surface, 150 g perpendicular load, reading at 15 s, 5 measurements with 30 s unloading, random sectioning order (p.608-9). Item 6=1 (with reservation): 'arbitrary' load of 150 g and without soft tissues or tendons, acknowledged by the authors. Item 7=0: home-made LVDT without declared precision/resolution or calibration. Item 8=0: only mean±SEM; no statistical test (n=6). Item 9=1: Table 1 with values per specimen and ligament (p.609). Item 11=1: reconstruction of the radial collateral/dorsoradial ligament (p.610). Item 12=1: explicit paragraph (non-physiological load, soft tissues removed, only dorsoradial direction) (p.610). Item 13=1: 'RCL was essential… during the described loading protocol', cautious.
Mechanical advantage of the thumb muscles	1998	1	1	1	1	1	1	1	1	1	1	1	1	1	13/13	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'The purpose of this study was to measure the moment arms of the thumb muscles at the IP, MP and CMC joints… in the same specimens' (p.565). Item 2=1: 7 hands (4 L/3 R) (p.565). Item 3=1: 4 M/2 F, mean 77 y (72-84) (p.565). Item 4=1: fresh-frozen (abstract); Mayo IRB (p.565). Item 5=1: nylon lines, screws at the origin, Plexiglas fixation, intramedullary rod, 9 potentiometers with 19 mm pulley and 200 g, plane guides, defined joint ranges, 15 Hz, 3 repetitions (p.565-6). Item 7=1: potentiometers linearity 0.5%, 3Space 0.5 mm/0.5°, validation of the setup with known pulleys (0.1 mm) (p.566). Item 8=1 (borderline item; resolved by consensus): descriptive study; polynomial regression (≤6th order, RMSE<0.1 mm) to derive moment arms, mean±SD; no tests, consistent with the design. Item 9=1: Tables 1-5 with mean (SD) by muscle and angle (p.567-8). Item 11=1: rehabilitation, splints, surgery, dynamic stabilizers (p.569). Item 12=1: 4 explicit limitations (p.569). Item 13=1.
An Anatomic Study of the Stabilizing Ligaments of the Trapezium and Trapeziometa	1999	1	1	1	1	1	1	1	0	1	1	1	1	1	12/13	92%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'to provide a detailed and comprehensive anatomic description of the ligaments… and to determine how these ligaments contribute to thumb stability' (p.787). Item 2=1: 37 hands from 24 cadavers (p.787). Item 3=1: 17 M (6 pairs)/20 F (7 pairs), mean 73 y (p.787). Item 4=1: fresh-frozen; radiographs, only Eaton I-II (27/10) (p.787). Item 5=1: detailed dorsal/volar/FCR tunnel dissection sequence, 3.5x loupe, extraction of bone-ligament-bone complexes (p.787-8). Item 7=1: precision caliper 0.05 mm for length/width/thickness (p.788); ligament tension is assessed 'subjectively' by manual manipulation. Item 8=0: only mean±SD and prevalence; no statistical analysis or justification for its absence. Item 9=1: Table 2 (dimensions mean±SD and prevalence of 13 ligaments), origin/insertion and tension positions ligament by ligament (p.789-95). Item 11=1: Eaton reconstruction, LRTI, arthroplasty (p.796). Item 12=1: explicit final paragraph ('assignment of functional significance… can only be inferred… interpreted with caution') and caution about ex vivo measurement (p.788, 797). Item 13=1: functional conclusions presented as anatomical/teleological inference.
Material Properties of the Trapezial and Trapeziometacarpal Ligaments	2000	1	1	1	1	1	1	1	1	1	1	1	0	1	12/13	92%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'This study addresses the material properties of the ligaments stabilizing the trapezium and TMC joint' with justification of the 7 ligaments chosen (p.1085-6). Item 2=1: 20 hands from 19 cadavers; 6 complexes per hand + T-III MC from 6 separate hands (p.1086-7). Item 3=1: 10 M (75±7.4 y)/10 F (67±11.6 y) (p.1086). Item 4=1: fresh-frozen at −20 °C (p.1086). Item 5=1: dissection with 3.5x loupe, sagittal saw, 0.36 mm cerclage, PMMA in 25.4 mm cylinders, 6-DOF mounting, preconditioning 1.78 N x10 cycles, hysteresis 7.13 N x5, failure at 25% length/s (p.1087-9). Item 7=1: caliper 0.01 mm (mean of 3), servohydraulic MTS with 45 kg load cell, operational definitions of each property (p.1087-9). Item 8=1: repeated-measures ANOVA + Bonferroni t; t and Wilcoxon for T-III MC; by sex (p.1089). Item 9=1: mean±SD of load, stress, strain, stiffness, toughness and hysteresis for 7 ligaments (Figs. 6-11) and failure location (p.1089-92). Item 11=1: 'Clinical Relevance' section (p.1094). Item 12=0: no limitations paragraph; only discusses discrepancies with Garcia-Elias (loading rate, n) and 'we did not evaluate the clinical significance of the gender differences'. Item 13=1: inference of stability from material properties stated as such; 'further research… required before making clinical recommendations'.
Trapeziometacarpal Joint Instability Affects the Moment Arms of Thumb Motor Tend	2000	1	1	1	1	1	1	1	1	1	1	1	1	1	13/13	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: explicit hypothesis of kinetic changes after destabilization (p.263). Item 2=1: 10 limbs (4 L/6 R), not paired (p.263). Item 3=1: 6 M/4 F, 45-85 y, mean 68.2 (p.263). Item 4=1: fresh-frozen, thawed at room temperature; AP/lateral radiographs and normal ROM (p.263). Item 5=1: tendons sectioned at the myotendinous junction, K-wires (MCP 30°, IP extension), 250 g per tendon, intrinsic pulleys, neutral position 30° abd/20° ext, 5 sequential conditions including Eaton-Littler reconstruction (p.263-5). Item 7=1: Bourns 3543S potentiometer and Penny & Giles electrogoniometer calibrated to ±0.1° and ±0.1 mm, 10 Hz, 3 cycles (p.264-5). Item 8=1: repeated-measures ANOVA + Tukey, p<0.05; quintic spline (p.265). Item 9=1: Tables 1-3 with mean±SD per tendon and condition (p.266-8). Item 11=1: pathomechanics of subluxation and adduction, surgical options (p.269-70). Item 12=1: explicit paragraph (no longitudinal rotation, ROM greater than in vivo, intrinsics not examined) (p.270). Item 13=1.
Importance du complexe ligamentaire postéromédial trapézométacarpien	2001	1	1	0	1	0	1	0	0	0	1	1	0	0	6/13	46%	Low	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	'Mise au point' article with experimental component. Item 1=1: 'préciser leur nombre, proposer une terminologie…, les classer en fonction de leur rôle et comprendre les mécanismes' (p.33). Item 2=1: 40 cadaveric thumbs (p.33). Item 3=0: no age or sex. Item 4=1: 'cadavres frais' (p.33). Item 5=0 (borderline item; resolved by consensus): mounting described (K-wires, plates at 45°, hand nailed to support), but mobilization is manual ('la manipulation… remplace l'action des muscles') without loads, and sectioning 'un par un… dans un ordre différent' is not specified (p.33). Item 7=0: pronosupination is read on a perpendicular plate without instrument or precision; drawer/forced pronosupination maneuvers are manual (p.33, 44). Item 8=0: no statistics. Item 9=0: narrative results; only figure 'supination forcée… 40 à 50 degrés' without dispersion or n; much of 'Résultats' is a theoretical model (mât de cocagne, homme dans l'embrasure) (p.37-45). Item 10=1 (borderline item; resolved by consensus): sectioning findings derive from the method, but the kinematic model is interpretative. Item 11=1: topographic diagnosis, ligament repair and prosthesis design (p.45-6). Item 12=0: no limitations. Item 13=0 (borderline item; resolved by consensus): strong claims without data ('Il n'y a aucune raison de douter de son efficacité fonctionnelle', 'restricted' role of the anterolateral ligament) from qualitative manipulation.

Study	Year	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Item 13	Total	%	Quality (threshold)	Basis of scoring	Justification
Sequential wear patterns of the articular cartilage of the thumb carpometacarpal	2003	1	1	1	1	1	1	1	1	1	1	1	0	1	12/13	92%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Items 2-3: 104 fresh-frozen specimens, 63M/41F, 18-97 years, mean 52.3±17.8 (p.598). Item 4: fresh-frozen, -40°C, 6 h thawing (p.598). Items 5,7: stereophotogrammetry, 25 µm precision, ~275 mesh points (p.599). Item 8: 2-factor repeated-measures ANOVA + Duncan + paired t, α=0.05 (p.599). Item 9: means±SD by stage and quadrant (Tables and Figs. 3-6). Item 12=0: the Discussion does not include an explicit section or paragraph on the study's own limitations.
Effects of the Deep Anterior Oblique and Dorsoradial Ligaments on Trapeziometaca	2007	1	1	1	1	1	1	1	1	1	1	1	1	1	13/13	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: explicit purpose and hypothesis (p.310-1). Item 2=1: 18 arms, 1 excluded ⍰ 17 (9 pAOL/8 DRL) (p.311). Item 3=1: 6 M/12 F, mean 84 y (p.311). Item 4=1: fresh-frozen at −20 °C, thawed at 5 °C overnight (p.311). Item 5=1: sutures and subcutaneous Teflon tubes, anchoring in OP, Steinmann pins, adjustable plate as stop, loads per muscle derived from PCSA and EMG (ADD 24.5 N, OP 7.8 N, FPL 11.1 N, APL 25.3 N in pinch; 9.0/15.5/22.1/25.3 N in opposition), preconditioning x2 (p.311-2). Item 7=1: 3Space Fastrak with coordinate systems by digitization and own accuracy test (0.1-0.2 mm with block milled to 0.025 mm) (p.311-3). Item 8=1: power analysis (0.2-1.2 mm; 1-5°), one-tailed t, ANOVA + post hoc, p≤0.05 (p.312). Item 9=1: translations/rotations per ligament and task with p (Figs. 2-7), 2D resultants (p.313-4). Item 11=1: surgical priority of reconstructing both ligaments with emphasis on the DRL (p.316). Item 12=1: limitations discussed substantively although without heading (mean age 84 y, muscle selection, magnitudes ≤1 mm) (p.314-6). Item 13=1.
Complex, Multidimensional Thumb Movements Generated by Individual Extrinsic Musc	2008	1	1	1	1	1	1	1	1	1	1	1	1	1	13/13	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: explicit objective and hypothesis (2 questions) (p.1289). Item 2=1: 10 right arms (12 minus 2 excluded: laxity and severe osteoarthritis) (p.1289). Item 3=1: 4 M/6 F, 52.8±6.4 y (p.1289). Item 4=1: fresh-frozen, thawed at room temperature, 0.9% saline (p.1289). Item 5=1: mounting (elbow 90°, 5 mm Schanz screws, fingers 2-5 fixed), baseball suture, 15 s preconditioning, load at 10% of maximum force in 10 s, random order, 3 trials (p.1289-90). Item 7=1: Nano17 transducer + LabVIEW, VICON 460 with 12 markers of 5 mm, 100 Hz synchronized, Euler angles (p.1290). Item 8=1: one-sample one-tailed t vs 5°, α=0.05; correlation and regression (p.1290). Item 9=1: mean±SD of coefficients (Tables 1-2), ROM per muscle/joint (Fig. 4), trajectories (Fig. 3). Item 11=1: median neuropathy, Froment sign, transfers (p.1294). Item 12=1: explicit paragraph with 4 limitations (p.1294). Item 13=1: conclusions confined to the force range studied.
Sonography of the Anterior Oblique Ligament of the Trapeziometacarpal Joint: A S	2010	1	1	0	1	1	1	1	1	1	1	1	1	1	12/13	92%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Mixed study: 4 cadaveric hands (validation with methylene blue) + 40 asymptomatic volunteers. Item 1=1: 'to assess the ability of high-resolution ultrasound to delineate the thickness and echogenicity of the normal AOL' (W428-9). Item 2=1: 4 cadaveric hands; 40 volunteers (80 hands) (W429). Item 3=0: donors are only described as 'skeletally mature', without age or sex (volunteers are: 21 F/19 M, mean 36 y, 19-63). Item 4=1: embalmed cadavers, disarticulated at mid-humerus (W429). Item 5=1: 5-13 MHz probe, injection of 0.1% methylene blue with guided 27G needle, immediate dissection; volunteer protocol with position, stress maneuver and measurement method (W429-31). Item 7=1: Antares (Siemens) and Logiq E9 with ML6-15; dimensions to the nearest 0.1 mm (W430). Item 8=1: paired/unpaired t, Pearson, Bonferroni correction (p<0.008), SPSS 17 (W431). Item 9=1: Tables 1-3 with mean, SD and 95% CI; 4/4 cadavers confirmed (W431-2). Item 11=1: diagnosis of AOL injury, conservative management vs reconstruction (W432-3). Item 12=1: explicit paragraph (operator-dependent, no inter-observer reliability, no pathological cases) (W433). Item 13=1.
High-resolution ultrasound evaluation of the trapeziometacarpal joint with empha	2011	1	1	1	1	1	1	1	0	1	1	1	1	1	12/13	92%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Ultrasound feasibility study: 10 cadaveric hands + 10 thumbs of 5 volunteers. Item 1=1: 'This study evaluates the feasibility of ultrasound of the anterior oblique ligament' (p.897). Item 2=1: 10 hands (6 R/4 L) from 7 cadavers; 5 volunteers (p.898). Item 3=1: 6 M/1 F, 58-92 y (volunteers 4 F/1 M, 24-29 y) (p.898). Item 4=1: fresh-frozen at −40 °C ≥30 days, thawed 24 h (p.898). Item 5=1: thumb position and approach, equipment and probes, 2 ml saline injection with 22G needle, progressive dissection according to De Maeseneer, detectability criteria (p.898-9). Item 7=1: IU22 with 15-17 MHz probe (cadaver) and Aplio XG 8-15 MHz + golf-club 12 MHz (volunteers); thickness measured in mm without declared resolution (p.898). Item 8=0: no statistical analysis (descriptive); the only justification ('observational and feasibility study') refers to inter-observer agreement. Item 9=1: Tables 1-2 with sex, age, side, detectability, OA and thickness per specimen/volunteer (p.901-2). Item 11=1: early assessment of the ligament, intra-articular fluid as contrast (p.902-3). Item 12=1: explicit paragraph (no clinical data of donors, no pathological cases, different equipment, consensus without inter-observer reliability) (p.903). Item 13=1: 'is feasible… further studies are necessary'.
Innervation patterns of thumb trapeziometacarpal joint ligaments	2012	1	1	1	1	1	1	1	1	1	1	1	1	1	13/13	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: explicit hypothesis of innervation with proprioceptive function (p.706-7). Item 2=1: 10 hands; 5 ligaments per hand (50 samples) (p.707). Item 3=1: 3 F/5 M (10 hands from 8 cadavers, cf. Ladd 2012), mean 65 y (53-74), age unknown in 2 (p.707). Item 4=1: fresh-frozen; Outerbridge (9 with mild OA ≤25%) (p.707). Item 5=1: complete protocol of fixation (4% formalin), paraffin, 8 µm sections, antigen retrieval, antibodies p75 1:100 and PGP9.5 1:400, secondaries Alexa 488/647, DAPI, controls with median nerve (p.707-8). Item 7=1: Zeiss Observer.Z1 microscope + AxioVision, multidimensional acquisition, previously published ordinal scale (+++ to −) (p.708-9). Item 8=1: linear mixed-effects regression with simultaneous pairwise comparisons (familywise 95% CI), location effect and interaction (p.709). Item 9=1: Fig. 6 with grade per ligament and specimen, Fig. 7 mean differences with p (p.712). Item 11=1: 'Clinical relevance' section and neuromuscular re-education (p.706, 713). Item 12=1 (borderline item; resolved by consensus): no heading; one paragraph discusses the quality of frozen tissue and how it was mitigated; the ordinal scale/absence of power are acknowledged in Ladd 2012, not here (p.711). Item 13=1: 'infers a proprioceptive function' presented as inference.
Macroscopic and Microscopic Analysis of the Thumb Carpometacarpal Ligaments: A C	2012	1	1	1	1	1	1	1	1	1	1	1	1	1	13/13	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: explicit hypothesis (p.1468-9). Item 2=1: 35 hands, 5 excluded ⍰ 30 (10 fresh-frozen/20 embalmed) from 19 cadavers; histology in the 10 fresh ones (p.1469). Item 3=1: 8 F/11 M, mean 76 y (43-99), unknown in 4; histological subgroup 3 F/5 M, mean 65 y (p.1469). Item 4=1: fresh-frozen and embalmed, with justification for using only fresh ones for immunofluorescence (p.1469). Item 5=1: dissection by two surgeons with 3.5-4.5x loupe, Berger technique to identify ligaments, measurement at maximum passive tension (Bettinger), arthrotomy, triple IHC protocol and 12 areas of 320 µm² per ligament for cell counting (p.1469-70). Item 7=1: digital caliper 0.02 mm, mean of 3 measurements; Zeiss microscope, ordinal scale (p.1469-70). Item 8=1: Student's t for dimensions; mixed-effects regression for cellularity and innervation with simultaneous comparisons (p.1470). Item 9=1: Table I (mean±SD of 7 ligaments), Figs. 6-7 (p.1473-4). Item 11=1: 'Clinical Relevance' section (p.1468). Item 12=1: 'Limitations of the Study' heading (age, male predominance, embalmed tissue, manual force, ordinal scale, no power) (p.1476). Item 13=1: the reclassification of the AOL as capsule is phrased as 'we suggest'.
Thumb Carpometacarpal Ligaments Inside and Out: A Comparative Study of Arthrosco	2013	1	1	1	0	1	1	1	0	1	1	1	1	1	11/13	85%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Items 2-3: 5 cadavers, 4M/1F, right, mean 69.2 (50-93), IRB approved (Methods). Item 4=0: the method of specimen preservation is not stated. Items 5,7: 1U and thenar portals, 2.7 mm 30° arthroscope, marked 0.028 K-wires, confirmatory dissection according to Berger. Item 8=0: descriptive study, no statistical analysis (n=5). Item 12=1: explicit limitations paragraph (small sample, 1 woman, no histology, all with OA, suboptimal DR visualization).

