Trapeziectomy with Ligament Reconstruction and Tendon Interposition versus Trapeziometacarpal Joint Replacement for Thumb Carpometacarpal Osteoarthritis: A Systematic Review and Meta-Analysis

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Abstract

Background The trapeziometacarpal articulation in the thumb is a joint that is second-most commonly affected by osteoarthritis, and this can lead to considerable hand pain and disability. Currently, there is a multiplicity of surgical options available to address this problem, yet none has proven to be significantly superior to the others.

Objective This study aims to compare the outcome of trapeziectomy with ligament reconstruction and tendon interposition versus trapeziometacarpal joint replacement for thumb carpometacarpal osteoarthritis.

Materials and Methods A systematic review and meta-analysis was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement standards. The NICE Healthcare Databases Advanced Search (HDAS) tool was used to search articles. One randomized controlled trial (RCT), one prospective cohort study and two retrospective cohort studies were identified.

Results Our results demonstrate a significant difference in the Quick Disabilities of the Arm Shoulder and Hand (QDASH) score between the trapeziectomy with ligament reconstruction and tendon interposition (LRTI) and Joint Replacement groups with the joint replacement group exhibiting better QDASH scores than the LRTI group. We also found that those who had a joint replacement had a significantly better thumb opposition than those in the LRTI group, as demonstrated by a superior Kapandji score. However, the complication rate of joint replacement appears to be higher.

Conclusion Our study reveals that while both treatment options are valid, the limited body of evidence currently available shows that joint replacement carries more risks and thus should not replace the current standard treatment of trapeziectomy with LRTI. This study highlights the need for more trials to be performed to more accurately

Keywords
- trapeziectomy
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compare the two treatment modalities. For the time being, we advocate that joint replacement is only performed by surgeons who perform this procedure regularly to reduce the risk of complications.

The trapeziometacarpal articulation in the thumb is a joint that is second-most commonly affected by osteoarthritis, and this can lead to considerable hand pain and disability.[1,2] Trapeziometacarpal arthritis typically occurs in those aged between 50 and 70 years, and it is often associated with obesity and having a manual occupation.[3] Currently, there is a multiplicity of surgical options available to address this problem, yet none has proven to be significantly superior to the others.[4] The most commonly performed procedure is a trapeziectomy augmented with ligament reconstruction and tendon interposition (LRTI). The latter technical modification was developed to help prevent postoperative loss of strength, thumb shortening, and risk of scaphoid impingement.[5,6] Total joint replacement has evolved since its introduction in the 1970s,[7,8] and recent studies have suggested that it can provide a quicker rehabilitation period and improved function in the short term when compared with the LRTI.[9–12]

In this article, the postoperative outcomes of trapeziectomy with LRTI and trapeziometacarpal joint replacement have been compared. Up to 2019, there had been no randomized controlled trials (RCTs), with most studies being nonrandomized and comparative in nature. Our aim was to perform a systematic review of the literature and meta-analysis to examine the patient related outcomes.

Materials and Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[13] formed the basis on which this systematic review was performed.

Eligibility Criteria

The Population, Intervention, Control, Outcome, and Time (PICOT) criteria[14] was used to formulate the eligibility criteria, therefore reducing ambiguity. All RCTs and observational studies comparing the outcomes of trapeziectomy with LRTI and trapeziometacarpal joint replacement for thumb carpometacarpal osteoarthritis that met the criteria were included. Thumb carpometacarpal osteoarthritis was the pathology of interest.

Outcome Measures

Five outcome measures were compared: The Quick Disabilities of the Arm, Shoulder, and Hand (QDASH) score, Kapandji score, grip strength, pinch strength, and the Visual Analog Scale (VAS) for pain score.

