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Original Research

Efficacy of Surgical Interventions for Trapeziometacarpal (Thumb Base) Osteoarthritis: A Systematic Review

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Purpose: This systematic review (SR) aimed to identify the surgical interventions available for trapeziometacarpal osteoarthritis and document their efficacy on pain, physical function, psychological well-being, quality of life, treatment satisfaction, and/or adverse events.

Methods: This PROSPERO-registered SR's protocol was developed based on the Cochrane intervention review methodology and Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.

Results: Among 9049 potential studies identified, 1 SR, 18 randomized controlled trials, and 40 nonrandomized controlled trials were included. We identified 11 categories of surgical techniques: first metacarpal osteotomy, first metacarpal and trapezium partial resection, arthrodesis, trapeziectomy (T), T+ligament reconstruction (LR), T+tendon interposition (TI), T+ligament reconstruction and tendon interposition (LRTI), hematoma distraction arthroplasty (HDA), chondrocostal graft interposition, autologous fat injection, and manufactured implant use. These findings supported by low-quality evidence revealed moderately or largely superior effects of the following interventions: (1) trapeziectomy over T+LRTI using ½ flexor carpi radialis (FCR) and metacarpal tunnel (MT) or using abductor pollicis longus (APL) and FCR for adverse events; (2) trapeziectomy over T+TI using palmaris longus (PL) for pain; (3) T+LR with ½FCR-MT over T+LRTI with ½FCR-MT for physical function; (4) trapeziectomy by anterior approach over that by posterior approach for treatment satisfaction and adverse events; (5) T+LRTI using ½FCR-MT over T+TI with PL for pain; and (6) T+HDA over T+LR using APL-MT-FCR for pain, physical function, and adverse events. GraftJacket (Wright Medical Group, Memphis, TN), Swanson (Wright Medical Group, Letchworth Garden City, UK), and Permacol (Tissue Science Laboratories, Aldershot, UK) implants and hardware (plate/screw) would cause more complications than an autograft. The effect estimates of other surgical procedures were supported by evidence of very low quality.

Conclusions: This SR provided evidence of the efficacy of various surgical interventions for trapeziometacarpal osteoarthritis. Some interventions showed a moderate-to-large superior effect on the studied outcome(s) compared with others. However, these findings must be interpreted with caution because of low-quality evidence. To provide stronger evidence, more randomized controlled trials and methodological uniformization are needed.

Type of study/level of evidence: Therapeutic I.

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Trapeziometacarpal osteoarthritis (TMO) is one of the most prevalent and painful forms of hand osteoarthritis.^{1–3} It not only reduces thumb mobility⁴ but also limits hand functions needed for daily activities.³ The TMO care pathway usually begins with nonsurgical interventions, and when they are unsuccessful, patients might undergo surgery.⁵

Among the numerous surgical techniques available for TMO, trapeziectomy with ligament reconstruction and tendon interposition (T+LRTI) is the most popular among surgeons in the United States^{6–8} despite its higher cost compared to that of other procedures such as simple complete trapeziectomy.⁹ Moreover, the choice of a given surgical procedure can affect the length of a patient's sick leave period.¹⁰ Therefore, surgical procedures must be judiciously chosen, taking into account their benefits, adverse effects, and costs. Unfortunately, evidence of the efficacy of surgical interventions for this pathology is lacking, leaving surgeons and patients unsupported in their decision-making process ("efficacy" here is defined as the performance of a treatment under ideal and controlled circumstances, such as randomized controlled trials [RCTs], as opposed to "effectiveness," which is defined as the performance of a treatment under usual or "real-world" circumstances¹¹). Although some systematic reviews (SRs) examining the efficacy of surgical interventions exist, they are not exhaustive (including solely particular surgical techniques),^{12,13} are methodologically suboptimal (eg, omitting critical appraisal^{14,15}), or are methodologically sound but need to be updated because their included articles were published before 2013.¹⁶ Therefore, we performed a comprehensive SR in terms of surgical procedures using a rigorous methodology. Our explicit questions to be answered by this SR were as follows: (1) What are the surgical interventions available for TMO whose efficacy has been documented?; and (2) What are the effects of these surgical interventions on pain, physical function, psychological well-being, quality of life, treatment satisfaction, and/or adverse events?

Materials and Methods

The protocol of this PROSPERO-registered SR (PROSPERO CRD42015015623) was developed based on the Cochrane intervention review¹⁷ and Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines¹⁸ and has been previously published.¹⁹

Search strategy and criteria

As seen in Figure 1, a literature search of 16 bibliographic databases up to July 4, 2018, was conducted by an experienced medical librarian. The following search terms were used: thumb, trapeziometacarpal (TM) joint, carpometacarpal joint, osteoarthritis, intervention, and pain (an example of our search strategy is presented in Appendix 1 [available on the *Journal's* Web site at www.jhsgo.org]). Languages were restricted to English and French. Manual searching of reference lists of included studies was also performed.

Inclusion/exclusion criteria

Two reviewers independently screened the titles/abstracts of studies based on eligibility criteria and then read the full-text copies of potentially relevant studies. Any disagreement was discussed until a consensus was reached. The eligibility criteria were as follows:

- Study designs: SR, RCTs, and non-RCTs (NRCTs). The inclusion of SR was considered necessary to avoid redundant work for

studies already reviewed. NRCTs were also included in cases where there was no SR/RCT for a given intervention or outcome.

