Trapeziometacarpal Total Joint Arthroplasty versus Trapeziectomy

Clinical Outcomes, Patient Experiences and Postoperative Care



Elske Bonhof-Jansen

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Never say never...

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Chapter 1

GENERAL INTRODUCTION

The trapeziometacarpal joint

The trapeziometacarpal joint (TMJ) of the thumb, also referred to by some as the carpometacarpal joint of the thumb, is formed by the trapezium and the first metacarpal (Figure 1). Due to its saddle form, the joint has a high degree of mobility, allowing flexion-extension, abduction-adduction and pro-supination. This enables opposition of the thumb, necessary for grasping, holding and manipulating objects. The cost of the high degree of mobility is the low intrinsic joint stability predisposing the joint to dorsoradial subluxation and metacarpal adduction during forceful thumb activities [1,2]. Therefore, ligaments are essential for stabilization of the TMJ during pinch and grasp functions and with the musculature they contribute to the stability and neuromuscular control of the joint through ligamentomuscular reflexes [3]. Ligamentous laxity or weakness can also change normal muscle function hereby reducing the joint alignment and stability. When subluxation of the TMJ occurs, the abductor pollicis longus was found to be the primary destabilizer and increased dorsoradial subluxation whereas the first dorsal interosseous muscle caused the least dorsoradial translation [4]. The greatest muscle strength is produced during flexion and adduction, corresponding with a strong key pinch. Compression forces at the TMJ has been found to be up to 12 times greater than the contact forces at the thumb's pulpa, typically during (key) pinch activities [5]. These biomechanical factors could add to factors predisposing the TMJ to degenerative changes like osteoarthritis (OA)[1–3].

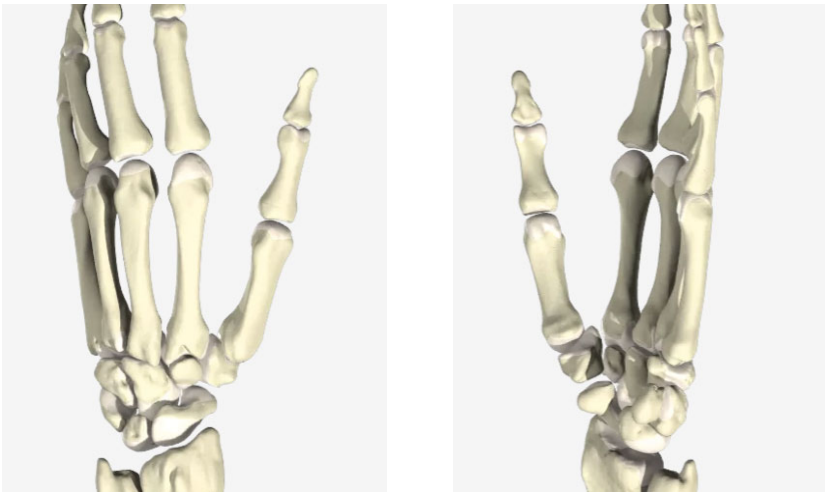


Figure 1. Left trapeziometacarpal joint from a dorsoradial and volar-ulnar view.
(Reproduced with kind permission from © Pharma Intelligence UK Ltd (trading as Primal Pictures), 2023. www.primalpictures.com, www.anatomy.tv)

Osteoarthritis of the trapeziometacarpal joint

TMJ OA is a common cause of pain and weakness in the thumb, leading to hand disability [2,6–10]. The prevalence of radiographic TMC OA rises with increasing age and is higher in females compared with males [11,12]. In the female Dutch population this prevalence ranges from 15% at the age of 55-59 years to 52% at the age of 80+ years [6,12,13]. It was found that symptomatic hand OA is twice as common in women than in men [11]. Radiographic signs of OA are weakly associated with pain [14,15]. The Eaton and Glickel radiographic classification is most commonly used to describe the severity of TMJ OA to support the diagnosis and for clinical decision making [16].