Literature Search Strategy

Two independent co-authors (M.K.Q. and U.H.) used the NICE Healthcare Databases Advanced Search (HDAS) tool to search articles in the PubMed, Medline, EMBASE, and Cochrane Central Register of Controlled Trials databases. The most recent search was performed on August 16, 2020. Articles included in this review were critically evaluated by using the Critical Appraisal Skills Program tool[15] and Cochrane Handbook for Systematic Reviews of Interventions.[16]

Study Selection

Two co-authors assessed the titles and abstracts of all the identified studies from the literature search. Of the studies which were deemed applicable, the full texts were evaluated and those which met the eligibility criteria were selected. A third co-author was involved if there were any discrepancies identified within the study selection.

Data Collection

The Cochrane's data collection criteria for intervention reviews were used to produce a data extraction sheet. Study data extraction included authors, journal, study design, sample size, follow-up period, and outcome measures recorded. Demographics such as mean age and sex were collected. Two independent co-authors extracted the data, and where there were any discrepancies a third co-author was consulted.

Data Synthesis and Statistical Analysis

For the key continuous outcome measures of interest (QDASH, VAS score, grip strength, pinch strength, and Kapandji score), the mean differences between the trapeziectomy with LRTI and thumb carpometacarpal joint replacement groups were calculated.

Review manager 5.3 software (Cochrane Community, Oxford, United Kingdom) was selected for data analysis. Fixed and random-effect models were employed as necessary. Random-effects modelling was only applied if substantial heterogeneity was present between the studies. Forest plots using 95% confidence intervals (CI) were used to display the results. The I^2 was calculated to reveal any inconsistencies between the studies. However, 0 to 25% suggested low heterogeneity, 25 to 75% suggested moderate heterogeneity, and 75 to 100% suggested high heterogeneity.

Methodological Quality and Risk of Bias Assessment

The risk of bias was assessed by using the Cochrane tool[17] and Newcastle-Ottawa Scale (NOS).[18] All articles were evaluated by two independent co-authors. The Cochrane tool analyses bias specifically existing in RCTs in domains such as selection, reporting, and attrition. The NOS employs a 1-star (lowest risk) to 9-star (highest risk) scale to judge the quality of each study on three broad areas; the comparability of the groups, the selection of each study group, and the ascertainment of outcome of interest. If any dispute arose between assessments of both co-authors, a third independent co-author was consulted.

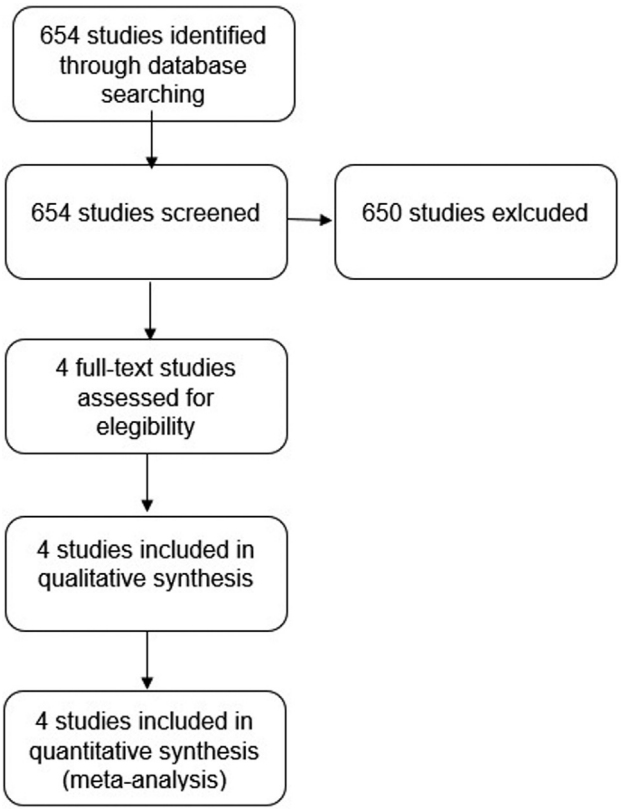

Fig. 1 Study flow diagram.