Study	Year	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Item 13	Total	%	Quality (threshold)	Basis of scoring	Justification
Comparison of the Anatomical Dimensions and Mechanical Properties of the Dorsora	2014	1	1	1	1	1	1	1	1	1	1	1	1	1	13/13	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: explicit objective (anatomical data and material properties of the DRL vs AOL to guide reconstruction/approach) (p.3). Item 2=1: 13 thumbs from 9 specimens; 26 bone-ligament-bone complexes (p.3-4). Item 3=1: Table 2 with age and sex per specimen (52-88 y, mean 74; 5 M/4 F) (p.3). Item 4=1: fresh-frozen at −18 °C; radiographs and inspection, Eaton III-IV excluded (p.3). Item 5=1: 3T MRI with arthro-gadolinium (sequences and voxel), dissection with 4.5x loupe according to Berger, measurement at maximum passive tension (Bettinger), ultrasonic saw, Bose LM1 at 2 Hz, 40 cycles, 0.5 N preload, stiffness at cycle 20 (p.3-4). Item 7=1: voxel 0.253-0.284 mm + ImageJ, Mitutoyo caliper 0.01 mm, Bose bench; NOTE: stiffness is expressed in N/mm in the text and in 'MPa' in Tables 4-5 (inconsistency of units to be flagged). Item 8=1: paired Wilcoxon, α=0.05, justified by non-normality (p.4-5). Item 9=1: Tables 3-5 with individual values, mean, SD and %RSD (p.6-7). Item 11=1: 'Clinical Relevance' section (p.9). Item 12=1: 'Limitations of the study' section (age, two measurement methods, exclusion of advanced OA) (p.9). Item 13=1. Funding: Materialise chair (declared).
The effect of individual isometric muscle loading on the alignment of the base o	2016	1	1	1	1	1	1	1	1	0	1	1	1	1	12/13	92%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: explicit hypothesis and objective (p.1). Item 2=1: 10 hands (p.2). Item 3=1 (borderline item; resolved by consensus): mean 73 y (67-80), but 'four female and two male' sums to 6, not 10 ⁇ discrepancy to be queried. Item 4=1: fresh-frozen, thawed at room temperature, prior radiograph (p.2). Item 5=1: dissection preserving thenars/ligaments/retinacula, 2.4 mm Steinmann pins in IP and 3rd MC, jig, 1 N tone + loads proportional to PCSA (Table 1), 5 repetitions with reset (p.2-3). Item 7=1: Fastrak (Polhemus), 40 Hz, precision 0.15° and 0.08 mm (p.3). Item 8=1: repeated-measures ANOVA + Bonferroni (p.4). Item 9=0: only Fig. 5 and extreme values in text (OPP +1.15; FDI −2.1; APL −4.97; FDI +0.53 mm); no table of means±SD per muscle or p values despite the declared ANOVA. Item 11=1: neuromuscular re-education of the DIO, tenotomy of the accessory APL (p.4-5). Item 12=1: explicit paragraph (isometric, pronosupination uncontrolled, cadaver) (p.5). Item 13=1: recommendation to strengthen the DIO phrased as 'suggest/may'.
The role of the carpometacarpal ligaments of the thumb in stability and the deve	2017	1	1	1	1	1	1	0	1	1	0	1	0	0	9/13	69%	Moderate	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Published in Acta Orthop Belg 2017;83:449-457 (the abstract cites '2015, 83'). Item 1=1: four objectives listed (p.451). Item 2=1: 25 hands (p.451). Item 3=1 (borderline item; resolved by consensus): 14 F/11 M; mean 65 y (51-92) in the abstract vs 67 y (51-94) in methods. Item 4=1: fresh-frozen (p.451). Item 5=1 (borderline item; resolved by consensus): dissection according to Berger, caliper at maximum passive tension (Bettinger); but the dorsoradial displacement/translation 'measured in millimeters' does not describe how it was loaded or measured, and two different calipers are cited (0.01 and 0.05 mm; text taken from Bettinger 1999). Item 7=0: the main variable (metacarpal translation associated with rupture) has no instrument or precision; stability was 'assessed' in neutral/flexion/extension without defined force (p.451). Item 8=1 (borderline item; resolved by consensus): χ^2 and Student's t (SPSS 18); χ^2 applied to displacements in mm (Table III) is debatable. Item 9=1: Table II (dimensions mean±SD), Table III (ruptures, mean displacement without SD, p), OA stages, contact areas by position (p.453-4). Item 10=0: the Discussion states 'Our results also indicate that the DRL has a higher stiffness than AOL' (p.456) when no mechanical property was measured: sentence copied from D'Agostino 2014; orphan datum. Item 11=1: repair the DRL in reconstruction (p.456). Item 12=0: only 'the mean age of our specimens was relatively high' (p.456). Item 13=0: 'Our results support the hypothesis of pathologic joint instability as the cause of TM osteoarthritis' from cross-sectional associations (rupture-OA in the same specimen), unable to establish causal direction, plus the unmeasured stiffness conclusion.
Trapeziometacarpal Ligaments Biomechanical Study: Implications in Arthroscopy	2016	1	1	1	1	1	1	1	1	1	1	1	1	1	13/13	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: explicit objective and hypothesis (p.278). Item 2=1: 14 radiographed, 3 excluded ⁇ 11 (p.278). Item 3=1 (borderline item; resolved by consensus): mean 73 y (67-80), but '5 females and 2 males' sums to 7, not 11 ⁇ discrepancy to be queried. Item 4=1: fresh-frozen, thawed at room temperature, prior radiograph (p.278). Item 5=1: same setup as Mobargha 2015, PCSA loads (Table 1), pins, thumb at 30° abd/30° flex, random sectioning by groups (p.278-9). Wording inconsistencies to flag: '150 g (10 N)' and 'neutral abduction' in abstract vs 30°/30° in methods. Item 7=1: FasTrak 0.15°/0.08 mm, 40 Hz, 3 sensors (p.278-9). Item 8=1: one-way ANOVA + paired t, p<0.05 (p.279). Item 9=1 (borderline item; resolved by consensus): means±SD of the 3 groups on the X axis (0.150±0.072; 0.064±0.301; 0.523±0.0512; p=0.004); Y/Z axes only 'not significant' without figures (p.280). Item 10=1: cumulative sequential sectioning attributed to the last group cut, assumed without confounding (p.279). Item 11=1: detailed arthroscopic implications (p.281-2). Item 12=1: explicit limitations section (age, single position) (p.282). Item 13=1.
Three-dimensional dynamic motion analysis of the first carpometacarpal ligaments	2017	1	1	1	1	1	1	1	1	1	1	1	1	1	13/13	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'The purpose of this study was to analyze the dynamic motion of the first CMC ligaments on a 3-D surface model and to examine the changes in their lengths…' (p.2). Item 2=1: 6 limbs (3 pairs) (p.2). Item 3=1: 3 men, 62-69 y, mean 64.3 (p.2). Item 4=1: fresh-frozen (p.2). Item 5=1: half-pins in radius/ulna, 2 mm graphite rod with marker triad, 3 screws in trapezium, 50 g per tendon (Imaeda/Koff) and incremental load 0.5-6 lb per muscle, dissection and marking of insertions, 3 paths (r/c/u) per ligament (p.2-3). Item 7=1 (borderline item; resolved by consensus): MicroScribe-3DX + Spider software (UTMB); the digitizer precision is not stated. Item 8=1 (borderline item; resolved by consensus): unpaired t to compare positions within the same specimen (should be paired) and paired t between paths, SPSS 21, p<0.05 (p.3). Item 9=1: Tables 1-2 with mean (SD) and % change for 4 ligaments x 5 positions x 3 paths (p.4-5). Item 10=1: describes 'active motion' by tendon traction and then digitized 'passive motion'; confusing wording but the data derive from the method. Item 11=1: fracture-dislocation, repair/reconstruction (p.6). Item 12=1: explicit paragraph (small n, in vitro kinematics, age) (p.6). Item 13=1 (borderline item; resolved by consensus): 'the DRL is the primary stabilizer' is inferred from length changes in 6 specimens, phrased as 'suggests'.
Radiographic Analysis of Simulated First Dorsal Interosseous and Opponens Pollic	2018	1	1	1	1	1	1	1	1	1	1	1	1	1	13/13	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: explicit purpose and null hypothesis (p.41). Item 2=1: 11 hands from 8 donors; 7 complete series (4 lost due to OP rupture) (p.41-2). Item 3=1: 7/8 donors male, mean 68 y (45-87) (p.41). Item 4=1: fresh-frozen, thawed 24 h, screening radiographs (p.41). Item 5=1: loads per muscle for 25 N pinch (Table 1), Steinmann pins, pulleys, capsulotomy + 50 N dorsolateral, increments 25-100% of OP/DIO (p.41-2). Item 7=1: fluoroscopy, RS/AW ratio (Wolf 2011) in ImageJ normalized with standard objects, a single rater; Chatillon dynamometer (p.42). Item 8=1: ANOVA + post hoc contrasts, p<0.05 (p.42). Item 9=1: Table 2 with mean and SD of all loading conditions (p.43). Item 11=1: selective OP/DIO strengthening programs (p.43-4). Item 12=1: explicit paragraph (cadaveric tissue, 'worst-case' capsulotomy, small n) (p.43-4). Item 13=1: support for SSM presented as a starting point that 'needs further investigation'.
The Stabilising Effect of the Anterior Oblique Ligament to Prevent Directional S	2018	1	1	0	1	1	1	1	0	1	1	1	0	0	9/13	69%	Moderate	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'The aim of this study was to measure the direction of subluxation resisted by the AOL' + explicit prediction (p.105-6). Item 2=1: 6 radiographed, 3 included (p.106-7). Item 3=0: mean 81.3 y (SD 10.6), no sex (p.107). Item 4=1: fresh-frozen (p.106). Item 5=1: Zwick/Roell z005 + TestXpert, 5 mm/min up to 5 mm, 5 cycles (1st discarded), 3 planes defined by the nail and the APL, AOL sectioning preserving capsule (p.107-8). Item 7=1: commercial testing machine with capture software (p.107); no declared resolution. Item 8=0: Mann-Whitney with p<0.001 on n=3 specimens is only possible by treating the 4 repeated cycles as independent observations (pseudoreplication) (p.110). Item 9=1: Tables 1-3 with mean±SD per specimen and plane, pre/post (p.109). Item 11=1: support for AOL reconstruction with FCR (p.110). Item 12=0: no limitations paragraph; only comments on variation between specimens and 'a longitudinal study would be useful'. Item 13=0: 'The AOL can now be recommended as the major target for repair' with n=3 and inadequate statistics; it also declares 'Level of evidence: III' for a cadaveric study.