- Population: Adults with primary TMO
- Interventions: Any type of interventions was first included. Because of the tremendous volume of data, surgical and nonsurgical interventions were separated, and only the surgical ones were included in this SR. An SR of nonsurgical interventions has been previously published.²⁰
- Outcomes: Pain, physical function, psychological well-being, quality of life, treatment satisfaction, and adverse events were included. These outcomes are considered as core outcomes for chronic pain trials.^{21,22}

Risk-of-bias assessment

Among 9049 potential studies identified after the bibliographic database search, 68 were eligible (Fig. 1), comprising 10 SRs,^{12–16,23–27} 18 RCTs,^{28–45} and 40 NRCTs,^{46–85} which represented a total of 3878 thumbs in 3658 participants. The characteristics of the included studies are presented in Appendices 2 (SRs) and 3 (RCTs/NRCTs) (Appendices 2 and 3 are available on the *Journal's* Web site at www.jhsgo.org). A total of 276 full-text articles did not meet the selection criteria (the list of the excluded articles is available upon request).

Two reviewers independently assessed the risk of bias (RoB) in the 10 identified SRs using the Assessment of Multiple Systematic Reviews checklist.⁸⁶ Any disagreement between the reviewers was discussed until a consensus was reached; otherwise, a third reviewer was consulted. The mean total score of the 10 SRs according to the Assessment of Multiple Systematic Reviews checklist was relatively low at 4.4 ± 2.6 (0 = worst score, 11 = best score; Appendix 2). More than half of the SRs had an unclear or high RoB based on criteria 1, 2, 4, 5, 6, 10, and 11 (Fig. 2A). Because of the suboptimal methodological quality of majority of the SRs, we questioned the validity of these SRs' findings. Therefore, to integrate only a valid body of evidence from previous SRs into our SR, we decided to apply a minimum set of criteria based on the Agency for Healthcare Research and Quality's guidance⁸⁷ for the 10 identified SRs: (1) multiple data source search; (2) application of pre-defining eligibility criteria for study selection; (3) performing RoB assessment; and (4) considering evidence quality. Only 1 SR¹⁶ met these criteria (Appendix 2).

To assess RoB in RCTs/NRCTs, the Cochrane Effective Practice and Organization of Practice's risk-of-bias tool⁸⁸ was used. The criterion of "similarity of baseline characteristics between experimental and control groups" was assessed by considering the following confounders: age, sex, occupation, hand dominance, affected side, radiographic stage, and symptom duration. When $\geq 80\%$ of these factors were balanced between groups, RoB was considered low; when 60%–79% were balanced, RoB was considered unclear; when $< 60\%$ were balanced, RoB was considered high.⁸⁹ Blinding was considered for the following 3 parties: participant, performer (surgeon), and assessor. The results of the RoB assessments reported for the included SR¹⁶ were taken into account to ascertain our judgment.⁸⁷ Figure 2B shows the results on each item assessed using the risk-of-bias tool: 40 trials suffered from a selection bias due to a nonrandomized design. More than half did not assess the similarity of baseline outcomes and characteristics between groups. When reported, these data were mainly limited to age and sex. Except for 1 RCT,³⁴ all the trials had unclear or high RoB results regarding blinding participants, either because of the presence of K-wire(s), which had likely informed the participants of the type of surgery,^{38,42,48,63} or the retrospective nature of the studies.^{47,49–51,53,57–60,62–65,67,69–73,75,76,78,79,83,84} Blinding the

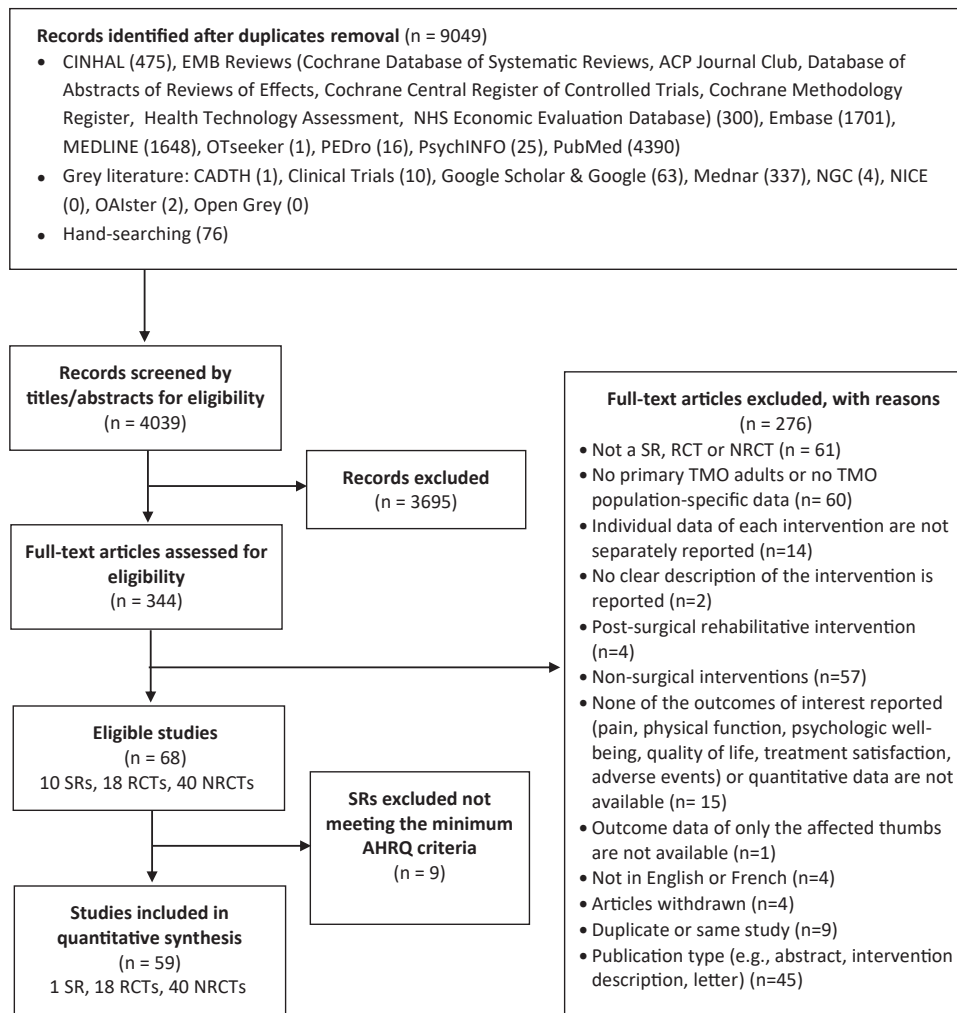


Figure 1. Flow chart of study identification. ACP, American College of Physicians; AHRQ, Agency for Healthcare Research and Quality; CADTH, Canadian Agency for Drugs and Technologies in Health; CINHAL, cumulative index to nursing and allied health literature; EMB, evidence-based medicine; NGC, National Guideline Clearing House; NHS, National Health Service; NICE, National Institute for Health and Care Excellence; OAlster, Open Archives Initiative; OTseeker, Occupational Therapy Systematic Evaluation of Evidence; PEDro, Physiotherapy Evidence Database.