Sensitivity Analysis

To evaluate the strength of our data and to investigate possible sources of heterogeneity, sensitivity analysis was performed. To investigate the effect each study had on the overall effect heterogeneity, the statistical analyses were performed multiple times once each study had been removed separately.

Results

Literature Search Results

A total of 654 articles were identified during the literature search, of which four met the inclusion criteria for this review (►**Fig. 1**). This consisted of one RCT,[9] one prospective cohort study,[11] and two retrospective cohort studies.[12,19]

Patient Demographics and Follow-Up

The total number of patients who underwent treatment in these articles was 583. Of those, 358 underwent trapeziectomy with LRTI and 225 underwent an arthroplasty procedure. The mean age of the patients was 68 years. The percentage of female patients was 84%. The mean follow-up period was 54 months. Height and weight were not recorded in any of the selected studies. ►**Table 1** presents the characteristics of each study included Methodological Quality and Risk of Bias.

►**Figure 2** represents the outcomes of the methodological quality assessment of all the studies included.

Outcome: Quick Disabilities of the Arm, Shoulder, and Hand Score

The QDASH score was recorded in four studies[9,11,12,19] involving 583 patients (►**Fig. 3**). There was a significant difference in the QDASH score between the trapeziectomy with LRTI and joint replacement groups ($Z = 3.37$, $p = 0.0008$). The joint replacement group exhibited better QDASH scores than the trapeziectomy group. Heterogeneity was deemed to be low among the studies ($I^2 = 0\%$, $p = 0.42$). The mean difference in QDASH score was 4.32 (95% CI: 1.80–6.83) in favor of joint replacement.

Outcome: Visual Analog Scale Score

The VAS score was recorded in three studies[11,12,19] involving 543 patients (►**Fig. 3**). There was no significant difference in the VAS score between the trapeziectomy with LRTI and joint replacement groups ($Z = 0.89$, $p = 0.38$). Heterogeneity was deemed to be high between the studies ($I^2 = 82\%$, $p = 0.004$). The mean difference in VAS score was 0.39 (95% CI: −0.47 to 1.25) in favor of joint replacement.

Outcome: Kapandji Score

The Kapandji score was recorded in three studies[9,11,12] involving 251 patients (►**Fig. 3**). There was a significant difference in the Kapandji score between the trapeziectomy with LRTI and joint replacement groups ($Z = 3.09$, $p = 0.002$). The joint replacement group exhibited better Kapandji scores when compared with the trapeziectomy with LRTI group. Heterogeneity was deemed to be moderate between the studies ($I^2 = 40\%$, $p = 0.19$). The mean difference in

Table 1 Baseline characteristics of the included studies

Study (Year)	Journal title	Study design	Follow-up (mo)	Sample size	Trapeziectomy + LRTI	Arthroplasty	Mean age (y)	Female (%)
Thorkildsen et al[9] (2019)	Journal of Plastic Surgery and Hand Surgery	RCT	48	40	20	20	62.5	70
Cebrian-Gomez et al[11] (2019)	The Journal of Hand Surgery (European volume)	Prospective	45.5	146	62	84	60.65	92.15
Robles-Molina et al[12] (2017)	Orthopaedics	Retrospective	57.5	65	34	31	58.43	83
Vandenberghe et al[19] (2013)	The Journal of Hand Surgery (European volume)	Retrospective	64.8	332	242	90	59.5	91.57

Abbreviations: LRTI, ligament reconstruction and tendon interposition; RCT, randomized controlled trial.