Study	Year	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Item 13	Total	%	Quality (threshold)	Basis of scoring	Justification
Influence of the trapeziometacarpal joint fusion on thumb muscles and thumb-tip	2019	1	1	1	1	1	1	1	1	1	1	1	1	0	12/13	92%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'to investigate how the TMC joint fixation changes the area of thumb-tip trajectory…' (p.9). Item 2=1: 6 left upper limbs (p.9). Item 3=1: 3 M/3 F, mean 88 y (82-95) (p.9). Item 4=1: fresh-frozen; exclusion radiographs; ethics committee 2013-213 (p.9). Item 5=1: markers on 5 bones, 2.4 mm threaded pins, servomotor at 2 mm/s for 4 extrinsics, weights 0-4.90 N on 4 intrinsics, 3 measurements (mean of last 2), arthrodesis with 2 K-wires 1.8 mm in slight opposition (p.10). Item 7=1 (borderline item; resolved by consensus): OptiTrack Flex 13 with bone reconstruction by CT; system precision is not stated. Item 8=1: paired t or Wilcoxon according to normality, α=0.05, power analysis (p.11). Item 9=1 (borderline item; resolved by consensus): changes in % with p and power (APL −54%; APB/FPB −70%; OP −85%; ADP −30%; area 32.8%), Figs. 5-6; no table of absolute values with SD. Item 11=1: arthrodesis and ADL (p.13). Item 12=1: five explicit limitations (p.13). Item 13=0 (borderline item; resolved by consensus): 'arthrodesis can be the first-line treatment' and 'tolerable for performing daily activities' exceed what a cadaveric trajectory study allows (tolerability rests on Hume 1990, not on own data).
Ligamentous constraint of the first carpometacarpal joint	2021	1	1	1	1	1	1	1	1	1	1	1	1	1	13/13	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: explicit objective and hypothesis (p.2). Item 2=1: 16 specimens (10 bilateral, 6 unilateral), a priori sample size n=14 (α=0.05, power 0.80) (p.2). Item 3=1: 8 M/8 F, 52.4±11.7 y (p.2). Item 4=1: fresh-frozen, thawed 24 h; CT without osteophytes; tissue committee (p.2). Item 5=1: dissection preserving capsule by a single surgeon, specific 3D-printed alignment molds from CT (ISB), Instron 8874, 5x5 ball table, linear actuator with PID in LabVIEW, 10 N compression, loads in 10 N increments in 4 directions, sectioning order AOL-UCL-IML-DRL (p.2-3). Item 7=1: 1 kN load cell (resolution 0.001 N), 25 kgf in-series cell, two 30 mm LVDTs (p.3). Item 8=1: normality of residuals, repeated-measures ANOVA (Huynh-Feldt) or Friedman, post hoc/Wilcoxon with Bonferroni (p<0.008) (p.3). Item 9=1: Table 1 with mean±SD of translation in 2 axes x 4 directions x 4 states; supplementary material (p.4). Item 11=1: hypermobility, IML/DRL reconstruction, capsulodesis (p.5). Item 12=1: explicit paragraph (fixed sectioning order, force control, AOL as a single structure, no muscles, orientation of the 2nd MC) (p.5). Item 13=1: conclusions confined to the sequence used.
Internal brace augmentation improves the biomechanical properties of trapeziomet	2024	1	1	1	1	1	1	1	1	1	1	1	1	1	13/13	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: explicit hypothesis (p.1). Item 2=1: 14 hands (7 matched pairs) (p.1). Item 3=1: 4 M/3 F, 61.9±7.4 y (p.1). Item 4=1: fresh-frozen, thawed overnight (p.2). Item 5=1: midcarpal disarticulation, K-wires in IP and trapezium-2nd MC, DRL sectioning of 10.5±0.5 mm, repair with FiberWire 3-0 + SwiveLock 3.5 mm (± LabralTape 1.5 mm), forces 2 N (ROM) and 2.5 N (translation) with 5 preload cycles, test to failure at 1 mm/s with clinical failure at 2 and 3 mm (p.2-3). Item 7=1 (borderline item; resolved by consensus): Microscribe 3DLX digitizer with registration holes, Instron; digitizer precision is not stated. Item 8=1: repeated-measures ANOVA + Bonferroni; paired t for matched pairs (p.3). Item 9=1: mean±SE of loads at 2/3 mm and maximum, failure modes per specimen, Figs. 4-6 (p.3-5). Item 11=1: early mobilization after repair (p.5). Item 12=1: five explicit limitations (p.5). Item 13=1: 'may improve clinical outcomes', confined to the immediate postoperative period. Funding and conflict of interest with Arthrex declared (p.5) — consider in the synthesis.
The multidirectional roles of the anterior oblique ligament and dorsoradial liga	2024	1	1	1	1	1	1	1	1	1	1	1	1	1	13/13	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: explicit objective and hypothesis (p.2391). Item 2=1: 16 right forearms (8 AOL / 8 DRL) (p.2391). Item 3=1: 7 M/9 F, 27-74 y according to methods; Table 1 includes a minimum of 20 y (internal discrepancy) (p.2393). Item 4=1: fresh-frozen; CT (p.2391). Item 5=1: resin mounting, sensor on trapezium with K-wires, fiducials, CT 0.391x0.391x0.625 mm, KUKA KR6 robot + simVITRO, neutral position defined by torques/forces, 3 protocols (24 rotational directions, IR/ER, 8 translational) at 1°/s or 1 mm/s up to 1 Nm/30 N, 3-cycle preconditioning, sectioning by a hand surgeon (p.2391-3). Item 7=1: Optotrak (precision 0.1 mm, resolution 0.01 mm), ATI 6-DOF load cell, coordinate systems by joint curvature (p.2391-2). Item 8=1: linear mixed models (GLIMMIX), contrasts, Holm correction, post hoc power (p.2393). Item 9=1: means and 95% CI per direction (Figs. 4-7), excluded directions quantified (1%, 8%, 7%) (p.2393-5). Item 11=1: LRTI vs dorsoradial capsulodesis, implant design (p.2397). Item 12=1: explicit limitations (power by sex, specimens with osteophytes/OA, AOL as a single structure) (p.2397). Item 13=1.
The trapeziometacarpal screw home torque mechanism as a clinical indicator of th	2024	1	1	1	1	1	1	1	1	1	1	1	1	1	13/13	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: five objectives listed (p.389). Item 2=1: 20 hands (a priori n 18) (p.389-91). Item 3=1: mean 79.2 y (70-89), 60% men; Table 4 with 10 donors (p.391-3). Item 4=1: fresh-frozen, sectioned at distal humerus, thawed (p.389). Item 5=1: PA, Robert and lateral radiographs in a custom frame, TROM with spring dynamometer at 5 N, transverse K-wire in the head of M1, adapter to torque screwdriver, torques 21 and 34 Nm derived from pilot, 3 repetitions in random order, dissection and ligament classification by two raters (p.389-91). Item 7=1: torque screwdriver ±0.5%, inclinometer ±0.2°, measurements in DICOM by a hand surgeon, ICC 0.86-0.99 (Table 1) (p.389-93). Item 8=1: ICC (2-way mixed), paired t, Pearson and Kendall tau-b (p.391). Item 9=1: Tables 1-5 (reliability, correlation matrices with mean±SD, demographics, reduction by grade) (p.392-3). Item 11=1: 'Implications to hand therapy' section (p.394). Item 12=1: 'Limitations' section (movement not restricted to the TMC, creep) (p.394). Item 13=1: negative conclusion consistent with the data ('did not support the SHTM as indicator').
Distribution of strength potential of the thumb muscles and their relationship t	2025	1	1	1	1	1	1	1	1	1	1	1	1	1	13/13	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: explicit purpose and hypothesis (p.2). Item 2=1: 19 hands from 10 cadavers (a priori n 18) (p.3-4). Item 3=1: mean 79.2±7.1 y, 60% men; Table 2 per donor (p.4). Item 4=1: fresh-frozen; PBS moistening (p.2-3). Item 5=1: systematic dissection of the 10 muscles, total and belly mass, 25 fascicle sites by 3 examiners and 10 pennation angles in ImageJ, PCSA formula (Martin/Olson), normalization to body mass; Eaton-Glickel grades, TMC index and 9-zone joint map (Dourthe/Xu) (p.2-4). Item 7=1: AND HX-400 scale (0.1 g), ImageJ, intra/inter ICC 0.81-1.0 (Table 1). Item 8=1 (borderline item; resolved by consensus): Spearman/Pearson with 95% CI, ICC; the 19 hands from 10 cadavers (bilateral) are treated as independent (p.4). Item 9=1: Tables 1-4 with all correlations and their significance (p.4-5). Item 11=1: support for strengthening recommendations in hand therapy, with caution (p.5). Item 12=1: 'Limitations' section (age, 6 eburnated joints, number of fibers, ex situ pennation) (p.5). Item 13=1: 'exploratory' study, cautious conclusions.
Association of ligament mechanical properties… (Gordon)	2026	1	1	1	1	1	1	0	1	1	1	1	1	1	12/13	92%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'This study aims to characterize the associative relationships among ligament mechanical properties, articular surface topography, and joint kinematics… across OA stages' (p.3). Item 2=1: 'Forty-six fresh-frozen female cadaver arms… (22 right/24 left)' (p.3); n per module in Figs. 5-7. Item 3=1: groups with mean age±SD; women only (p.3). Item 4=1: 'fresh-frozen… organ procurement service (2020-2023, IRB approved)' (p.3). Item 5=1*: immobilization, loading system, markers, axes, protocols (p.4-5); reproducible details referred to the Protocol Supplement. Item 6=1: 'no conflicts of interest'; NIH/NIGMS (p.1, 11). Item 7=0*: adequate instruments but no precision/error of the tracking or of manual marking; validation marker without figure (p.3-5). Item 8=1: GLM, type III ANOVA, Holm-Bonferroni, bootstrap PCA, K-means (p.5-6). Item 9=1*: differences with 95% CI and mean±SE figures; absolute means only in supplement. Item 10=1. Item 11=1: 'Cluster 2… may represent a critical window for early intervention' (p.8). Item 12=1: limitations paragraph (p.10). Item 13=1*: associative conclusion consistent; the abstract overinterprets DRL attenuation.

Study	Year	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Item 13	Total	%	Quality (threshold)	Basis of scoring	Justification
Proprioceptive role of the abductor pollicis longus… (Lamas)	2026	1	1	1	1	1	1	0	1	1	1	1	1	1	12/13	92%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'We hypothesized that variability of the APL tendon and proprioceptive innervation of its insertions are associated with structural degeneration' (p.1221). Item 2=1: 'Twenty fresh-frozen cadaver hands' (p.1221). Item 3=1: '13 female, mean age 68 years, range 53–95… 11 right, 9 left' (p.1224). Item 4=1: 'stored at −18 °C and used within one month' (p.1222). Item 5=1*: dissection with 3.5x loupe, 3 µm sections (p.1222-3); no operational criterion for 'fascicle'. Item 6=1: 'no funding… no competing interests' (p.1229). Item 7=0*: caliper 0.01 mm and blinded pathologist, but 'absence of validated inter- and intra-observer reliability data' (p.1228). Item 8=1: non-parametric, Spearman with 95% CI, effect size r (p.1223-4). Item 9=1*: Tables 1-2 complete; mechanoreceptor counts announced but not reported. Item 10=1*: the APL–osteophyte association of the objective is not reported. Item 11=1: 'preserving or enhancing proprioceptive input may represent a complementary target' (p.1228). Item 12=1: extensive limitations (p.1228-9). Item 13=1*: 'evidence was weak… interpreted with caution' (p.1229); title and discussion exceed what dichotomous S-100 allows.
Revisiting the critical pathology… volar beak ligament degeneration (Pellegrini)	2026	1	1	1	1	1	1	1	0	1	1	1	1	1	12/13	92%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'We sought to fill a knowledge gap regarding the association of dorsal or volar capsuloligamentous degeneration with cartilage wear' (p.4). Item 2=1: '80 thumbs from 40 embalmed human anatomical donors… Of the 71 joints analyzed' (p.4, 6). Item 3=1: '20 men, 20 women; average age 83… 24 men, 16 women; average age 90' (p.4). Item 4=1*: 'embalmed… harvested en bloc' (p.4); no embalming method. Item 5=1: capsulotomies, staining, photography and ImageJ described (p.4). Item 6=1*: 'No benefits in any form have been received' (p.11); no funding source. Item 7=1*: 'free-marginal kappa… (κ 0.88; 95% CI 0.84–0.91)' (p.6) for eburnation; qualitative ligament integrity by consensus without reliability. Item 8=0*: 'A one-sided t test assessed differences between eburnation ratios' (p.6); single test, no ligament–stage analysis or pairing. Item 9=1*: Tables 1–3 with n and %; ratios without SD/CI. Item 10=1. Item 11=1: 'should inform surgical treatment' (p.3, 10-11). Item 12=1: 'Observational data… can only provide associations… embalmed nature… distortion' (p.10). Item 13=1*: association well supported; 'most plausible physiologic event inciting…' (p.11) exceeds the cross-sectional design.
The central dorsal component of the DRL… (Margüenda-Fernández) — cadaveric component	2025	1	1	0	1	1	1	0	1	1	1	1	1	0	10/13	77%	High (borderline)	Full-text reading (AI-assisted pre-scoring) – verified and validated by the second reviewer (article by the first author of the review)	Item 1=1: objectives (1) identify the DRL and its three fascicles, (2) landmarks, (3) ultrasound protocol (p.2). Item 2=1: 'five cadaveric specimens' (Abstract; 2.2). Item 3=0*: no donor age/sex (2.2). Item 4=1*: 'embalmed… embalming mixture… femoral artery' (fragments 2.2). Item 5=1*: planes and maneuvers (2.2; Figs. 1–3; Discussion). Item 6=1: 'No funds, grants, or other support was received' (p.7). Item 7=0: qualitative identification without instrument; 'intra- and interobserver reliability… a limitation' (p.6-7). Item 8=1*: statistics adequate for the in vivo phase (2.3.5); none for the cadaver (0 if only the cadaver is scored). Item 9=1*: Table 1 mean ± SD by side and sex; cadaver only qualitative (0 if only cadaver). Item 10=1. Item 11=1: 'potential applications in assessing OA progression' (p.6-7). Item 12=1: limitations paragraph (fragments). Item 13=0*: 'The DRL can be reliably and accurately assessed… identifying ligamentous insufficiency' without reliability or patients. Strict cadaver-only reading: 8/13 (moderate).
Biomechanical comparison of monofascicular and bifascicular reconstruction… (Domínguez Font)	2026	1	1	1	1	1	1	0	0	1	1	1	1	0	10/13	77%	High (borderline)	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'our objective was to analyze and compare the stabilizing effect of 2 different DRL reconstructions' (p.2). Item 2=1: 'Ten fresh-frozen human cadaveric upper extremities' (p.2). Item 3=1: '8 male and 2 females, 5 right and 5 left hands… mean age of 82.1 years (range 72-100)' (p.2). Item 4=1: 'fresh-frozen… thawed at room temperature' (p.2). Item 5=1*: mounting, pins, 30° pulley and 0.5 kg load described (p.4); how the bifascicular reconstruction was converted to the monofascicular is not described. Item 6=1: 'no potential conflicts of interest… no financial support' (p.7). Item 7=0*: Fastrak without declared precision or reliability (p.4). Item 8=0*: Student's t or Mann-Whitney U for repeated comparisons in the same specimens, without adjustment for multiple comparisons (p.5). Item 9=1: Table 1 with individual data, means, SD and p (p.5). Item 10=1. Item 11=1: implications for surgical technique (p.6-7). Item 12=1: limitations section (p.7). Item 13=0*: 'restores the original stability' from a non-significant difference with n=10, and 'not necessary to reconstruct the ulnar ligament' without specific test (p.7).
The effect of the joint capsule and anterior oblique ligament… (Norton)	2020	1	1	1	1	1	1	1	1	1	1	0	1	1	12/13	92%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=1: 'This study had two objectives' (p.2). Item 2=1: 11 frozen forearms (p.2). Item 3=1: 10 men and 1 woman; mean age 72 years (54–88) (p.2). Item 4=1: frozen; storage of at least six months declared (p.4). Item 5=1: fixation with Kirschner wires, positions, loads per tendon (0.8–13.4 N) and sequence of conditions (p.2). Item 6=1: simulated lateral pinch with sequential sectioning allows comparison of the effect of the capsule and the AOL. Item 7=1: AP radiograph with C-arm, definition of the subluxation percentage (Fig. 4) and error estimated with ten repeated measurements (SD 2%) (p.3). Item 8=1: repeated-measures ANOVA, $p < 0.05$ (p.3). Item 9=1: mean ± SD and range per condition and values per specimen (Fig. 5) (p.3). Item 10=1. Item 11=0: the discussion deals with the validity of opening the capsule in the experiments and does not develop clinical implications. Item 12=1: explicit limitations paragraph (p.4). Item 13=1 (borderline item): concludes that the AOL 'may not play a large role' in lateral pinch, with the caution that all specimens had osteoarthritis.