performer—ie, the surgeon—was obviously not feasible. Unblinding of participants consequently compromised a detection bias for subjective (patient-reported) outcomes (eg, pain). For the assessment of objective outcomes (eg, infection), one-third of the trials had high RoB because of a visible scar, which would have informed the assessor of the allocated intervention,^{35–37,40,42,44,46,48,63,65,68,80} or because of the inability to blind the assessors who conducted chart reviews in the retrospective studies.^{47,49,72} Other sources of biases included cotreatment (eg, metacarpal-phalangeal arthrodesis);^{32,53} recall bias;⁵⁰ data exclusion from analyses (eg, dissatisfied patients);^{64,90} potential conflicts of interest;⁶⁶ inclusion of traumatic TMO;^{47,57} comorbidity (eg, De Quervain tendinitis);⁴⁷ and substantial group differences in anesthetic procedures or tourniquet time,^{32,52} postoperative care,^{46,52,54,56,71,74} follow-up time,^{47,49–51,55,57,62,68,70,71,75,77,78,80,90} and radiographic severity at baseline.⁵⁹

Data collection

Two reviewers independently extracted data from the identified studies using the Cochrane Effective Practice and Organization of Practice's data abstraction form.⁹¹ Missing data were first sought by contacting the authors via e-mail. When medians and (interquartile

ranges were available, means and standard deviations were estimated using an approximation method.⁹² When graphic data were available, the Plot Digitizer software⁹³ was used to digitize these data.

Meta-analysis methodology

The effect estimates of a given intervention—standardized mean differences for continuous outcomes and risk ratios for dichotomous ones—were first searched for in the included SR.¹⁶ If unavailable, we computed them using RCT data. If no RCTs were available, NRCTs were consulted. When a given outcome was measured at different time points, only the effect estimate of the last measured point was included. It was not possible to use a meta-analytic approach because of significant treatment heterogeneity in most of the cases, but when possible, the results were expressed using forest plots (Fig. 3A–C). A publication bias analysis using a funnel plot was not feasible because the number of pooled studies was <10.¹⁷

Rating the quality of evidence

The quality of evidence of effect estimates was rated using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) system.⁹⁴ The evidence quality reported for the