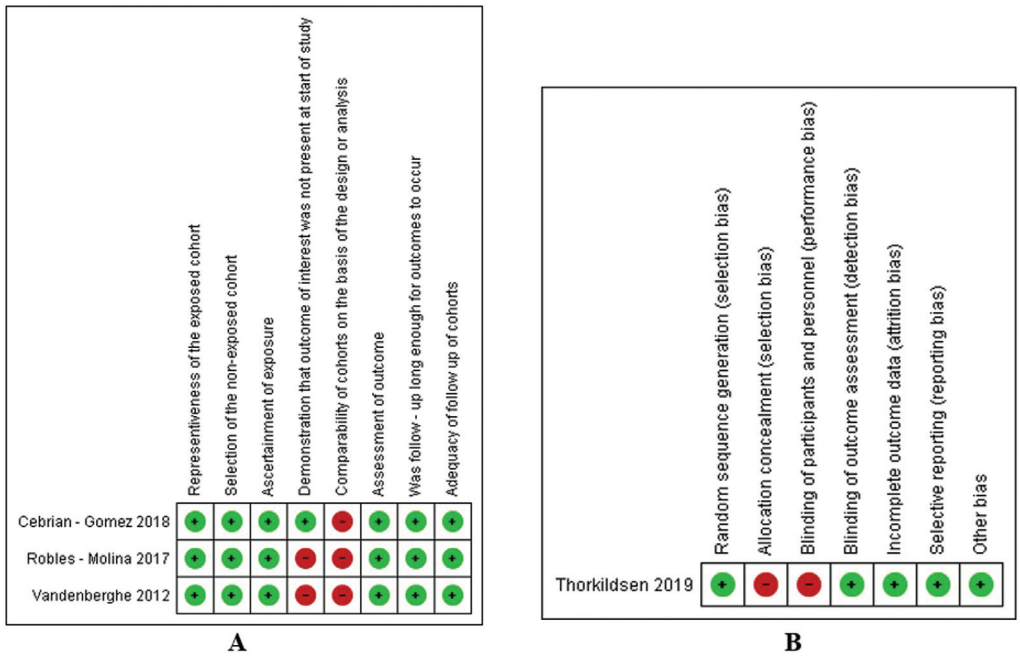

Fig. 2 Risk of bias graph showing authors' judgements about each risk of bias item for observational studies (**A**) and randomized trials (**B**).

Kapandji score was 0.53 (95% CI: 0.87–0.19) in favor of joint replacement.

Outcome: Grip Strength

The grip strength was recorded in two studies[9,11] involving 186 patients (►**Fig. 3**). There was no significant difference in grip strength between the trapeziectomy with LRTI and joint replacement groups ($Z = 0.57$, $p = 0.57$). Heterogeneity was deemed to be low among the studies ($I^2 = 0\%$, $p = 0.50$). The mean difference in grip strength was −0.61 (95% CI: −2.71 to 1.48) in favor of trapeziectomy with LRTI.

Outcome: Pinch Strength

The pinch strength was recorded in three studies[9,11,12] involving 251 patients (►**Fig. 3**). There was no significant difference in grip strength between the trapeziectomy with LRTI and joint replacement groups ($Z = 0.94$, $p = 0.35$). Heterogeneity was deemed to be high between the studies ($I^2 = 88\%$, $p = 0.0002$). The mean difference in pinch strength was −0.87 (95% CI: −2.67 to 0.93) in favor of trapeziectomy with LRTI.

Randomized Controlled Trials

One RCT involving 40 patients was included in this study. No significant differences in the primary outcomes measured was noted between the groups at 2 years. No significant difference in the objective measurements was noted between the groups at 2 years.

Radiological Assessment

Thorkildsen et al preoperatively assessed the patients with standardized anteroposterior (AP) and lateral radiographs of both thumbs as well as computed tomography scans of the involved hand. Repeat radiographs were taken 6 weeks postoperatively and at all subsequent follow-up appointments. In the arthroplasty group, lesions were analyzed by using the lateral radiograph in the zones described by Chakrabarti et al.[20] For the trapeziectomy group, the ratio of the trapezial space to the length of the proximal phalanx was calculated pre- and postoperatively. At the final follow-up, the trapezial space height was described according to Downing and Davis.[21]

Cebrian-Gomez et al assessed standard AP and lateral radiographs of the affected hand. The Eaton classification[22] was used to assess the preoperative trapeziometacarpal status. In the joint replacement group, the latest radiographs at follow-up were compared with 2-week postoperative radiographs as described by Wacht et al.[23]

Robles-Molina et al and Vandenberghe et al did not describe their radiological assessment within their studies.