Table S3. JBI-PEDro

Study	First author	Year	Manu-script ref.	Design	Tool	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Yes / appli-cable	%	Quality (threshold)	Basis of scoring	Justification (evidence per item)
Coupling between mechan-ical and neural behaviour in the human first dorsal interosseous muscle	Hudson	2009	[33]	Physiological experi-mental study in healthy volunteers (n=15)	JBI analytical cross-sectional	N*	Y	Y	NA	Y	Y	Y	Y	—	—	—	6/7	86%	High	Full-text reading (AI) – verified and validated by both reviewers	Item 1=0 (borderline item; resolved by consensus): only '15 healthy adult volunteers', without explicit inclusion/exclusion criteria. Item 2=1: 32±10 years, 7 women, right arm, laboratory. Item 3=1: defined postures, thumb fixed with tape, 7.5° increments, random order. Item 4=NA (healthy). Items 5-6=1: they identify extensor co-contraction, positional EMG artifact and lumbrical; radial nerve block in 5/15, paired extensor EMG, normalization to Mmax. Item 7=1: load cell, EMG normalized to Mmax, ultrasound calipers (ultrasound in only 6 subjects). Item 8=1: 2-way RM ANOVA + Tukey, paired t. No sample size calculation.
Digit mechanics in relation to endpoint compliance during precision pinch	Nataraj	2015	[75]	Experimental study in healthy volunteers (n=13)	JBI analytical cross-sectional	Y	Y	Y	NA	Y	Y	Y	Y*	—	—	—	7/7	100%	High	Full-text reading (AI) – verified and validated by both reviewers	Item 1=1: healthy right-handed men, no hand pathology, normal vision. Item 2=1: 13 men 31.2±6.3 years, pinch aperture 18.0±1.0 cm; Cleveland Clinic. Item 3=1: compliance by elastic bands verified (R^2>0.99; ±3% of predicted value). Item 4=NA. Items 5-6=1: homogeneous sex, force rate controlled with visual feedback, randomized blocks, only 25-75% of the ramp. Item 7=1: Vicon 100 Hz, 6-DOF load cells, joint centers by validated protocol (Nataraj & Li 2013), SIMM inverse dynamics. Item 8=1 (border-line item; resolved by consensus): Pearson, K-S, t-tests without correction for multiple comparisons. Indirect TMC relevance (CMC moments).
In Vivo Length and Changes of Ligaments Stabilizing the Thumb Carpometacarpal Joint	Tan	2011	[70]	Observational study in healthy volunteers with CT (n=6)	JBI analytical cross-sectional	Y	Y	N*	NA	Y	Y	N	Y*	—	—	—	5/7	71%	High	Full-text reading (AI) – verified and validated by both reviewers	Item 1=1: healthy, no systemic disease or symptoms, no wrist trauma, normal prior radiograph. Item 2=1: 6 (3M/3F), 20-32 years, right wrist; Nantong. Item 3=0 (borderline item; resolved by consensus): 'maximal' positions actively maintained in a non-metallic frame, without quantifying the joint angle reached. Item 4=NA. Items 5-6=1: they discuss incremen-tal movement, hysteresis, insertions taken from the literature; verification with dissection of 2 hands and CT of 2 cadaveric hands. Item 7=0: the authors acknowledge that 'accurate and precise measurement of the length of such short ligaments is not possible' (2-3 mm discrepancy in ligaments of ~1 cm), without reliability. Item 8=1 (borderline item; resolved by consensus): RM ANOVA + post hoc paired t with n=6, without correction. Borderline score (71%).
In vivo recruitment patterns in the anterior oblique and dorsoradial ligaments of the first carpometacarpal joint	Halilaj	2015	[25]	In vivo cross-sectional observational study with CT (n=44)	JBI analytical cross-sectional	N*	Y	Y	NA	Y	Y	Y*	Y	—	—	—	6/7	86%	High	Full-text reading (AI) – verified and validated by both reviewers	Item 1=0 (borderline item; resolved by consensus): '44 healthy subjects' from a larger study; inclusion/exclusion criteria referred to Halilaj 2014, not stated here. Item 2=1: 4 age/sex groups with means and SD, domi-nant hand; Brown. Item 3=1: CT 0.625 mm, markerless registration (Marai 2006), CMC coordinate system, loading at 80% max. with load cell. Item 4=NA. Items 5-6=1: sex and age analyzed (2-way ANOVA), 3 fibers per ligament, bone penetration constraint. Item 7=1 (borderline item; resolved by consensus): insertions manually selected by a student under surgeon supervision, without inter-observer reliability; true resting length not measurable (acknowledged). Item 8=1: RM ANOVA, Holm-Sidak, multiple regression.
Kinematics of Trapeziometa-carpal Joint During First Dor-sal Interosseous Maneuver in Osteoarthritic Patients	Ooishi	2025	[72]	Comparative observa-tional study (10 patients with thumb base osteo-arthritis vs 10 thumbs of 5 healthy individuals)	JBI analytical cross-sectional	Y	Y	Y	Y	N	N	Y	N*	—	—	—	5/8	63%	Moderate	Full-text reading (AI) – verified and validated by both reviewers	Item 1=1: Eaton II-IV female patients; controls without history. Item 2=1: 10 women 64 years (52-83), controls 5 women 49.4 years (40-57); Kochi. Items 3-4=1: radiographic Eaton stage. Item 5=0: the age differ-ence between groups (64 vs 49 years) and the non-independence of 2 thumbs per control are not identified; only the 'women only' limitation is discussed. Item 6=0: no adjustment for age; only randomized image order. Item 7=1: real-time MRI with 2 blinded raters, ICC 0.81-0.88 / 0.69-0.83; the ultrasound classification is qualitative without reliability. Item 8=0 (borderline item; resolved by consensus): sample size calculation; but 95% CIs in Table 2 are inconsistent with the differences (e.g., 1.69 [0.39-0.83]) and paired pre-post analyzed with Mann-Whitney instead of Wilcoxon.
Ligamento-Muscular Reflex Patterns Following Stimula-tion of a Thumb Carpometa-carpal Ligament	Mobargha	2019	[34]	Invasive EMG experi-mental study in healthy volunteers (n=10)	JBI analytical cross-sectional	Y	Y	Y	NA	Y	Y	Y	N*	—	—	—	6/7	86%	High	Full-text reading (AI) – verified and validated by both reviewers	Item 1=1: healthy convenience sample, no trauma, normal CMC1 stability examination. Item 2=1: 10 (5F/5M), 28 years (24-37); Karolinska. Item 3=1: fine-wire electrode in the DRL guided by ultrasound, stimulus 2× sensory threshold and below pain threshold (note: the abstract says '200 MHz', erratum for 200 Hz). Item 4=NA. Items 5-6=1: pain afferents, cross-talk, only 4 muscles, no imaging; subnociceptive stimulus, needle elec-trodes, negative control at rest. Item 7=1: 4-channel needle EMG, RMS, force at 25% max. with dynamometer; no reliability. Item 8=0 (borderline item; resolved by consensus): Student's t in 20 ms intervals × 4 muscles × 3 positions without multiplicity correction; criterion 'significant in most subjects' not defined.

Study	First author	Year	Manu-script ref.	Design	Tool	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Yes / appli-cable	%	Quality (threshold)	Basis of scoring	Justification (evidence per item)
Osteoarthritis of the car-pometacarpal joint of the thumb: a new MR imaging technique for the standard-ized detection of relevant ligamental lesions	Dumont	2014	[13]	Prospective comparative study (28 joints of 22 patients vs 20 of 14 volunteers)	JBI analytical cross-sectional	Y	Y	Y	Y	Y*	N	Y*	N*	—	—	—	6/8	75%	High	Full-text reading (AI) – verified and validated by both reviewers	Item 1=1: explicit definitions and exclusions for both groups. Item 2=1: volunteers 8F/6M 43 years, patients 20F/2M 53 years, Eaton I-III, NRS, DASH; Göttingen 2011-12. Items 3-4=1: symptomatic + radiographs clas-sified by Eaton-Littler by consensus. Item 5=1 (borderline item; resolved by consensus): the authors acknowledge 'not adjusted according to sex or age' despite age and sex differences between groups. Item 6=0: no strategy. Item 7=1 (borderline item; resolved by consensus): 3T MRI 0.5×0.5×0.4 mm in standardized planes, defined rupture criteria; reading by consensus of 2 experts without ICC or declared blinding. Item 8=0 (borderline item; resolved by consensus): Mann-Whitney but the table uses t-test; medians with SD; unit of analysis = joint with 12 bilateral; the text inverts the dorsal translation values (6.4 vs 5.4 mm) with respect to the abstract. Borderline score (75%).
Subject-specific thumb mus-cle activity during functional tasks of daily life	Kerkhof	2016	[73]	Fine-wire EMG experi-mental study in healthy women (n=10)	JBI analytical cross-sectional	Y	Y	Y	NA	Y	Y	Y*	N*	—	—	—	6/7	86%	High	Full-text reading (AI) – verified and validated by both reviewers	Item 1=1: healthy young women; exclusion of musculoskeletal, trauma, surgical or neurological pathology. Item 2=1: 11 women 22.9±4.75 years (1 excluded for incomplete data), dominant hand; KU Leuven. Item 3=1: polycarbonate jig with load cell (Brown protocol), 80% max. with visual feedback. Item 4=NA. Items 5-6=1: effect of electrode insertion checked pre/post, women only, effort at 80% acknowledged as masking; ultrasound-guided insertion by a female surgeon. Item 7=1 (borderline item; resolved by consensus): Trigno fine wire 4000 Hz, RMS; opponens excluded because of placement uncertainty; scaled to the peak between tasks (not MVC). Item 8=0 (borderline item; resolved by consensus): Mann-Whitney with pooled muscles (n1=30, n2=40) treats repeated measures of 10 subjects as independent (pseudoreplication); 't=7.133, df=1' inconsistent.
Phasic relationships of the intrinsic and extrinsic thumb musculature	Johanson	1996	[74]	Dynamic fine-wire EMG in healthy volunteers (n=5)	JBI analytical cross-sectional	N*	Y	Y	NA	Y	Y*	N	N	—	—	—	4/7	57%	Moderate	Full-text reading (AI) – verified and validated by both reviewers	Item 1=0 (borderline item; resolved by consensus): 'normal adult volunteers' right-handed with normal neurological and hand function; no explicit criteria. Item 2=1: 5 (3M/2F), 33-52 years, occupations; Shriners San Francisco. Item 3=1: tasks and proximal positions defined and super-vised, force at 50% max. with pinch gauge, phases by electrogoniometer. Item 4=NA. Item 5=1: substitution by gravity, confounding with flexed wrist, adults vs children. Item 6=1 (borderline item; resolved by consen-sus): placement verified by stimulation, video; no other strategies. Item 7=0: phasic/continuous/silent classification by visual inspection by 2 investigators without reliability; goniometer axis estimated on a skeleton. Item 8=0: only counts and percentages, no inferential analysis.
Effects of a dynamic stability approach in conservative in-tervention of the carpometa-carpal joint of the thumb: A retrospective study	O'Brien	2013	[43]	Retrospective sin-gle-group pre-post series (35 records; the authors call it a 'retrospective cohort')	JBI quasi-experi-mental	Y	NA	NA	N	N	N	Y	Y*	Y*	—	—	4/7	57%	Moderate	Full-text reading (AI) – verified and validated by both reviewers	Item 1=1: the intervention precedes the outcome. Items 2-3=NA: single group without comparison. Item 4=0: no control group. Item 5=0: only initial and 'last' QuickDASH (2 measurements). Item 6=0: from 455 re-cords to 35 by coding criteria and availability of ≥2 QuickDASH; losses not described; variable interval 17-195 days. Item 7=1: QuickDASH in all. Item 8=1 (borderline item; resolved by consensus): validated QuickDASH, but pain is item 9 (Likert 1-5) and the timing of the 2nd measurement is not standardized. Item 9=1 (borderline item; resolved by consensus): paired t and regression; t on a Likert item. In addition: heterogeneous intervention (7 clinics, 16+6 therapists, uncontrolled orthoses and education), adher-ence not monitored (acknowledged).
Trapeziometacarpal Stabili-zation Through Dorsoradial Ligament Reconstruction: An Early Post-Surgery In vivo Biomechanical Analyses	Kerkhof	2018	[71]	Surgical pre-post case series (n=4) with matched healthy controls	JBI case series	N*	N	N*	N	N	Y	N*	Y	Y	N*	—	3/10	30%	Low	Full-text reading (AI) – verified and validated by both reviewers	Item 1=0 (borderline item; resolved by consensus): 'pain and clinically established laxity' without operational definition; the authors them-selves note the lack of a definition of TMC instability. Item 2=0: laxity by non-standardized clinical examination. Item 3=0 (borderline item; resolved by consensus): radiographs to exclude osteoarthritis (valid) but instability is not quantified. Item 4=0: consecutive inclusion not stated. Item 5=0: 5 recruited, 1 lost; not stated whether all eligible were included. Item 6=1: Table 1 with age, sex, months post-op, matched control. Item 7=0 (borderline item; resolved by consensus): preoperative pain and func-tion not quantified; clinical outcome only as 'satisfied, less pain, return to work'. Item 8=1: kinematics and proximity areas per patient, Tables 3-7. Item 9=1: KU Leuven/AZ Groeninge, one surgeon >15 years. Item 10=0 (borderline item; resolved by consensus): 2-way RM ANOVA with n=4; the authors acknowledge 'power constraints'. If the 4 borderline items are accepted: 7/10 (high).
Dynamic stabilization home exercise program for treatment of thumb carpo-metacarpal osteoarthritis: A prospective randomized control trial	McVeigh	2022	[41]	Multicenter RCT (84 ran-domized; 67 analyzed)	PEDro	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	6/10	60%	Moderate	Full-text reading (AI) – verified and validated by both reviewers	Item 1 (not scored)=1: explicit inclusion/exclusion criteria. Item 2=1: com-puter randomization by minimization (Pocock-Simon) stratified by center. Item 3=1: 'Allocation to treatment was concealed'. Item 4=1: no baseline differences (P ≥ .21, Table 1). Items 5-7=0: no blinding of patients, ther-apists or assessors (acknowledged: 'therapists were not blinded'). Item 8=0: 67/84 (80%) with outcome; 17 excluded as untraceable, with lower baseline pain. Item 9=1: analysis declared as intention to treat. Items 10-11=1: Wilcoxon between groups of the change; mean differences with 95% CI. Did not reach the planned sample size (120). Matches the 6/10 score of the PEDro database. Intention to treat is as declared by the source; it excluded 17 without follow-up and is not equivalent to recover-ing their outcomes. Losses are considered in GRADE.