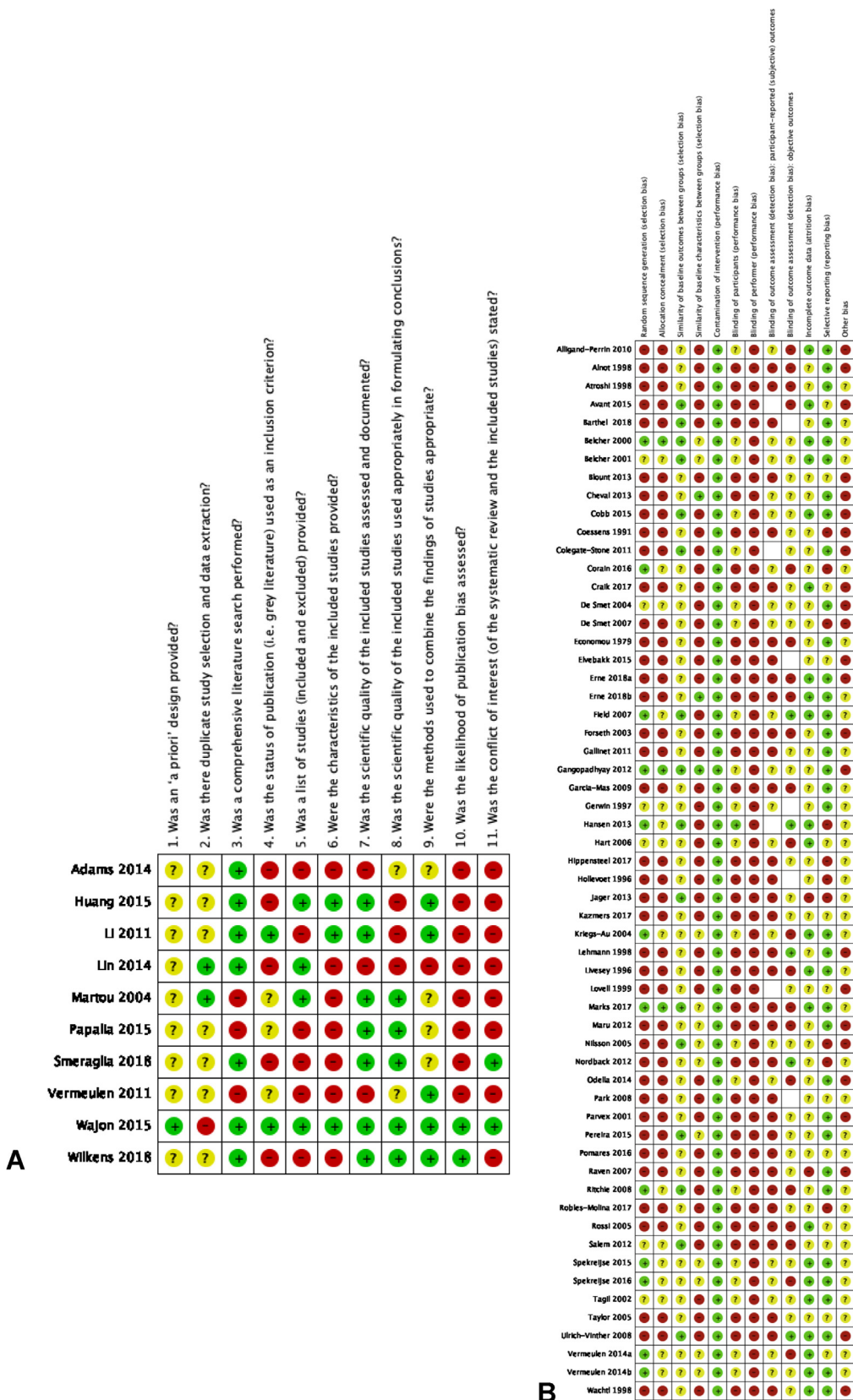


Figure 2. A Results of each Assessment of Multiple Systematic Reviews (AMSTAR) risk-of-bias item of the included systematic reviews. **B** Results of each item of the EPOC risk-of-bias tool of the included RCTs and NRCTs. +, low risk of bias; ?, unclear risk of bias; -, high risk of bias; AMSTAR, Assessment of Multiple Systematic Reviews; EPOC, Cochrane Effective Practice and Organisation of Care Group.

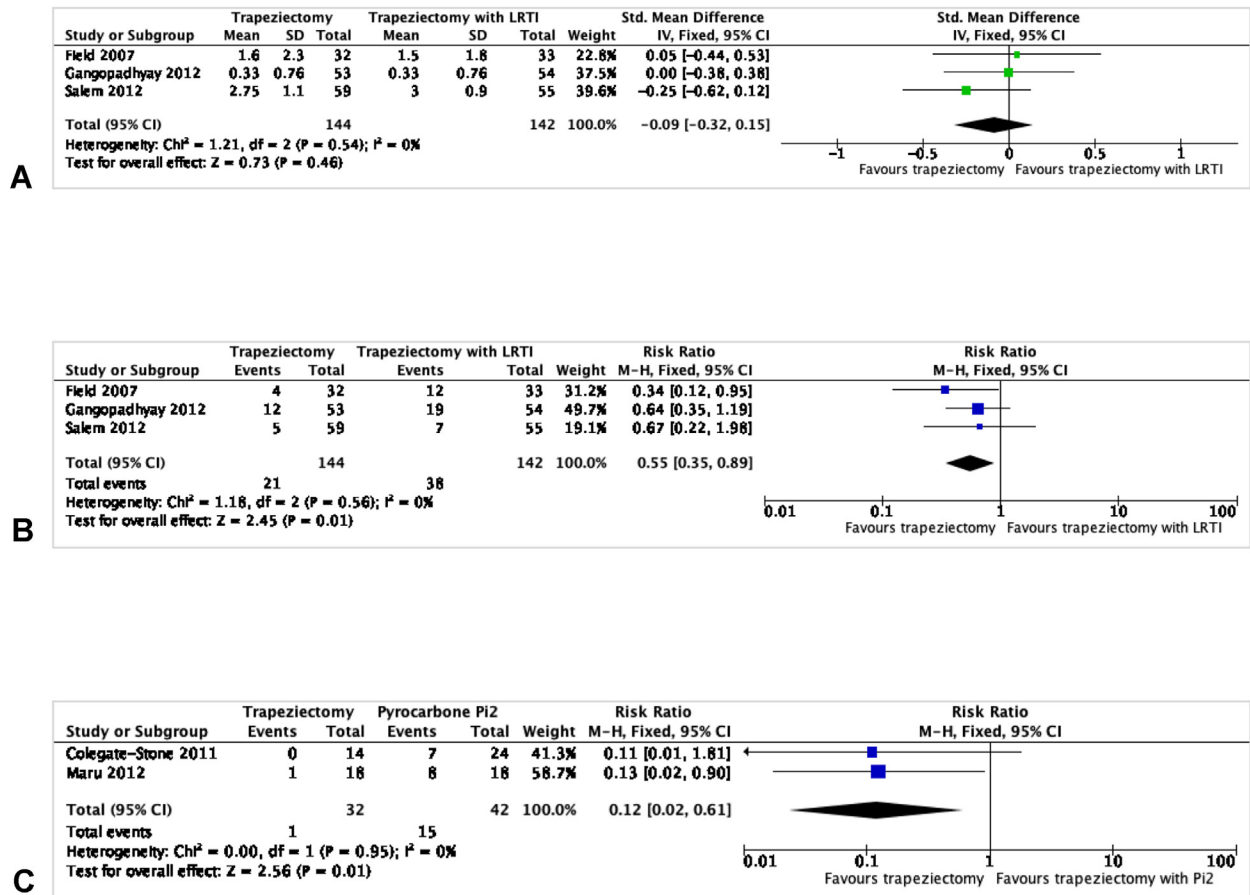


Figure 3. Results of the meta-analyses conducted. **A** T versus T+LRTI using 1/2FCR strip and metacarpal tunnel for relieving pain. **B** T versus T+LRTI using 1/2FCR strip and metacarpal tunnel for reducing the number of adverse events. **C** T versus T+Pyrocarbion Pi2 spacer for reducing the number of adverse events.

included SR¹⁶ was also taken into consideration to support our judgment.⁸⁷

Results

Question 1: What are the surgical interventions available for TMO whose efficacy has been documented?