Surgical Technique

Thorkildsen et al describe using a hydroxyapatite coated Elektra total joint replacement (Small Bone Innovations International, ZA Les Bruyères, Pèronnas, France), which was inserted by a single expert level 3 according to Tang and Giddins criteria[24] surgeon under general anesthetic via a dorsal approach. Trapeziectomy with LRTI was also performed by using a dorsal approach. The trapezium was removed in two pieces and flexor carpi radialis (FCR) was harvested and inserted into the trapezial void. Capsular and skin closure were identical in both procedures. The postoperative rehabilitation was identical in both groups.

Cebrian-Gomez et al describe using a cementless modular Ivory system (Stryker, Memometal, Bruz, France) prosthesis,

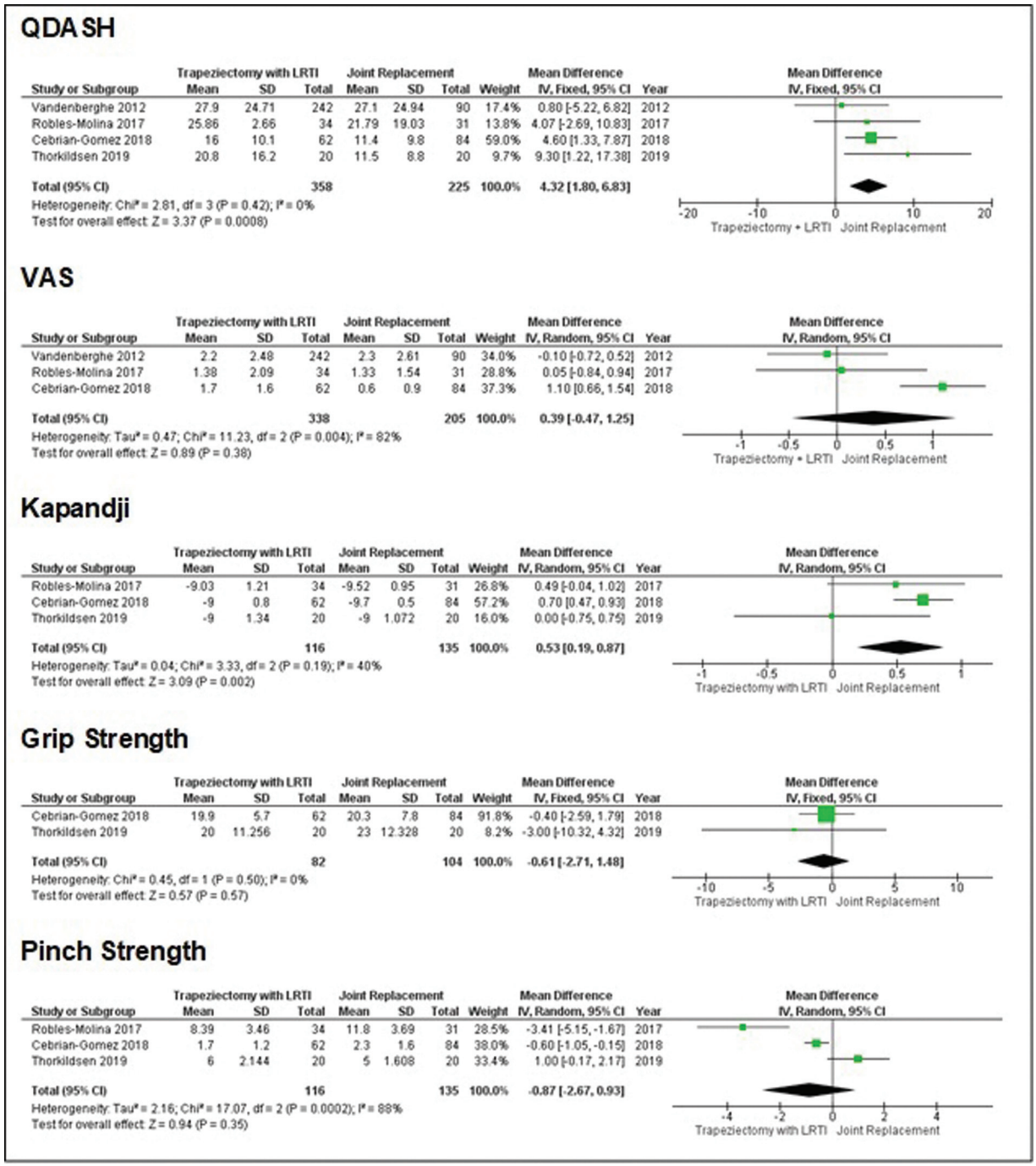

Fig. 3 Forest plots of the comparisons of the Quick Disabilities of the Arm, Shoulder, and Hand score (QDASH), the Visual Analogue Scale (VAS) for pain score, Kapandji score, grip strength and pinch strength.

which was inserted via the dorsal approach by a single surgeon with expertise level 3 according to Tang and Giddins criteria. In the trapeziectomy group, the operative technique was similar to that described by Burton and Pellegrini.[25] Both procedures were undertaken under regional anesthesia.

Robles-Molina et al describe using the Arpe cementless prosthesis introduced by Biomet (Valence, France) via the Wagner anterolateral approach.[26] A modified Burton-Pellegrini technique was performed in the trapeziectomy with LRTI group, removing the trapezium via a lateral approach. Unlike the original technique, the full thickness of the FCR tendon was used to suspend the first metacarpal through a bone tunnel, and no intermetacarpal stabilization with Kirschner wire was performed. In this study, there was neither mention of the number of surgeons nor their expertise level.

Vandenberghe et al state that two different prosthesis were used: a cemented prosthesis (De La Caffiniere [Stryker, Howmedical]) and the Roseland (DePuy International Ltd, Leeds, England). A radiopalmar approach was used. In the trapeziectomy group, a Burton-Pellegrini technique was employed via a dorsal approach.