Study	First author	Year	Manuscript ref.	Design	Tool	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Yes / applicable	%	Quality (threshold)	Basis of scoring	Justification (evidence per item)
Pilot randomized controlled trial comparing specific dynamic stability exercises with general exercises for thumb carpometacarpal joint osteoarthritis	Davenport	2012	[44]	Pilot RCT (n=39; 22 complete at 6 months)	PEDro	Y	Y	Y	Y*	Y	N	Y	N	N	Y	Y	7/10	70%	Moderate	Full-text reading (AI) – verified and validated by both reviewers	Item 1 (not scored)=1: explicit eligibility. Item 2=1: sealed envelopes 1:1. Item 3=1: sequence generated and assigned by an assistant unrelated to treatment and assessment. Item 4=1 (borderline item; resolved by consensus): groups comparable in age, sex, grade, DASH; but pinch and APL moment significantly greater in the general group. Item 5=1: participants blinded to allocation. Item 6=0: therapist not blinded (acknowledged). Item 7=1: assessor blinded until the end. Item 8=0: 22/39 (56%) complete at 6 months: 16 losses (41%) and 1 later exclusion; 17/39 (44%) without final data. Item 9=0: analysis only with complete data. Item 10=1: between-group comparison (independent t, GLM). Item 11=1: means (SD) and medians (IQR).
First dorsal interosseous muscle contraction results in radiographic reduction of healthy thumb carpometacarpal joint	McGee	2015	[39]	In vivo repeated-measures experiment in one group; conditions in random order; secondary cross-sectional component. The authors label it a case series in the abstract.	JBI quasi-experimental	Y	NA	NA	N	N	Y	Y	Y	N	—	—	4/7	57%	Moderate	Full-text reading (AI) – verified and validated by both reviewers	JBI quasi-experimental: item 1 Y, the contraction condition precedes the image (pp. 2–3); 2 and 3 NA, single group, following the criterion applied to O'Brien; 4 N, no parallel group; 5 N, one image per condition, not multiple pre/post time measurements (three readers are not three follow-ups); 6 Y, justified exclusion of two thumbs for OA and complete immediate analysis of the 32 eligible (p. 6); 7 Y, same radiographic protocol in both conditions; 8 Y, three blinded readers and ICC 0.70–0.82 (Table 2); 9 N, combined analysis of 32 thumbs from 17 individuals without bilateral adjustment, although comparisons by side are also presented (Table 3). Total 4/7 = 57.1%, moderate quality by operational threshold. The article calculates a minimum n of 12 individuals. Additional limitations: manual load not quantified and co-activation not ruled out (pp. 7–9).
Thumb rotation patterns during pinch in patients with TMC OA	Tsukamoto	2026	[60]	In vivo cross-sectional, OA (36 hands) vs control (19 hands), inertial sensor	JBI analytical cross-sectional	Y	Y	Y	Y*	Y*	N*	Y*	Y*	—	—	—	7/8	88%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=Y: diagnosis by hand surgeons with pain, examination and radiograph + exclusion criteria (p.329). Item 2=Y: 27 consecutive patients, center and dates; Table 1. Item 3=Y: Eaton-Littler and KL; controls with negative radiograph. Item 4=Y*: standard criteria; no inter-observer reliability. Item 5=Y*: age, sex, dominance compared; structural stiffness acknowledged as an alternative; not pain/strength/bilaterality. Item 6=N*: no adjustment; bilateral hands (36/27; 19/11) and repeated pinches treated as independent; sex imbalance not handled. Item 7=Y*: MicroStone gyroscope, Kuroiwa 2018 method, standardized protocol; no test-retest in this article. Item 8=Y*: Shapiro-Wilk, Mann-Whitney, Spearman, Fisher, a priori sample size calculation; does not consider intra-subject dependence.
Thumb CMC OA and fatty infiltration of the opponens pollicis	El Hor	2026	[62]	Retrospective cross-sectional imaging study (747 MRIs; 307 OA vs 440 without OA)	JBI analytical cross-sectional	Y	Y*	Y*	Y	Y	Y*	N	Y	—	—	—	7/8	88%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=Y: 'Consecutive MRI scan of the wrist… November 2022 to July 2023… exclusion criteria' (p.2). Item 2=Y*: Table 1; indications not broken down; race collected but not reported. Item 3=Y*: 'at least three different radiographic views… within 6 months… Eaton–Littler' (p.2); 10 staged by MRI; reliability of EL questioned by the authors (p.5). Item 4=Y: Eaton-Littler. Item 5=Y: 'age, sex, race, BMI, past medical history of steroid injection… radiographic OA severity were collected' (p.2). Item 6=Y*: multivariable model (age, sex, BMI, stage, infiltration); BMI missing 16% without described handling. Item 7=N: 'assessed… by one of us (HEH)… scored in a binary fashion' (p.2); 'absence of the quantification of the OPP FI' (p.5); no blinding or reliability. Item 8=Y: binomial CIs, t/χ^2, logistic regression (p.2); note error in Table 2 and p/CI inconsistency for age.
Shear wave elastography of thenar muscles in TMC OA	Karademir	2026	[63]	In vivo cross-sectional, OA (18 women/29 thumbs) vs control (13/26), SWE	JBI analytical cross-sectional	Y	Y	Y*	Y*	Y*	Y	Y	Y	—	—	—	8/8	100%	High	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=Y: clinical diagnosis + provocative tests + PA radiograph; explicit exclusions (p.2). Item 2=Y: hand surgery clinic, March 2023–March 2024; Table 1; Eaton distribution (p.2, 5). Item 3=Y*: OA confirmed with radiographs in cases; 'Radiographic imaging was not performed in the control group' (p.2). Item 4=Y*: 'disease stage… Eaton–Littler' (p.2); controls only clinical criterion. Item 5=Y*: age, sex, dominance, prior physical activity; not BMI/occupation/stage in the model. Item 6=Y: 'Group…, hand dominance…, and their interaction… fixed effects. A random intercept… for each subject' + Bonferroni (p.5). Item 7=Y: single radiologist 'blinded to the group allocation' (p.3); 3 measurements; pilot ICC 0.81–0.89 (p.4) in a different sample. Item 8=Y: REML linear mixed model for thumbs from the same subject (p.5); post hoc power.
Association of clinical assessments of hand function and quantitative ultrasound metrics in first CMC OA	Nwawka	2020	[65]	In vivo cross-sectional, OA (5 patients/9 thumbs) vs control (9/9), SWE	JBI analytical cross-sectional	N*	N*	Y*	Y*	Y	N	N	Y*	—	—	—	4/8	50%	Moderate	Full-text reading (AI-assisted pre-scoring) – verified and validated by both reviewers	Item 1=N*: patients ≥18 years with CMC osteoarthritis 'as determined by clinical and/or radiological measures'; prior surgery excluded; controls 'non-patient volunteers' without explicit criteria. Item 2=N*: tertiary hospital, March 2016–July 2018; mean age and range by group; no sex, dominance or other characteristics. Item 3=Y*: modified Eaton-Littler grade on standard radiographs in patients; 'control subjects did not undergo radiography'. Item 4=Y*: Eaton-Littler (2/2/2/3 thumbs per grade); controls only asymptomatic. Item 5=Y: age, sex and dominance identified ('not age matched; the control group had a younger mean age'). Item 6=N: 'the small sample size limited adjusting for any confounders such as age, sex'. Item 7=N: SWE by a single radiologist, mean of 3 measurements; no blinding or reliability. Item 8=Y*: linear mixed-effects model and Spearman's rho with subject-clustered bootstrap CIs; group means and p values not reported in the text.

Y = yes; N = no; NA = not applicable, excluded from the denominator; * = borderline decision from the previous matrix; — = item does not exist. High/moderate/low quality: JBI ≥70%/50–69%/<50%; PEDro 8–10/6–7/≤5. The categories are not validated risk of bias. Item-level detail and validation status are documented in this table.

Table S4. Exclusions after full-text assessment: initial search (nos. 1–15) and update (nos. 16–32)

No.	Study (title)	Reference	Design	Reason for exclusion (PICOS criteria)
1	An Exercise Program for Carpometacarpal Osteoarthritis Based on Biomechanical Principles	Valdes K, von der Heyde R. An Exercise Program for Carpometacarpal Osteoarthritis Based on Biomechanical Principles. J Hand Ther. 2012;25(3):251–263.	Narrative review of biomechanical and anatomical studies (Level of evidence: 4)	Narrative review (level 4)
2	Dynamic stabilization of the painful thumb: A historical and evidence-informed synthesis	O'Brien VH, Johnson J, Pisano K, Enke A. Dynamic stabilization of the painful thumb: A historical and evidence-informed synthesis. J Hand Ther. 2022;35(3):388-399. doi: 10.1016/j.jht.2022.06.007	Expert opinion with narrative literature review	Expert opinion / narrative review
3	Effect of first dorsal interosseous strengthening on clinical outcomes in patients with thumb osteoarthritis: a study protocol for a randomized controlled clinical trial	Tossini NB, Pereira ND, de Oliveira GS, Serrão PRMS. Trials. 2022;23:191. Study protocol.	Randomized, controlled, double-blind (assessor and patient), parallel clinical trial; study protocol.	Study protocol without results
4	Functional Ligamentous Anatomy of the Trapezium and Trapeziometacarpal Joint (Gross and Arthroscopic)	Bettinger PC, Berger RA. HAND CLINICS, VOLUME 17, NUMBER 2, MAY 2001: 151-168.	Descriptive anatomy (anatomical study, review and correlation with arthroscopy)	Descriptive anatomical review (Hand Clinics), without quantitative primary data
5	Phasic relationships of the extrinsic muscles of the normal hand	Johanson ME, Skinner SR, Lamoreux LW, St. Helen R, Moran SA, Ashley RK. Phasic relationships of the extrinsic muscles of the normal hand. J Hand Surg Am. 1990;15A: 587-594.	Cross-sectional observational study (electromyographic assessment in healthy volunteers)	Does not assess thumb/TMC musculature (note by the extractor)
6	Response to "Letter to the editor: First dorsal interosseous muscle contraction results in radiographic reduction of healthy thumb carpometacarpal joint"	McGee C, O'Brien V, Van Nortwick S, Adams J, Van Heest A. Response to "Letter to the editor: First dorsal interosseous muscle contraction results in radiographic reduction of healthy thumb carpometacarpal joint". J Hand Ther. 2016;29(1):e3-e4. doi: 10.1016/j.jht.2015.11.002	Reply letter to editor; refers to a previous cross-sectional study with healthy controls	Letter to the editor
7	Rhizarthrosis Part II: A New Approach of Manual Therapy and Therapeutic Exercise	Colonna S, Borghi C. Rhizarthrosis Part II: A New Approach of Manual Therapy and Therapeutic Exercise. Cureus. 2024;16(1):e52999.	Technical report / Proposal of a therapeutic protocol (not an experimental or observational study)	Protocol proposal / technical report without primary data
8	The Carpometacarpal Joint of the Thumb: Stability, Deformity, and Therapeutic Intervention	Neumann DA, Bielefeld T. The Carpometacarpal Joint of the Thumb: Stability, Deformity, and Therapeutic Intervention. Journal of Orthopaedic & Sports Physical Therapy. 2003;33(7):386-399.	Clinical commentary / narrative review	Narrative review / clinical commentary (JOSPT)
9	The Puzzle of the Thumb: Mobility, Stability, and Demands in Opposition	Ladd AL, Crisco JJ, Hagert E, Rose J, Weiss AC. The 2014 ABJS Nicolas Andry Award: The puzzle of the thumb: mobility, stability, and demands in opposition. Clin Orthop Relat Res. 2014;472(12):3605-3622. doi: 10.1007/s11999-014-3901-6	Narrative review based on own studies and previous literature; comparative anatomical, biomechanical and multimodal study	Narrative review (CORR)
10	The Thumb Carpometacarpal Joint: Anatomy, Hormones, and Biomechanics	Ladd AL, Weiss AC, Crisco JJ, Hagert E, Wolf JM, Glickel SZ, Yao J. The thumb carpometacarpal joint: anatomy, hormones, and biomechanics. Instr Course Lect. 2013;62:165-179.	Narrative review with original anatomical and biomechanical studies, literature analysis and surgical case series	Narrative review (Instr Course Lect)
11	Therapy management of thumb carpometacarpal osteoarthritis: Exploring UK therapists' perceptions of joint instability	Jansen V, Hendrick P, Ellis J. Therapy management of thumb carpometacarpal osteoarthritis: Exploring UK therapists' perceptions of joint instability. Hand Ther. 2017;22(3):118–128. doi: 10.1177/1758998317698099.	Qualitative study, individual semi-structured interviews	Qualitative study without quantitative stability outcomes