We identified the following 11 TMO surgical techniques: first metacarpal osteotomy,⁴⁸ first metacarpal and trapezium partial resection,^{52,71} arthrodesis,^{35,40,44,56,57,70–73,81,82} trapeziectomy,^{28–32,37,38,53–55,58,60,65,76–78} trapeziectomy with hematoma distraction arthroplasty (HDA),^{42,69} trapeziectomy and ligament reconstruction (T+LR),^{16,33,36,42,48,49,51,76,84} trapeziectomy and tendon interposition (T+TI),^{32,63,71,83,84} trapeziectomy with ligament reconstruction and tendon interposition (T+LRTI),^{16,29–33,35,36,38–41,43–47,50,55,59,62–64,66,67,69,70,72,74,78,80–82,85} chondrocostal graft interposition,^{58,69} autologous fat injection,⁸⁰ and the use of the following manufactured implants: Arx,^{61,83} ARPE,^{77,85} Artelon,^{50,66} De la Caffinière,^{55,75} Elektra,^{34,74} Graft-Jacket,^{43,52} Guepar,⁴⁷ Ivory,⁷⁹ Ledoux,⁷⁵ Maia,⁶¹ Permacol,²⁸ Pi₂,^{46,51,54,65} PyroDisk,⁶⁸ Pyrocardan,⁶⁸ and Swanson.^{39,53,56,62,64,70,73}

Question 2: What is the efficacy of the identified surgical interventions?

The effect estimates of each TMO surgical procedures are presented in Table 1 for studies with evidence of low quality (due

to a RoB and imprecision) that are still the best studies available for their subject matter. We can summarize the efficacy of TMO surgeries whose effect estimates are moderate or large as follows.

T+LRTI

T+LRTI with 1/2 flexor carpi radialis (FCR)-MT was moderately inferior to trapeziectomy by posterior approach for reducing the number of adverse events (Table 1^{31,32,38} and Fig. 3B), largely inferior to T+LR with 1/2FCR-MT for physical function improvement (Table 1³⁶) and moderately superior to T+TI using PL for pain reduction (Table 1³²). T+LRTI (1/2FCR-APL-1/2FCR) was largely superior to arthrodesis by plate-screw fixation for reducing pain improving physical function, and reducing the number of adverse events (Table 1^{40,44}) and moderately superior to T+GraftJacket allograft for reducing the number of adverse events (Table 1⁴³). T+LRTI using APL-FCR-APL was moderately inferior to trapeziectomy by posterior approach (Table 1²⁹) and largely superior to T+Swanson implant for reducing the number of adverse events (Table 1³⁹).

T+LR

T+LR using 1/2FCR-MT was largely superior to T+LRTI with 1/2FCR-MT for physical function improvement (Table 1³⁶). T+LR using APL-MT-FCR was moderately-to-largely inferior to HDA for reducing pain improving physical function, and reducing the number of adverse events (Table 1⁴²).