Complications

Thorkildsen et al experienced complications in nine patients: six in the joint replacement group and three in the trapeziectomy with LRTI group. There were two cup loosenings, resulting in one being revised to trapeziectomy with LRTI and the other to a cemented revision polyethylene cup. Three patients had dislocations. Of these, one patient required a closed reduction only, the second was revised to trapeziectomy with LRTI and the third patient underwent an arthrodesis. One patient was treated for suspected periprosthetic joint infection and required a two-stage revision with the final procedure being an arthrodesis. In the trapeziectomy group, one patient had transitory hematoma in the forearm and two patients experienced long-term pain, but no cause was identified.[9] Cebrian-Gomez et al state that seven patients (8.3%) in the prosthesis group had complications, including one superficial infection, two cases of dysesthesia in the superficial radial nerve, and one algodystrophy. Two patients had dislocations, one of which trapezial cup loosening and both required revision surgery to LRTI and removal of metacarpal stems. One patient had his prosthesis revised to a new prosthesis. In the trapeziectomy group, there were five patients (9.7%) with complications, but no revisions. Two patients had collapse of the trapeziometacarpal space with continuous pain, two had painful degenerative changes at the scaphotrapezial joint and one had algodystrophy. Robles-Molina et al state that five patients in their prosthesis group experienced complications. Two patients had dysesthesia of the superficial branch of the radial nerve. Dislocations were observed in three patients who all underwent revision surgery with prosthesis removal and LRTI. In the trapeziectomy group, four patients experienced complications. Two patients had dysesthesia of the superficial branch of the radial nerve, and two patients required further surgery to correct metacarpophalangeal hyperextension.