No.	Study (title)	Reference	Design	Reason for exclusion (PICOS criteria)
12	Trapeziometacarpal Joint Stability: The Evolving Importance of the Dorsal Ligaments	Lin JD, Karl JW, Strauch RJ. Trapeziometacarpal joint stability: The evolving importance of the dorsal ligaments. Clin Orthop Relat Res. 2014;472(4):1138–1145. doi: 10.1007/s11999-013-2879-9.	Literature review	Review (secondary, no primary data)
13	[illegible] / BIOMECHANICAL EVALUATION OF STABILITY OF THE VOLAR CAPSULAR LIGAMENT COMPLEX	Wang R, Huang F, Cen S, Xiang Z. [Biomechanical evaluation of stability of the volar capsular ligament complex]. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2008;22(6):684–687. PMID: 18630563.	Experimental biomechanical study in cadavers	Wrist joint, not TMC (outside PICOS population)
14	The biomechanical interaction between ligaments and joint shape in the thumb	Rusli WMR. The biomechanical interaction between ligaments and joint shape in the thumb [doctoral thesis]. London: Imperial College London; 2019.	Doctoral thesis	Non-indexed doctoral thesis; its primary data were published in Rusli et al. (J Biomech. 2021), included in the review
15	Biomechanics of the trapeziometacarpal joint	Zancolli EA, Ziadenberg C, Zancolli E Jr. Biomechanics of the trapeziometacarpal joint. Clin Orthop Relat Res. 1987;(220):14-26.	Classic anatomical-functional description	Descriptive anatomical review without verifiable primary data (no methods section or number of specimens; investigations are referred to a previous work by the authors). Exclusion agreed by consensus after full reading during the quality assessment.
Search update (21 September 2026): exclusions after full-text assessment				
16	Variations in the Minimum Joint Distance During Flexion and Abduction of the Thumb CMC Joint (Matsuta 2025)	Matsuta M, et al. Cureus. 2025;17(11):e98044. doi: 10.7759/cureus.98044	In vivo cross-sectional pilot (static CT, 5 men, 8 positions)	No outcome on stabilizers or TMC stability (only minimum joint distance and contact location; does not measure, section or load any ligament or muscle, and does not record translation, subluxation or laxity)
17	Thumb Carpometacarpal Instability: An International Survey on Terminology, Diagnostic Workup, and Treatment	Nieuwdorp NJ, et al. Hand (N Y). 2026. doi:10.1177/15589447261469600	International survey of 208 surgeons (38 countries)	Survey or qualitative study (international survey of surgeons)
18	Imaging of the intrinsic muscles of the hand – part I: high-resolution ultrasound and 3 T MRI appearance of symptomatic anatomical variants	Bouredoucen H, et al. RöFo. 2026;198:457-78. doi:10.1055/a-2761-4259	Narrative/iconographic review (ultrasound and 3 T MRI)	Narrative review without primary data (iconographic imaging review; also, without TMC focus)
19	Small bone replacement leads to greater gait asymmetry, cartilage damage, and osteophyte formation than ligament injury in a porcine wrist model	Vaughan QM, et al. Osteoarthr Cartil Open. 2026;8:100824. doi:10.1016/j.ocarto.2026.100824	In vivo animal model (8 minipigs), radiocarpal/intercarpal wrist	No focus on the TMC joint (other joint and species)
20	A normative dataset of thumb muscle fascicle lengths in healthy, young adults: an extended field-of-view ultrasound study	Benoit AR, Nichols JA. J Biomech. 2025;192:112964. doi:10.1016/j.jbiomech.2025.112964	Normative cross-sectional (18 healthy), extended-field-of-view ultrasound	No outcome on stabilizers or TMC stability (normative muscle architecture unrelated to stability or osteoarthritis)
21	Assessing active thumb palmar and radial abduction in persons with thumb CMC OA via intermetacarpal distance methods	Ergen HI, et al. Clin Rheumatol. 2026;45:2845-53. doi:10.1007/s10067-026-08003-3	Psychometric (n=40 TMC OA)	No outcome on stabilizers or TMC stability (abduction range)
22	Sex differences in orthosis wear on pain, function, and grip in patients with thumb CMC OA	Gasavi Nezhad Z, et al. Hand Ther. 2026;31(1):45-53. doi:10.1177/17589983251372951	Quasi-experimental (orthosis 6 weeks, 14 M/14 F)	Intervention not aimed at active stabilization (orthosis)

No.	Study (title)	Reference	Design	Reason for exclusion (PICOS criteria)
23	Is joint denervation a durable treatment for thumb CMC OA? A multicenter long-term outcome study	Nieuwdorp NJ, et al. Plast Reconstr Surg. 2026;158:40S. doi:10.1097/PRS.0000000000012905	Prospective cohort (69 patients/76 thumbs)	Intervention not aimed at active stabilization (denervation)
24	Multiple, not single, recipient muscle tendon transfers produce well-directed thumb-tip forces in lateral pinch grasp: a simulation study	Garcia O, Towles JD. J Biomech. 2025;191:112882. doi:10.1016/j.jbiomech.2025.112882	Simulation (tendon transfers in tetraplegia)	No outcome on stabilizers or TMC stability (the 'stability' studied is that of the pinch)
25	Magnitude and location of isolated thumb forces in control and LRTI surgery participants: mapping force to three-dimensional kinematics	Chrzan AJ, et al. J Biomech Eng. 2025;147(11):111002. doi:10.1115/1.4069394	Cross-sectional + pre/post LRTI (52 healthy, 13 OA)	No outcome on stabilizers or TMC stability (maximum thumb strength; the surgical part also provides no data on native stabilizers)
26	Analysis of trapeziometacarpal joint mechanics during spanning and nonspanning fixation for thumb metacarpal distraction lengthening	Lockwood WC, et al. Hand (N Y). 2026;21(5):722-9. doi:10.1177/15589447251322916	Cadaveric (20 paired limbs), external fixation	Surgery without data on native stabilizers (the variable is the external fixator; incompetence of the anterior oblique in 7 of 20 specimens is an incidental finding). Online publication probably prior to the cut-off date
27	What is the most important mechanical factor involved in TMC OA development? A sensitivity analysis based on biomechanical modelling	Valerio T, et al. Comput Methods Biomech Biomed Engin. 2026;29(6):1225-33. doi:10.1080/10255842.2024.2430446	Finite element model (675 simulations)	No outcome on stabilizers or TMC stability (only contact pressure; passive stiffness is introduced as nine global springs). Published online on 19-11-2024, before the cut-off date
28	Pre- and postoperative 4D CT analysis of thumb CMC joint kinematics after first metacarpal extension osteotomy	Guebeli A, Honigmann P, Dobbe JGG, Keller M. Arch Orthop Trauma Surg. 2026;146:317. doi:10.1007/s00402-026-06455-5	Pre/post cohort (6 OA Eaton I–II, Wilson osteotomy + Brunelli) with reference of 5 healthy; 4D CT (contact by quadrants)	No outcome on stabilizers or TMC stability (only distribution of joint contact, without data on any ligament or muscle; the postoperative part combines osteotomy and ligamentoplasty). Decision by consensus of both reviewers; sample of 6 patients and 5 controls
29	Comparative biomechanical analysis of three ligamentous reconstruction techniques for trapeziometacarpal joint instability: a cadaveric study (Le Ngoc 2025)	Le Ngoc Q, Nguyen H, Khuong Anh T. Orthop Rev (Pavia). 2025;17:151463. doi:10.52965/001c.151463	Cadaveric (21 reconstructions in 14 hands): Eaton-Littler versus Zhang and modified Zhang	Surgery without data on native stabilizers (all ligaments are sectioned and only displacement after each reconstruction is measured; there is no intact or sectioned state of the native stabilizers)
30	Conservative rehabilitation approach for trapeziometacarpal osteoarthritis (Boccolari 2025)	Boccolari P, Nesti A, Arcuri P, et al. Hand Surg Rehabil. 2025;44:102216. doi:10.1016/j.hansur.2025.102216	Letter to the editor	Letter to the editor without primary data (conservative treatment proposal)
31	Prevalence, morphometric characteristics of the accessory abductor pollicis longus muscle and clinical implications: a cadaveric study (Duque-Colorado 2025)	Duque-Colorado J, Rodriguez-Torrez VH, García-Orozco L, Algieri RD, Ottone NE. Diagnostics (Basel). 2025;15(19):2455. doi:10.3390/diagnostics15192455	Descriptive cadaveric (16 forearms)	No outcome on stabilizers or TMC stability (prevalence and morphometry of the accessory abductor longus as a graft source; no loading, sectioning or stability measurement)
32	Osteoarthritis progression, pain, and function in early carpometacarpal osteoarthritis: a six-year longitudinal study (Ajayi 2025)	Ajayi PT, Morton AM, Ladd AL, Weiss APC, Crisco JJ. J Hand Surg Glob Online. 2025;7(5):100795. doi:10.1016/j.jhsg.2025.100795	Longitudinal cohort (86 patients with early osteoarthritis and 22 controls; 6 years)	No outcome on stabilizers or TMC stability (radiographic progression, pain, function and strength; no data on ligaments, muscles or stability)
—	Distribution of strength potential of the thumb muscles… (Normand 2025)	Normand M, et al. Clin Biomech. 2025;124:106489. doi: 10.1016/j.clinbiomech.2025.106489	Retrieved again in the update	Study already included in the previous version [37]; not counted as new

Summary of reasons: narrative reviews or expert opinions, or without verifiable primary data (8: nos. 1, 2, 4, 8, 9, 10, 12, 15); no focus on the TMC joint (2: nos. 5, 13); protocol without results (1: no. 3); qualitative study (1: no. 11); letter to the editor (1: no. 6); technical proposal without primary data (1: no. 7); non-indexed doctoral thesis (1: no. 14). The 2016 reply letter and the 2015 original study are different publications; the original is included in S1. Update: 17 full-text exclusions (nos. 16–32): no outcome on stabilizers or stability (9), intervention not aimed at active stabilization (2), surgery without data on native stabilizers (2), survey (1), narrative review (1), letter to the editor (1) and other joint and species (1); one record corresponded to an already included study. Nos. 29–32 could not initially be retrieved; they were obtained in October 2026 and assessed with the same criteria.

JBI-PEDro criteria (S3)

Checklist	Item	Statement (working translation)
JBI – Analytical cross-sectional studies (8 items)	1	Were the criteria for inclusion in the sample clearly defined?
JBI – Analytical cross-sectional studies (8 items)	2	Were the study subjects and the setting described in detail?
JBI – Analytical cross-sectional studies (8 items)	3	Was the exposure measured in a valid and reliable way?
JBI – Analytical cross-sectional studies (8 items)	4	Were objective, standard criteria used for measurement of the condition?
JBI – Analytical cross-sectional studies (8 items)	5	Were confounding factors identified?
JBI – Analytical cross-sectional studies (8 items)	6	Were strategies to deal with confounding factors stated?
JBI – Analytical cross-sectional studies (8 items)	7	Were the outcomes measured in a valid and reliable way?
JBI – Analytical cross-sectional studies (8 items)	8	Was appropriate statistical analysis used?
JBI – Quasi-experimental studies (9 items)	1	Is it clear what is the cause and what is the effect?
JBI – Quasi-experimental studies (9 items)	2	Were the participants included in any comparisons similar?
JBI – Quasi-experimental studies (9 items)	3	Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?
JBI – Quasi-experimental studies (9 items)	4	Was there a control group?
JBI – Quasi-experimental studies (9 items)	5	Were there multiple measurements of the outcome, both pre and post the intervention/exposure?
JBI – Quasi-experimental studies (9 items)	6	Was follow-up complete, and if not, were differences between groups in terms of their follow-up adequately described and analyzed?
JBI – Quasi-experimental studies (9 items)	7	Were the outcomes of participants included in any comparisons measured in the same way?
JBI – Quasi-experimental studies (9 items)	8	Were outcomes measured in a reliable way?
JBI – Quasi-experimental studies (9 items)	9	Was appropriate statistical analysis used?
JBI – Case series (10 items)	1	Were there clear criteria for inclusion in the case series?
JBI – Case series (10 items)	2	Was the condition measured in a standard, reliable way for all participants?
JBI – Case series (10 items)	3	Were valid methods used for identification of the condition?
JBI – Case series (10 items)	4	Did the case series have consecutive inclusion of participants?
JBI – Case series (10 items)	5	Did the case series have complete inclusion of participants?
JBI – Case series (10 items)	6	Was there clear reporting of the demographics of the participants?
JBI – Case series (10 items)	7	Was there clear reporting of clinical information of the participants?
JBI – Case series (10 items)	8	Were the outcomes or follow-up results of cases clearly reported?
JBI – Case series (10 items)	9	Was there clear reporting of the presenting site(s)/clinic(s) demographic information?
JBI – Case series (10 items)	10	Was appropriate statistical analysis used?
PEDro (11 items; the 1st is not scored)	1	Eligibility criteria (not scored)
PEDro (11 items; the 1st is not scored)	2	Random allocation
PEDro (11 items; the 1st is not scored)	3	Concealed allocation
PEDro (11 items; the 1st is not scored)	4	Groups similar at baseline
PEDro (11 items; the 1st is not scored)	5	Blinding of subjects

Checklist	Item	Statement (working translation)
PEDro (11 items; the 1st is not scored)	6	Blinding of therapists
PEDro (11 items; the 1st is not scored)	7	Blinding of assessors
PEDro (11 items; the 1st is not scored)	8	Measures obtained from >85% of subjects
PEDro (11 items; the 1st is not scored)	9	Intention-to-treat analysis
PEDro (11 items; the 1st is not scored)	10	Between-group comparison
PEDro (11 items; the 1st is not scored)	11	Point measures and measures of variability
Allocation by design		Analytical cross-sectional (12): Hudson, Nataraj, Tan, Halilaj, Ooishi, Mobargha 2019, Dumont, Kerkhof 2016, Johanson, Tsukamoto 2026, El Hor 2026 and Karademir 2026. Quasi-experimental (2): O'Brien 2013 and McGee 2015; in McGee the single-group experimental contrast is assessed, despite the case-series label in the abstract. Case series (1): Kerkhof 2018. PEDro (2): McVeigh and Davenport.
Source		Joanna Briggs Institute. JBI Critical Appraisal Tools: checklists for analytical cross-sectional studies, quasi-experimental studies and case series. Available from: https://jbi.global/critical-appraisal-tools. Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M. Reliability of the PEDro scale for rating quality of randomized controlled trials. Phys Ther. 2003;83(8):713-721.