Table 1
Summary of Findings Supported by Evidence of Low Quality

Surgical Interventions Compared	Outcome(s): Pain, PF, Psychological Well-Being, QoL, TS, AE	Study Design, Reference, Year of Publication, (Mean Follow-Up Time)	Effect Estimate*: SMD or Risk Ratio (RR) [95% CI] (No. of Thumbs Included)	Magnitude of Effect Estimate	Favored Intervention
1. T versus T+LRTI (FCR-MT)	Pain (VAS) PF (DASH)	RCT, De Smet et al, ³⁰ 2004, (T group 34 mo; T+LRTI group 26 mo)	SMD 0.39 [−0.16, 0.94] (55) SMD 0.23 [−0.31, 0.78] (55)	Small Small	T+LRTI (FCR-MT) T+LRTI (FCR-MT)
2. T+LRTI (½FCR-MT) versus T+LRTI (½FCR-APL-½FCR)	Pain (PRWHE pain) PF (PRWHE activities) PF (DASH) TS (no. of patients with good/excellent satisfaction) AE (scar tenderness, sensory changes, infection, tendinitis, neuroma, carpal tunnel syndrome, and worsening scaphotrapezoidal osteoarthritis)	RCT, Spekreijse et al, ⁴⁵ 2015 (mean 5.3 y) RCT, Spekreijse et al, ⁴⁵ 2015 (1–5 y)	SMD 0.05 [−0.41, 0.52] (72) SMD −0.05 [−0.52, 0.41] (72) SMD −0.41 [−0.88, 0.05] (72) RR 1.07 [0.85, 1.35] (72)	Trivial Trivial Small Trivial	T+LRTI (½FCR-APL-½FCR) T+LRTI (½FCR-MT) T+LRTI (½FCR-MT) T+LRTI (½FCR-MT)
3. T by posterior approach versus T+LRTI (½FCR-MT)	Pain (VAS, 0–6, the patient evaluating measure pain score) PF (DASH) AE (nerve dysfunction, tendon pulling sensation, tender scars, CRPS, and De Quervain's disease)	3 RCTs, Field and Buchanan, ³¹ 2007 (12 mo) Gangopadhyay et al, ³² 2012 (median 6 y) Salem and Davis, ³⁸ 2012 (6 y) RCT, Salem and Davis, ³⁸ 2012 (6 y) 3 RCTs, Field and Buchanan, ³¹ 2007 (12 mo) Gangopadhyay et al, ³² 2012 (median 6 y) Salem and Davis, ³⁸ 2012 (6 y)	SMD −0.09 [−0.32, 0.15] (142) (Fig. 3A) SMD 0.14 [−0.23, 0.51] (114) RR 0.55 [0.35, 0.89] (286) (Fig. 3B)	Trivial Trivial Moderate	T by posterior approach T+LRTI (½FCR-MT) T by posterior approach
4. T+LR (½FCR-MT) versus T+LRTI (½FCR-MT)	Pain (no. of patients with occasional to constant pain) PF (no. of patients with mild-to-severe difficulty) TS (no. of satisfied patients) AE (radial nerve irritation and CRPS)	RCT, Kriegs-Au et al, ³⁶ 2004 (48.2 mo) SR, Wajon et al, ¹⁶ 2015, and RCT, Kriegs-Au et al, ³⁶ 2004 (48.2 mo)	RR 0.85 [0.47, 1.57] (31) RR 0.30 [0.07, 1.24] (31) RR 1.32 [0.98, 1.78] (31) RR 0.71 [0.14, 3.68] (31)	Trivial Large Small Small	T+LR (½FCR-MT) T+LR (½FCR-MT) T+LRTI (½FCR-MT) T+LR (½FCR-MT)
5. T+LRTI (½FCR-MT) versus T+TI (PL)	Pain (0–6) AE (nerve dysfunction, tendon pulling sensation, tender scar, and CRPS)	RCT, Gangopadhyay et al, ³² 2012 (median 6 y)	SMD −0.56 [−0.97, −0.16] (100) RR 0.90 [0.54, 1.50] (100)	Moderate Trivial	T+LRTI (½FCR-MT) T+LRTI (½FCR-MT)
6. Arthrodesis (K-wire) versus T+LRTI (½FCR-MT-K-wire)	AE (CRPS)	RCT, Hart et al, ³⁵ 2006 (early after surgery)	RR 1.00 [0.16, 6.42] (40)	No effect difference	Arthrodesis (K-wire) = T+LRTI (½FCR-MT-K-wire)
7. T+LR (½FCR-MT-Minimitek) versus T+LRTI (½FCR-MT-Minimitek)	PF (no. of patients capable of doing 6 ADLs) TS (no. of satisfied patients)	RCT, Gerwin et al, ³³ 1997 (23 mo)	RR 1.00 [0.83, 1.20] (20) RR 0.92 [0.51, 1.65] (20)	No effect difference Trivial	T+LR (½FCR-MT-Minimitek) = T+LRTI (½FCR-MT-Minimitek) T+LRTI (½FCR-MT-Minimitek)
8. Arthrodesis (plate/screws) versus T+LRTI (½FCR-APL-½FCR)	Pain (PRWHE pain) PF (DASH) TS (no. of satisfied patients) AE (tendinitis, neuroma, nonunion requiring surgery, and CRPS)	RCT, Spekreijse et al, ⁴⁴ 2016 (5 y) RCT, Vermeulen et al, ⁴⁰ 2014 (12 mo) Spekreijse et al, ⁴⁴ 2016 (5 y)	SMD 0.85 [0.18, 1.52] (38) SMD 1.46 [0.73, 2.18] (38) RR 0.62 [0.38, 1.00] (38) RR 6.18 [0.80, 47.96] (38)	Large Large Small Large	T+LRTI (½FCR-APL-½FCR) T+LRTI (½FCR-APL-½FCR) T+LRTI (½FCR-APL-½FCR) T+LRTI (½FCR-APL-½FCR)
9. T+LRTI (½FCR-APL-½FCR) versus T+Graftjacket allograft	Pain (Michigan Hand Questionnaire pain) PF (DASH) QoL (SF-12 physical component) QoL (SF-12 mental component) AE (CRPS, trigger thumb, persistent FCR pain, tendinitis, thenar atrophy, and FCR partial rupture)	RCT, Marks et al, ⁴³ 2017 (12 mo)	SMD −0.33 [−0.85, 0.19] (58) SMD −0.26 [−0.78, 0.26] (58) SMD 0.11 [−0.41, 0.62] (58) SMD −0.24 [−0.76, 0.27] (58) RR 0.50 [0.19, 1.28] (60)	Small Small Trivial Small Moderate	T+LRTI (½FCR-APL-½FCR) T+LRTI (½FCR-APL-½FCR) T+Graftjacket allograft T+LRTI (½FCR-APL-½FCR) T+LRTI (½FCR-APL-½FCR)

Table 1 (continued)

Surgical Interventions Compared	Outcome(s): Pain, PF, Psychological Well-Being, QoL, TS, AE	Study Design, Reference, Year of Publication, (Mean Follow-Up Time)	Effect Estimate*: SMD or Risk Ratio (RR) [95% CI] (No. of Thumbs Included)	Magnitude of Effect Estimate	Favored Intervention
10. T by posterior approach versus T+LRTI (APL-FCR-APL)	Pain (VAS)	RCT, Belcher and Nicholl, ²⁹ 2000 (14 mo)	SMD -0.11 [-0.71, 0.50] (42)	Trivial	T by posterior approach
	PF (VAS)		SMD -0.41 [-1.03, 0.20] (42)	Small	T by posterior approach
	AE (recurrent pain, instability, neuroma, sensory loss, and FCR rupture)		RR 0.40 [0.09, 1.77] (42)	Moderate	T by posterior approach
11. T+LRTI (APL-FCR-APL) versus T+Swanson silastic implant	Pain (VAS)	RCT, Tagil and Kopylov, ³⁹ 2002 (2–4 y)	SMD 0.30 [-0.47, 1.07] (26)	Small	T+Swanson silastic implant
	TS (no. of satisfied patients)		RR 0.85 [0.65, 1.11] (26)	Trivial	T+Swanson silastic implant
12. T+HDA versus T+LR (APL-MT-FCR)	AE (implant dislocation)		RR 0.20 [0.01, 3.80] (26)	Large	T+LRTI (APL-FCR-APL)
	Pain (VAS)	RCT, Corain et al, ⁴² 2016 (T+HDA group 6.6 y; T+LR group 7 y)	SMD -3.06 [-3.60, -2.53] (120)	Large	T+HDA
13. T by posterior approach versus T+TI (PL)	PF (DASH)		SMD -0.76 [-1.13, -0.39] (120)	Moderate	T+HDA
	AE (FCR tendinitis)		RR 0.06 [0.00, 1.01] (120)	Large	T+HDA
	Pain (0–6)	RCT, Gangopadhyay et al, ³² 2012 (median 6 y)	SMD -0.56 [-0.97, -0.16] (99)	Moderate	T by posterior approach
14. T by anterior approach versus T by posterior approach	AE (nerve dysfunction, tendon pulling sensation, tender scar, and CRPS)		RR 0.58 [0.31, 1.07] (99)	Small	T by posterior approach
	Pain (VAS)	RCT, Ritchie and Becher, ³⁷ 2008 (33 mo)	SMD -0.28 [-0.90, 0.34] (40)	Small	T by anterior approach
	PF (VAS)		SMD -0.11 [-0.73, 0.51] (40)	Trivial	T by anterior approach
	TS (VAS)		SMD -0.94 [-1.60, -0.29] (40)	Large	T by anterior approach
	AE (sensory alteration around scar)		RR 0.33 [0.08, 1.46] (40)	Large	T by anterior approach
	AE (numbness around scar)		RR 0.25 [0.03, 2.05] (40)	Large	T by anterior approach
15. T by posterior approach versus T+Permacol porcine xenograft	AE (tenderness in scar)		RR 0.33 [0.01, 7.72] (40)	Large	T by anterior approach
	AE (infection)		RR 1.00 [0.07, 14.90] (40)	No effect difference	T by anterior approach = T by posterior approach
	Pain (VAS)	RCT, Belcher and Zic, ²⁸ 2001 (median 6 mo)	SMD -0.94 [-1.75, -0.12] (26)	Large	T by posterior approach
	PF (VAS)		SMD -0.51 [-1.30, 0.27] (26)	Moderate	T by posterior approach
	TS (VAS)		SMD -1.27 [-2.12, -0.41] (26)	Large	T by posterior approach
16. Elektra uncemented cup versus Elektra cemented cup	AE (neuroma, sensory change, erythema, pain, and instability)		RR 0.38 [0.13, 1.11] (26)	Moderate	T by posterior approach
	AE (cementing failure, trapezium fracture, cup loosening, and migration)	RCT, Hansen and Stilling, ³⁴ 2013 (2 y)	RR 1.08 [0.18, 6.57] (28)	Trivial	Elektra uncemented cup