Discussion

The results of this systematic review and meta-analysis demonstrate that joint replacement confers a statistically significant benefit in physical function and symptoms compared with trapeziectomy with LRTI, as evidenced by superior QDASH and Kapandji scores. QDASH uses 11 items to measure physical function and symptoms in patients with musculoskeletal disorders of the upper limb, so is regarded as a useful tool for assessing overall upper limb performance. Joint replacement is shown to give significantly better thumb opposition than trapeziectomy with LRTI, as demonstrated by a superior Kapandji score.

When other tools are used to study particular aspects of function and symptoms, however, the differences between the two treatment modalities become less clear. No significant differences in grip strength or pinch strength have been demonstrated by our meta-analysis. Furthermore, we have found that neither treatment modality confers superior pain relief, given their similar VAS scores.

Overall, the current body of evidence does not reveal convincing data to show that joint replacement should supersede trapeziectomy with LRTI. Some may highlight the better QDASH and Kapandji scores for joint replacement as evidence for its superiority. However, certain caveats must be borne in mind. First, the mean difference in QDASH score was 4.32 (95% CI: 1.80–6.83) in favor of joint replacement, but this is much lower than the mean clinically important difference of 15 that was used in the only RCT that has so far been conducted.[9] Second, any benefit in function and symptoms must be balanced against the higher risk of complications which appear to come with joint replacement.

In a case series of 39 patients who received an Elektra joint replacement, there was a 24% revision rate at 36 months.[27] Moreover, the dislocation rates have been estimated at 7%.[28] In comparison, the revision rate for trapeziectomy (including those with and without LRTI) is said to be 4.6% at 10 years.[29] It may be hard to justify the small functional and symptom improvement conferred by joint replacement when revision rates are much higher than that of trapeziectomy. Moreover, trapeziectomy with LRTI has been shown to confer a greater degree of thumb opposition than joint replacement, with equivalent VAS pain scores, pinch strength, and grip strength.

There are several limitations to this systematic review and meta-analysis. First, a total of only 583 patients have been studied in the literature. In addition, only one RCT exists to date, and this was conducted in a single center, with all operations performed by a single surgeon.[9] Furthermore, this study only had a 2-year follow-up and was subject to selection and performance bias.[9] Moreover, the studies included in this meta-analysis used different implants and implantation techniques in their joint replacement groups. Questions remain as to which implant type and implantation method (cemented or uncemented) gives the best outcome.

This systematic review and meta-analysis therefore highlights the need for a more detailed and expansive comparisons of joint replacement with trapeziectomy and LRTI. A priority is the need for large, adequately powered multicenter RCTs which are double blinded. These must also have a sufficiently long follow-up to detect late complications, including polyethylene wear and implant loosening. Such studies would also be useful for investigating the properties of different components, such as cemented and uncemented stems and cups, as well as metal and ceramic heads. Additionally, they would be required to provide clear data on the frequency of the various complications of joint replacement. Once the benefits of joint replacement can be more confidently ascertained it would also be pertinent to perform cost-benefit analyses to see whether the additional cost of joint replacement are justified.

Conclusion

The existing literature suggests that joint replacement gives superior upper limb function and symptom improvement than trapeziectomy with LRTI, but the benefit does not appear to be clinically significant. Moreover, trapeziectomy with LRTI appears to confer a greater degree of thumb opposition than joint replacement. Our study reveals that both treatment

options are valid. While arthroplasty is less commonly done, we have identified that it carries a higher risk of complications than trapeziectomy with LRTI. As such, we advocate that this procedure is only performed by surgeons who perform them regularly to reduce the risk of complications.

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Conflict of Interest
None declared.

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