Table S5. Searches

Search	Database	Date	Search string	Filters applied	Records
Initial	PubMed/MEDLINE	5 May 2025	("Carpometacarpal Joints"[Mesh] OR "trapeziometacarpal"[Title/Abstract] OR "first carpometacarpal"[Title/Abstract]) AND ("ligament"[Title/Abstract] OR "ligaments"[Title/Abstract] OR "muscle"[Title/Abstract] OR "muscles"[Title/Abstract] OR "anterior oblique ligament"[Title/Abstract] OR "AOL"[Title/Abstract] OR "dorsoradial ligament"[Title/Abstract] OR "DRL"[Title/Abstract] OR "first dorsal interosseous"[Title/Abstract] OR "FDI"[Title/Abstract] OR "opponens pollicis"[Title/Abstract] OR "abductor pollicis longus"[Title/Abstract]) AND ("stability"[Title/Abstract] OR "biomechanics"[Title/Abstract] OR "kinematics"[Title/Abstract] OR "laxity"[Title/Abstract] OR "subluxation"[Title/Abstract])	No lower date limit	219
Initial	Scopus	5 May 2025	TITLE-ABS-KEY(("trapeziometacarpal" OR "first carpometacarpal" OR "carpometacarpal joint") AND ("ligament*" OR "muscle*" OR "dorsoradial" OR "anterior oblique" OR "first dorsal interosseous" OR "opponens pollicis" OR "abductor pollicis longus") AND ("stabilit*" OR "biomechanic*" OR "kinematic*" OR "laxity" OR "subluxat*"))	No lower date limit	374
Initial	EuropePMC	5 May 2025	((trapeziometacarpal OR "first carpometacarpal" OR "carpometacarpal joint") AND (ligament OR muscle OR "dorsoradial" OR "anterior oblique" OR "first dorsal interosseous" OR "opponens pollicis") AND (stability OR biomechanics OR kinematics OR subluxation))	No lower date limit	206
Initial	Dimensions.ai	5 May 2025	title_abstract_search: ("trapeziometacarpal" OR "first carpometacarpal") AND ("ligament" OR "muscle" OR "dorsoradial") AND ("stability" OR "biomechanics" OR "kinematics")	No lower date limit	46
Update	PubMed/MEDLINE	21 September 2026	("Carpometacarpal Joints"[Mesh] OR "trapeziometacarpal"[Title/Abstract] OR "first carpometacarpal"[Title/Abstract]) AND ("ligament"[Title/Abstract] OR "ligaments"[Title/Abstract] OR "muscle"[Title/Abstract] OR "muscles"[Title/Abstract] OR "anterior oblique ligament"[Title/Abstract] OR "AOL"[Title/Abstract] OR "dorsoradial ligament"[Title/Abstract] OR "DRL"[Title/Abstract] OR "first dorsal interosseous"[Title/Abstract] OR "FDI"[Title/Abstract] OR "opponens pollicis"[Title/Abstract] OR "abductor pollicis longus"[Title/Abstract]) AND ("stability"[Title/Abstract] OR "biomechanics"[Title/Abstract] OR "kinematics"[Title/Abstract] OR "laxity"[Title/Abstract] OR "subluxation"[Title/Abstract])	Publication date 2025/05/05–2026/09/21	25
Update	Scopus	21 September 2026	TITLE-ABS-KEY(("trapeziometacarpal" OR "first carpometacarpal" OR "carpometacarpal joint") AND ("ligament*" OR "muscle*" OR "dorsoradial" OR "anterior oblique" OR "first dorsal interosseous" OR "opponens pollicis" OR "abductor pollicis longus") AND ("stabilit*" OR "biomechanic*" OR "kinematic*" OR "laxity" OR "subluxat*"))	PUBYEAR > 2024	65
Update	EuropePMC	21 September 2026	((trapeziometacarpal OR "first carpometacarpal" OR "carpometacarpal joint") AND (ligament OR muscle OR "dorsoradial" OR "anterior oblique" OR "first dorsal interosseous" OR "opponens pollicis") AND (stability OR biomechanics OR kinematics OR subluxation))	FIRST_PDATE:[2025-05-05 TO 2026-09-21]	141

Search	Database	Date	Search string	Filters applied	Records
Update	Dimensions.ai	21 September 2026	title_abstract_search: ("trapeziometacarpal" OR "first carpometacarpal") AND ("ligament" OR "muscle" OR "dorsoradial") AND ("stability" OR "biomechanics" OR "kinematics")	No filter in the interface (132 records); those published in 2025–2026 were retained	17
	Total			Initial: 845 records (375 duplicates removed). Update: 248 records (65 duplicates removed: 64 before import and 1 in Rayyan).	

Note: strings applied unmodified in both searches; deduplication of the update was performed by DOI, PMID and normalized title before import into Rayyan. Reported according to PRISMA-S.

Table S6. PROSPERO

PROSPERO field	Original registration	Final report	Correction applied
Languages (Search language restrictions)	English and Spanish	English, Spanish, French and German; studies in French were included	Registry amendment to reflect the four languages applied
Eligible designs and population	Did not contemplate physical or computational models; less detailed exclusions	Includes physical or computational models (Comtet) and makes the exclusions explicit (reviews, letters, opinions, cases, conference abstracts, animal models)	Registry amendment with the criteria of section 2.1
Objectives (Review objectives)	Included synthesizing findings for the design of stabilization mechanisms in implants and orthoses	The objective was not developed; the review focused on implications for physiotherapy	Removed from the registry and declared as a protocol deviation
Quality assessment	JBI and/or QUACS for cadaveric and biomechanical studies; no PEDro	QUACS for cadaveric and mixed studies; JBI for non-randomized in vivo studies; PEDro for RCTs; physical model narratively	Registry amendment with allocation by design
Dates (Start / End date)	Start 15-09-2025; end 01-06-2026	Start 01-04-2025 (before the initial search of 05-05-2025); end 08-10-2026, after the update of 21-09-2026	The actual start and end dates of the review are recorded
Status (Current review stage / Review status)	Planned or ongoing; stages unticked	Review completed	Screening, extraction, quality assessment and synthesis are marked as completed; status: completed
Intervention or exposure (Included / Excluded)	Content of the fields swapped	Included: structures and programs assessed; Excluded: interventions not included	The content of both fields is corrected
Search update	Not planned	Performed on 21-09-2026 with the same strings	Added to the registry and reported according to PRISMA 2020
Inter-rater agreement	Not specified	Cohen's kappa for title and abstract screening	Added to the registry
Other identification methods	None	Cross-checking of the reference lists of the included studies (two studies added: one in the initial search and one in the update)	Added to the registry
Synthesis	Narrative synthesis	Synthesis without meta-analysis according to SWiM, grouped by question	The registry is updated
Certainty and effect measures	GRADE for primary outcomes; mean differences or standardized mean differences with 95% CI	GRADE domains, with exploratory confidence (non-validated adaptation) for biomechanical experiments; effect measures as per the studies, without combining them	The registry is updated
Conflict of interest	Not declared	First author of an included study (Margüenda-Fernández 2025), assessed by the second reviewer	Declared in the first author's details
Registry version	Version 1.0, published on 31-08-2026	Amendment submitted on 08-10-2026 (version 2.0) and minor amendment submitted on 21-10-2026 (version 2.1)	Version 2.1 declares the timing of registration
Timing of registration (Stage of the review)	Version 1.0 published on 31-08-2026 with the review ongoing and without indicating the stages already completed	Retrospective registration for the initial review (search of 05-05-2025, screening, extraction, quality assessment and synthesis completed before 31-08-2026) and prospective for the update (search of 21-09-2026, screening, extraction and assessment of the eight new studies and of the retrieved report)	Declared in the minor amendment of the registry (version 2.1, 21-10-2026) and in Methods; the risk of outcome selection bias is addressed in Limitations

File S7. PERSiST checklist

The PERSiST guidance (Ardern CL, Büttner F, Andrade R, et al. Br J Sports Med. 2022;56(4):175-195. doi: 10.1136/bjsports-2021-103987) adapts the 27 PRISMA 2020 items to reviews in sport and exercise medicine, musculoskeletal rehabilitation, and sports science, and does not include a checklist of its own. This table goes through the PRISMA 2020 items, summarizes the PERSiST recommendation for each one (authors' synthesis; the full wording appears in the original publication), and indicates how it was applied and where it is reported.

Section and topic	Item #	PERSiST recommendation (synthesis)	Compliance, application, and location
TITLE			
Title	1	Identify the report as a systematic review and, where possible, include the main elements of the question.	Yes. The title identifies the systematic review, the joint, and the stabilizers studied. Title page and manuscript title.
ABSTRACT			
Abstract	2	Follow PRISMA for Abstracts: search sources and dates, risk of bias assessment, synthesis, certainty of evidence, and registration.	Yes. The structured Abstract reports the eligible study types, databases and search dates, quality tools, SWiM synthesis, certainty by outcome, limitations, and PROSPERO registration number (under "Other information").
INTRODUCTION			
Rationale	3	Position the review in relation to previous reviews and justify what it adds, to avoid duplication.	Yes. 1. Introduction: the closest previous review (Lin et al., 2014), its limitations, and what this review adds are described.
Objectives	4	State the question with all its components (PICO or equivalent) and distinguish questions of mechanism, exposure, and efficacy.	Yes. 1. Introduction (last paragraph: aim and four questions: passive stabilizers, active stabilizers, in vivo behavior, and clinical efficacy); PICOS criteria in 2.1 Eligibility Criteria.
METHODS			
Eligibility criteria	5	Define criteria for each component and justify restrictions by language, date, or publication type; state how studies are grouped for the synthesis.	Yes. 2.1 Eligibility Criteria (PICOS; English, Spanish, French, and German languages; no lower date limit; exclusion of conference abstracts without complete data); grouping by question in 2.6 Synthesis of results and grading of evidence.
Information sources	6	Search several relevant databases, trial registries, and grey literature, check reference lists, and keep the search up to date relative to submission.	Partial. Four databases (PubMed/MEDLINE, Scopus, EuropePMC, and Dimensions.ai) and reference list checking; initial search on 5 May 2025, updated on 21 September 2026 (2.2 Sources of information and search strategy). Trial registries and specific grey literature sources were not searched.
Search strategy	7	Present the full strategy for each source with its limits; involvement of an information specialist and peer review of the strategy (PRESS) are recommended.	Partial. Full strategies for the four databases, with dates, filters, and record counts, in Table S5 (PRISMA-S); PubMed strategy in 2.2. The strategy was not submitted to PRESS review nor designed with an information specialist.
Selection process	8	Screening by at least two independent reviewers; describe how disagreements were resolved, automation tools, and agreement.	Yes. 2.3 Study selection: VMF and ABM, independently and blinded in Rayyan, with resolution by consensus; κ = 0.53 (initial search) and 0.52 (update), in 3.1 Selection of studies. AI-assisted prescreening in the update was verified by both reviewers (2.3 and Statement on the use of artificial intelligence).
Data collection process	9	Extraction by two independent reviewers using a piloted form; describe contact with authors to obtain missing data.	Partial. 2.4 Data extraction: predesigned form, independent duplicate extraction, and consensus; exception for the study by V.M.F., extracted by A.B.M. (2.3). Authors of the primary studies were not contacted; discrepancies within sources are kept as notes in Table S1.
Data items: outcomes	10a	Define the outcomes, their measures and time points, and the rule for choosing among multiple results.	Yes. 2.1, criterion "Outcome variables (O)" (primary and secondary outcomes and classification criterion); retention of each study's units in 2.6.
Data items: other variables	10b	Describe the extracted characteristics of participants and interventions (including exercise parameters) and funding, and the assumptions made for missing data.	Yes. 2.4 and Table S1 (design, sample, cadaveric preservation, instrumentation, loading or exercise protocol, limitations, and declared funding).

Section and topic	Item #	PERSiST recommendation (synthesis)	Compliance, application, and location
Study risk of bias assessment	11	Use design-specific, domain-based risk of bias tools, applied by two independent reviewers; avoid summary scores from quality scales as a measure of risk of bias.	Partial. 2.5 Assessment of methodological quality and risk of bias: QUACS (cadaveric and mixed studies), JBI checklists (non-randomized in vivo studies), and PEDro (RCTs), with the judgment for each item and its textual evidence in Tables S2 and S3. Total scores with non-validated operational thresholds are also reported, and these were not equated with GRADE domains. The final rating was set by consensus on an AI-assisted prescore, without independent duplicate assessment, and the study by V.M.F. was assessed by A.B.M. (2.3). Deviations are declared in Limitations (subsection of 4. Discussion).
Effect measures	12	Specify the effect measure for each outcome.	Yes, descriptively. No pooled effect measures were calculated; the measures of each study (mm, degrees, %, N, N/mm, MPa, %MVC; NRS, DASH or QuickDASH) are defined in 2.1 and presented in Tables 3, 4, 6, and S1.
Synthesis methods: eligibility for synthesis	13a	Explain which studies are included in each synthesis.	Yes. 2.6; grouping by question in 3.2.3 Biomechanical results, 3.4, 3.5, and Table 6.
Synthesis methods: data preparation	13b	Describe data preparation (conversions, imputations).	Yes. 2.4 and 2.6: unit conversions; no data were imputed.
Synthesis methods: tabulation and display	13c	Describe the tabulation or display of results.	Yes. 2.6; Tables 1 to 6 and Tables S1 to S6.
Synthesis methods: synthesis	13d	Justify the synthesis method; if no meta-analysis is performed, describe the alternative method (e.g., SWiM) and do not base the synthesis on counting significant results.	Yes. 2.6: synthesis without meta-analysis following SWiM, with the direction and magnitude of each study in Tables 3, 4, and 6.
Synthesis methods: heterogeneity	13e	Describe how heterogeneity was explored.	Yes, qualitatively (direction, position, loading vector, and disease): 2.6 and 4. Discussion (first paragraphs). No subgroups or meta-regression.
Synthesis methods: sensitivity analyses	13f	Describe sensitivity analyses.	Not applicable (no quantitative synthesis). For outcome 1a, it is stated how the rating would change with a stricter imprecision criterion (3.5 Certainty of the evidence and Table 6).
Reporting bias assessment	14	Describe how bias due to unreported results was assessed.	Partial. No formal methods because of the small number of comparable studies (2.6, last sentence); qualitative assessment in 4. Discussion (paragraph on publication bias).
Certainty assessment	15	Assess certainty by outcome, preferably with GRADE, and describe any adaptation.	Yes, with adaptation. 2.6: GRADE domains by outcome; for biomechanical experiments, a non-validated adaptation expressed as exploratory confidence.
RESULTS			
Study selection	16a	Describe the search and selection with a flow diagram; in updated reviews, distinguish previous and new studies.	Yes. 3.1 Selection of studies; Figure 1, PRISMA 2020 flow diagram for updated reviews.
Excluded studies	16b	Cite apparently eligible studies that were excluded and state the reason.	Yes. 3.1 Selection of studies and Table S4 (reference and reason for each exclusion).
Study characteristics	17	Cite each included study and present its characteristics.	Yes. 3.2 Study characteristics (3.2.1 to 3.2.3); Table 1; Table S1.
Risk of bias in studies	18	Present the risk of bias judgment for each study by domain or item, not only an overall score.	Yes. Item-by-item judgment with textual evidence in Tables S2 and S3; synthesis by design in 3.3 Methodological quality and risk of bias and Table 5.
Results of individual studies	19	Present the results of each study with their measures of precision.	Yes. Tables 3 and 4; Table 6; Table S1. The measures of dispersion reported by each original study are provided (for example, mean ± standard deviation in Table 3).
Results of syntheses: characteristics	20a	Summarize the characteristics and risk of bias of the studies in each synthesis.	Yes. 3.2.3 Biomechanical results; 3.3; Table 6.
Results of syntheses: results	20b	Present the results of each synthesis.	Yes (narrative). 3.2.3 and 3.4 Synthesis of results and neuromuscular coactivation. No statistical synthesis was performed.
Results of syntheses: heterogeneity	20c	Present investigations of the causes of heterogeneity.	Yes, qualitatively: 3.2.3 and 4. Discussion (first paragraphs).
Results of syntheses: sensitivity analyses	20d	Present sensitivity analyses.	Not applicable (none were performed).