ADL, activities of daily living; AE, adverse event; APL, abductor pollicis longus; CI, confidence interval; CRPS, complex regional pain syndrome; DASH, disabilities of the arm, Shoulder and Hand; FCR, flexor carpi radialis; HDA, hematoma distraction arthroplasty; LR, ligament reconstruction; LRTI, ligament reconstruction and tendon interposition; MT, metacarpal tunnel; PF, physical function; PL, palmaris longus; PRWHE, patient-report wrist hand evaluation; QoL, quality of life; RCT, randomized controlled trial; RR, risk ratio; SF, short-form; SMD, standardized mean difference; SR, systematic review; T, trapeziectomy; TI, tendon interposition; TS, treatment satisfaction; VAS, visual analog scale.

SMDs for continuous outcomes and RRs for dichotomous outcomes were used to establish the relative effect of each intervention. A relative effect was considered trivial when SMD <|±0.2| or 0.82 <RR <1.22, small when SMD = |±0.2| or RR = 1.22 (or 0.82), moderate when SMD = |±0.5| or RR = 1.82 (or 0.55), large when SMD = |±0.8| or RR = 3.0 (or 0.33).^{17,103,105} The null values, ie, SMD = 0 and RR = 1, indicate no difference in treatment effect between the 2 compared interventions.¹⁰⁴ SMD <0 indicates the superiority of the first interventions; SMD >0 indicates that the second intervention was superior. For dichotomous outcomes, when the outcome was undesirable (eg, number of patients in pain, adverse events), RR <1 indicates the superiority of the first interventions; RR >1 indicates that the second intervention was superior. When the outcome was desirable (eg, number of satisfied patients), RR >1 indicates the superiority of the first interventions and RR <1 indicates the superiority of the second intervention.

* Interpretation of effect size.

T+TI

T+TI using the PL tendon was moderately inferior to T+LRTI with ½FCR-MT and trapeziectomy by posterior approach for reducing pain (Table 1³²).

Trapeziectomy

Trapeziectomy by posterior (dorsolateral) approach was largely inferior to trapeziectomy by anterior approach (Table 1³⁷) for treatment satisfaction and reducing the number of adverse events. However this technique was moderately-to-largely superior to T+LRTI with ½FCR-MT and T+LRTI with APL strip-FCR-APL strip in terms of reducing the number of adverse events (Table 1^{29,31,32,38} and Fig. 3B); T+TI using PL for relieving pain (Table 1³²); and

T+Permacol xenograft for reducing pain improving physical function, ensuring treatment satisfaction, and preventing complications (Table 1²⁸).

Arthrodesis

Arthrodesis by plate-screw fixation was largely inferior to T+LRTI with ½FCR-APL-½FCR for relieving pain, improving physical function, and reducing the number of adverse events (Table 1^{40,44}).

HDA

HDA demonstrated moderate-to-large superiority compared to T+LR performed with APL-MT-FCR for pain, physical function, and adverse events (Table 1⁴²).

Manufactured implants

The GraftJacket allograft, Permacol xenograft, and Swanson implant were moderately-to-largely inferior to their comparators (T+LRTI with ½FCR-APL-½FCR, Table 1⁴³; T+LRTI with APL-FCR-APL Table 1³⁹; and trapeziectomy by posterior approach Table 1²⁸ respectively) for relieving pain improving physical function, ensuring treatment satisfaction, and/or reducing the number of adverse events.

The effect estimates of other surgical interventions supported by evidence of very low quality are presented in Appendix 4 (Appendix 4 is available on the Journal's Web site at www.jhsgo.org).

Discussion

TMO is one of the most prevalent and painful forms of hand osteoarthritis.^{1–3} The TMO care regimen usually starts with nonsurgical interventions; when they are unsuccessful, surgery may be chosen.⁵ Unfortunately, evidence of the efficacy of comprehensive surgical interventions for TMO was lacking. Therefore, we conducted an SR to identify all the surgical interventions for TMO and review their efficacy.