Section and topic	Item #	PERSiST recommendation (synthesis)	Compliance, application, and location
Reporting biases	21	Present the assessment of bias due to unreported results.	Partial. 4. Discussion (paragraph on publication bias); uncertainty recorded in Table 6 without further downgrading.
Certainty of evidence	22	Present the certainty of evidence for each outcome.	Yes. 3.5 Certainty of the evidence and Table 6.
DISCUSSION			
Discussion: interpretation	23a	Interpret the results according to the certainty of the evidence, without overstating them.	Yes. 4. Discussion; 5. Conclusions, which state the level of certainty or exploratory confidence of each statement.
Discussion: limitations of the evidence	23b	Discuss the limitations of the included evidence.	Yes. 4. Discussion (paragraphs on dynamic restraint and on cadaveric tissue).
Discussion: limitations of the review	23c	Discuss the limitations of the review process.	Yes. Limitations (subsection of 4. Discussion), including the risk of outcome selection bias because the protocol was registered after data extraction for the initial review.
Discussion: implications	23d	Present implications for clinical practice and the research agenda in a dedicated section, consistent with the certainty of the evidence.	Yes. Subsection "Implications for clinical practice and research" (of 4. Discussion).
OTHER INFORMATION			
Registration	24a	Register the protocol before starting the review and state the registry and its number; if registration was retrospective, declare it.	Partial. PROSPERO CRD420261330988. Retrospective registration for the initial review (version 1.0 of 31 August 2026, published after extraction and synthesis) and prospective for the update phase. This is declared in 2. Methods (opening paragraph), in Limitations (subsection of 4. Discussion), and on the Title page, "Registration" section.
Protocol	24b	State where the protocol can be accessed.	Yes. PROSPERO record; no separate protocol was published.
Amendments	24c	Describe and justify deviations from the registration or protocol.	Yes. Table S6, amendment to the registration (version 2.0, submitted on 8 October 2026) and minor amendment on the timing of registration (version 2.1, submitted on 21 October 2026); 2. Methods (opening paragraph).
Support	25	Describe the sources of funding and their role.	Yes. Title page, "Funding": no external funding.
Competing interests	26	Declare competing interests, including authorship of included studies and how this was managed.	Yes. Title page, "Conflicts of interest": V.M.F. is first author of an included study, whose extraction and assessment were performed by A.B.M.; see also 2.3 Study selection.
Availability of data, code and other materials	27	Make extraction forms, extracted data, synthesis data, and code publicly available, preferably in an open repository.	Partial. Extracted data, item-by-item quality matrices, excluded studies, search strategies, and differences from the registration in the supplementary material (Tables S1 to S6). Screening records, extraction forms, and AI prescores are available on request; they were not deposited in a public repository. No analytical code was used.

Compliance: "Yes", the recommendation is followed; "Partial", it is partly followed and the deviation is declared; "Not applicable", the item does not apply because no meta-analysis was performed.

File S8. PRISMA 2020 checklist

The items are summarized; the full official wording appears in Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. doi: 10.1136/bmj.n71.

Section and topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Title page and manuscript title (begins with "Systematic Review on…").
ABSTRACT			
Abstract	2	Present a structured abstract following the PRISMA for Abstracts checklist.	Abstract (structured abstract of 281 words: Background and objectives, Methods, Results, Discussion, and Conclusions; 293 words if "Other information", which reports registration and funding, is counted). It includes the eligible study types, databases and search dates, quality tools, synthesis method, certainty, limitations, registration, and funding.
INTRODUCTION			

Section and topic	Item #	Checklist item	Location where item is reported
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	1. Introduction (anatomical and biomechanical context, closest previous review by Lin et al., and contribution of this review).
Objectives	4	Provide an explicit statement of the objectives or questions the review addresses.	1. Introduction (last paragraph: aim and four review questions); PICOS criteria in 2.1 Eligibility Criteria.
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria and how studies were grouped for the syntheses.	2.1 Eligibility Criteria (PICOS framework, date and language limits, and exclusions); grouping of studies for the synthesis in 2.6 Synthesis of results and grading of evidence.
Information sources	6	Specify all databases, registers, and other sources searched, with the date of the last search.	2.2 Sources of information and search strategy (PubMed/MEDLINE, Scopus, EuropePMC, and Dimensions.ai; search on 5 May 2025 and update on 21 September 2026; checking of the reference lists of included studies, which yielded two additional studies: McGee 2015 in the initial search and Nwawka 2020 in the update).
Search strategy	7	Present the full search strategies for all databases and registers, including any filters used.	2.2 (PubMed strategy as an example); full strategies for the four databases, with date, filters, and number of records for each search, in Table S5 (PRISMA-S); language and date limits in 2.1.
Selection process	8	Specify the methods used to decide whether a study met the criteria, how many reviewers screened each record, whether they worked independently, and any automation tools used.	2.3 Study selection (two independent reviewers, VMF and ABM, in Rayyan blind mode; resolution by consensus; Cohen's kappa for screening; AI-assisted prescreening in the update, verified by both reviewers); deduplication and agreement in 3.1 Selection of studies; AI tools in the Statement on the use of artificial intelligence.
Data collection process	9	Specify the methods used to collect data, how many reviewers collected data, whether they worked independently, and any processes for confirming data with investigators.	2.4 Data extraction (predesigned form; independent duplicate extraction by VMF and ABM, with resolution by consensus). Exception: the study of which V.M.F. is first author was extracted and assessed by A.B.M. (2.3 Study selection; Title page, "Conflicts of interest"). Authors of the primary studies were not contacted.
Data items: outcomes	10a	List and define all outcomes for which data were sought, including compatible domains and measures.	2.1, criterion "Outcome variables (O)" (primary and secondary outcomes and classification criterion); retention of the original units in 2.6.
Data items: other variables	10b	List and define all other variables for which data were sought (participants, interventions, funding) and any assumptions made about missing or unclear information.	2.4 Data extraction (bibliographic data, design, sample, cadaveric preservation, instrumentation, and structures assessed). Internal discrepancies within sources are kept as notes, without combining incompatible values; per-study details in Tables S1 to S3.
Study risk of bias assessment	11	Specify the methods used to assess risk of bias, including the tools used, the number of reviewers, and whether they worked independently.	2.5 Assessment of methodological quality and risk of bias (QUACS, PEDro, and JBI checklists, with non-validated operational thresholds; AI-assisted prescore checked against the originals by both reviewers and final score by consensus, without independent duplicate assessment). Identifiers and period of use of each AI tool in the Statement on the use of artificial intelligence. Exception for the study by V.M.F., assessed by A.B.M. (2.3). Limitation declared in Limitations (subsection of 4. Discussion).
Effect measures	12	Specify the effect measure used in the synthesis or presentation of results for each outcome.	Yes, descriptively: no pooled effect measures were calculated, and the results of each study are presented in their original units (mm, degrees, %, N, N/mm, MPa, %MVC; NRS, DASH or QuickDASH in the clinical trials). Units are defined in 2.1, criterion "Outcome variables (O)", and retained in 2.6; results appear in Tables 3, 4, and 6 and in Table S1.
Synthesis methods: eligibility for synthesis	13a	Describe the processes used to decide which studies were eligible for each synthesis.	2.6 Synthesis of results and grading of evidence (grouping by question); application in 3.2.3 Biomechanical results, 3.4 Synthesis of results and neuromuscular coactivation, 3.5 Certainty of the evidence, and Table 6.
Synthesis methods: data preparation	13b	Describe any methods required to prepare the data (conversions, imputations).	2.4 Data extraction and 2.6: conversion from centimeters to millimeters (×10) and from ratios to percentages; no data were imputed. Internal discrepancies within sources are kept as notes in Table S1, without combining incompatible values.
Synthesis methods: tabulation and display	13c	Describe any methods used to tabulate or visually display the results of individual studies and syntheses.	2.6; Tables 1 to 6 and Supplementary Tables S1 to S6.
Synthesis methods: synthesis	13d	Describe the methods used to synthesize results and provide a rationale; if meta-analysis was performed, describe the model and software.	2.6: synthesis without meta-analysis following SWiM; estimates were not pooled because of the heterogeneity of protocols, populations, and outcomes (also in Limitations, subsection of 4. Discussion).
Synthesis methods: heterogeneity	13e	Describe any methods used to explore possible causes of heterogeneity.	Qualitative exploration by direction, position, loading vector, and disease: 2.6 and discussion of divergences in 4. Discussion (first paragraphs). No subgroup analyses or meta-regression were performed.

Section and topic	Item #	Checklist item	Location where item is reported
Synthesis methods: sensitivity analyses	13f	Describe any sensitivity analyses conducted to assess the robustness of the synthesized results.	No statistical sensitivity analyses were performed because there was no quantitative synthesis (2.6). For outcome 1a, it is stated how the rating would change with a stricter imprecision criterion (3.5 Certainty of the evidence and Table 6).
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (reporting biases).	No formal methods were applied (without meta-analysis, no funnel plots or asymmetry tests were constructed): 2.6, last sentence. The qualitative assessment of reporting and publication bias appears in 4. Discussion.
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for each outcome.	2.6: GRADE domains by outcome; for biomechanical experiments, the authors' own non-validated adaptation expressed as exploratory confidence; clinical outcomes without direct evidence are considered not gradable.
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified to the studies included, ideally using a flow diagram.	3.1 Selection of studies (initial search and update); Figure 1 (PRISMA 2020 flow diagram for updated reviews).
Excluded studies	16b	Cite studies that might appear to meet the inclusion criteria but were excluded, and explain why.	3.1 Selection of studies (15 full-text exclusions in the initial search and 18 in the update, with aggregated reasons); individual list with reference and reason in Table S4.
Study characteristics	17	Cite each included study and present its characteristics.	3.2 Study characteristics (3.2.1 to 3.2.3) and Table 1 (distribution by design); details of each study in Table S1. Table 2 presents the anatomical nomenclature of the stabilizers.
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	3.3 Methodological quality and risk of bias and Table 5 (synthesis by design); item-by-item scores with their textual evidence in Tables S2 and S3.
Results of individual studies	19	For all outcomes, present, for each study, the results and the estimates with their measures of precision.	Results by study in Tables 3 and 4, in the "Magnitude/Scope" column of Table 6, and in Table S1, with the measures of dispersion reported by each original study (for example, mean ± standard deviation in Table 3). No forest plots are presented because there is no quantitative synthesis.
Results of syntheses: characteristics	20a	Briefly summarize the characteristics and risk of bias of the studies contributing to each synthesis.	3.2.3 Biomechanical results; 3.3 Methodological quality and risk of bias; "Main evidence" and "Risk of bias" columns of Table 6.
Results of syntheses: results	20b	Present the results of all statistical syntheses; if meta-analysis was performed, provide the summary estimate and its precision.	Narrative synthesis in 3.2.3 and 3.4 Synthesis of results and neuromuscular coactivation, with the magnitudes of the primary studies. No statistical synthesis was performed (2.6).
Results of syntheses: heterogeneity	20c	Present the results of all investigations of possible causes of heterogeneity.	3.2.3 and 4. Discussion (first paragraphs): divergences between studies are attributed to direction, loading vector, joint position, and anatomical definition.
Results of syntheses: sensitivity analyses	20d	Present the results of all sensitivity analyses.	Not applicable (no sensitivity analyses were performed; see 13f).
Reporting biases	21	Present assessments of risk of bias due to missing results for each synthesis.	4. Discussion (paragraph on publication bias): no formal tests; the exclusion of abstracts without complete data and the lack of accessible protocols limit the assessment of selective reporting; the uncertainty is recorded in Table 6 without further downgrading.
Certainty of evidence	22	Present assessments of certainty in the body of evidence for each outcome.	3.5 Certainty of the evidence and Table 6.
DISCUSSION			
Discussion: interpretation	23a	Provide a general interpretation of the results in the context of other evidence.	4. Discussion (all sections) and 5. Conclusions.
Discussion: limitations of the evidence	23b	Discuss any limitations of the evidence included in the review.	4. Discussion (paragraphs on dynamic restraint and on cadaveric tissue: donor age, tissue preservation, absence of tone and synergies of the living hand, loss of specimens, bilateral dependence, funding of one study, and in vivo discordance).
Discussion: limitations of the review	23c	Discuss any limitations of the review processes used.	Limitations (subsection of 4. Discussion): registration after data extraction for the initial review, with risk of outcome selection bias; non-validated quality thresholds and GRADE adaptation; moderate agreement in screening; quality assessment without independent duplicate assessment; reports not retrieved; two studies added through reference list checking; study by the first author; synthesis without meta-analysis.

Section and topic	Item #	Checklist item	Location where item is reported
Discussion: implications	23d	Discuss implications of the results for practice, policy, and future research.	Subsection "Implications for clinical practice and research" (of 4. Discussion); invasive physiotherapy presented as a hypothesis and research gap in the subsection "Invasive physiotherapy: hypotheses and research gaps"; 5. Conclusions.
OTHER INFORMATION			
Registration	24a	Provide registration information, including the register name and registration number, or state that the review was not registered.	Abstract (Other information), 2. Methods (opening paragraph), and Title page, "Registration" section: PROSPERO CRD420261330988, with permanent link. Retrospective registration for the initial review (version 1.0 published on 31 August 2026, after the search of 5 May 2025, screening, extraction, quality assessment, and synthesis) and prospective for the update phase (search of 21 September 2026).
Protocol	24b	Indicate where the protocol can be accessed, or state that a protocol was not prepared.	The protocol can be accessed in the PROSPERO record (CRD420261330988); no separate protocol was published.
Amendments	24c	Describe and explain any amendments to information provided at registration or in the protocol.	2. Methods (opening paragraph) and Table S6: differences between the registration and the review were corrected through an amendment (version 2.0, submitted on 8 October 2026); a minor amendment (version 2.1, submitted on 21 October 2026) declares the timing of registration. The resulting risk of outcome selection bias is declared in Limitations (subsection of 4. Discussion).
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders.	Title page, "Funding" section: the research received no external funding. This is repeated in the Abstract (Other information).
Competing interests	26	Declare any competing interests of review authors.	Title page, "Conflicts of interest" section: V.M.F. is first author of an included study, whose extraction and assessment were performed by A.B.M.; A.B.M. declares no conflicts. See also 2.3 Study selection.
Availability of data, code and other materials	27	Report which of the following are publicly available and where: data collection forms, extracted data, data used for all analyses, analytic code, and any other materials.	Title page, "Data Availability Statement": full search strategies (Table S5), Supplementary Tables S1 to S4 (study characteristics, item-by-item quality matrices with their evidence, excluded studies, and criteria of the checklists used), differences from the registration (Table S6), and completed PERSiST checklist (File S7); screening records, extraction forms, and AI prescores available on reasonable request from the corresponding author.

Note: "Not applicable" is used for items relating to statistical synthesis, since the heterogeneity of designs and units precluded a meta-analysis; the synthesis was reported following the SWiM guideline (Campbell M, et al. BMJ. 2020;368:l6890).