We identified 11 categories of surgical techniques: first metacarpal osteotomy,⁴⁸ first metacarpal and trapezium partial resection,^{52,71} arthrodesis,^{35,40,44,56,57,70–73,81,82} trapeziectomy,^{28–32,37,38,53–55,58,60,65,76–78} T+HDA,^{42,69} T+LR,^{16,33,36,42,48,49,51,76,84} T+TI,^{32,63,71,83,84} T+LRTI,^{16,29–33,35,36,38–41,43–47,50,55,59,62–64,66,67,69,70,72,74,78,80–82,85} chondrocostal graft interposition,^{58,69} autologous fat injection,⁸⁰ and the use of manufactured implants.^{28,34,39,43,46,47,50–56,61,62,64–66,68,70,73–75,77,79,83,85}

Pertaining to the efficacy of these surgical techniques, the evidence quality was low at best. Although some readers may view evidence of such quality as unreliable, one must consider that generating robust evidence in the field of surgery is nearly impossible because of numerous obstacles in conducting high-quality RCTs (eg, impossibility to blind surgeons, urgent situations, learning curves, or patients' reluctance for randomization or participation in a trial).^{95–98}

If we systematically consider low-quality evidence unreliable, this research field will never generate new evidence through an SR (unless cumulative homogeneous RCTs reach a pooled sample size of 400), and all the efforts put in by the trialists of surgery research will be completely in vain. Therefore, we suggest considering low-quality evidence in such a context as “the best available” evidence. Indeed, a trivial or small effect estimate supported by low-quality evidence would not be indicative of anything, but a moderate-to-large effect estimate can at least suggest some superiority of 1 intervention over another. From this perspective, we can conclude the findings of the present review as follows: T+LRTI using ½FCR-MC or APL-FCR should not be recommended when compared to trapeziectomy, which has a simpler procedure, because of higher complication rates in T+LRTI groups.^{29,31,32,38} Choosing T+LRTI with ½FCR-MC is also not justified because of its largely inferior effect on physical function compared with the simpler procedure T+LR using ½FCR-MC.³⁶ T+TI using PL is also not recommended because of its moderate inferiority compared with trapeziectomy and T+LRTI with ½FCR-MC for relieving pain. HDA would be an interesting choice for surgeons because of its simpler procedure and capacity for maintaining “a metacarpal height to the scaphoid, an important aspect for restoring force” because it was moderately-to-largely superior to T+LR (APL-MT-FCR) for 3 outcomes (pain, physical function, and adverse events) in a relatively large sample size (n = 120).⁴² Trapeziectomy by anterior approach—less practiced than that by posterior approach—has shown large effects in terms of adverse events and higher treatment satisfaction compared with the latter,³⁷ probably because “removal of the trapezium via the

anterior approach is easier and, perhaps, can be achieved less traumatically.”³⁷ The use of the Swanson silastic prosthesis, Permacolxenograft, or GraftJacket allograft and hardware (screws/plate) increases the complication rate when compared to an autograft.^{10,28,39,40,44}

Pertaining to first metacarpal osteotomy, first metacarpal and trapezium partial resection, chondrocostal graft interposition, autologous fat injection, and the use of manufactured implants (Arex, ARPE, Artelon, De la Caffinière, Guepar, Ivory, Ledoux, Maia, Pi2, PyroDisk, Pyrocardan), the evidence quality was low (Appendix 4); thus, we have little confidence in their effect estimates.

Our results diverged from a previous SR conducted by Wajon et al,¹⁶ who concluded that “of the surgical options included, this systematic review has failed to identify any additional benefit in terms of pain, physical function, patient global assessment, strength, adverse events of any procedure over another.” The discrepancies between their SR and ours are due to the diverged interpretations of what is “not statistically significant,” which is commonly interpreted as “no effect difference” based on an arbitrary *P* value.⁹⁹ Yet, it should be interpreted as “no strong evidence that the intervention effects are different.”⁹⁹ Secondly, our SR included scientific papers published before July 4, 2018, whereas the SR conducted by Wajon et al¹⁶ included publications from before August 8, 2013. Consequently, our SR added knowledge generated from 6 new RCTs,^{40–45} which is presented in Table 1.

Despite its rigorous methodological quality based on the Cochrane and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses recommendations, the limitations of this SR need to be mentioned. First, the evidence provided by this SR was, at best, of low quality, thereby limiting our confidence in the effect estimates. Second, the literature search was limited to English and French. Yet, there is some evidence of the fact that the effect estimates of English language-restricted meta-analyses do not greatly differ from those that include other languages.¹⁰⁰ Thus, the bias related to languages in our findings may be negligible. Third, certain trials^{31,36,41–43,47,49,51,59,65,67,71,72,76,81,82} included patients with scaphotrapezial osteoarthritis, a common comorbidity of TMO. Other trials^{30,33,37–39,50,52,54–57,61–64,69,70,78} did not report whether they included patients with this type of osteoarthritis or not. This may have compromised the validity of our findings. However, according to a cross-sectional study,¹⁰¹ the presence of scaphotrapeziotrapezoid osteoarthritis accounted solely for 1% of the variance of pain intensity in patients with TMO. We, therefore, believe that the inclusion of patients with this type of osteoarthritis in our review did not threaten the validity of its findings.

The evidence quality supporting the efficacy of surgical interventions included in this SR was found to be low or very low. Indeed, it is highly challenging to conduct an RCT with minimal RoB in surgical research because of the aforementioned obstacles.^{95–98} To be able to generate more robust evidence (at least of moderate-level quality), more RCTs are needed to obtain a pooled sample size of 400 (200 per group), as required for the GRADE precision criteria for continuous variables.¹⁰² Performing a network meta-analysis comparing directly and indirectly different surgical interventions for TMO could also be useful to summarize their relative efficacy. However, this type of analysis requires clinical and methodological homogeneity among trials. Thus, concerted efforts toward harmonization of trial methodology are desired (eg, using the same outcome measures and assessment time points).

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