Table 1. Eaton and Glickel classification

Stage	Radiographic characteristics
I	Normal articular contours with mild joint space widening due to joint effusion or subluxation; minimal osteophyte formation.
II	Joint space narrowing, osteophyte formation <2 mm, subchondral sclerosis, and/or cyst formation. No significant subluxation.
III	Marked joint space narrowing, osteophytes >2 mm, subluxation or dislocation of the joint, more pronounced sclerosis and cysts.
IV	Same as Stage III plus involvement of adjacent joints, especially the scaphotrapeziotrapezoidal (STT) joint.

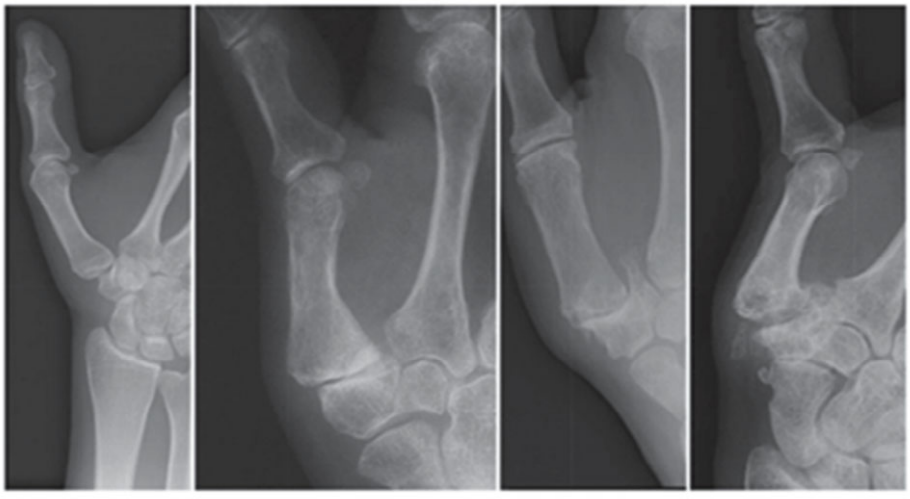


Figure 2. Radiographs of Eaton and Glickel stages I-IV (Used with kind permission of Elsevier, from Green's Operative Hand Surgery, edited by D. Barron & J. Catalano, 6th edition, 2011, p409. Permission conveyed through Copyright Clearance Center, Inc.)

Progressive subluxation as seen in stages III and IV leads to a decreased mobility, with limited TMJ abduction and opposition and narrowing of the first webspace [17]. The hyperextension of the metacarpophalangeal (MCP) joint occurs as a consequence of shortening of the thumb kinetic chain and functions as a compensatory mechanism, enabling sufficient thumb abduction to grasp larger objects despite decreased TMJ mobility. This is described as a z-deformity: "a collapse of multiple interconnected joints in alternating directions" (Figure 3) [1].



Figure 3. A typical Z-deformity during key pinch strength, showing a metacarpal dorsoradial subluxation, flexion of the first metacarpal bone, hyperextension of the metacarpophalangeal joint and flexion of the interphalangeal joint. (Courtesy: Elske Bonhof-Jansen, published with permission of patient)

Because the thumb plays a crucial role in hand function, especially in tasks involving precision grip, the impact of TMC OA on the patients' daily life can be profound and it can cause limitations in all domains within the International Classification of Function, Disability and Health (ICF). Aspects addressed by patients are constant pain and pain that interrupts sleep, limited motion, power grip and thumb strength as well as deteriorated performance of precision tasks. The pain is leading to limitations in daily activities such as wringing, grasping a cup or glass, writing, turning a key or opening packages. These limitations result in less participation and ultimately in a reduction of the quality of life [8,15,18,19].

Treatment

Treatment recommendations of TMC OA follow the stepped-care approach with consensus about non-surgical management as a first step. The aims are to reduce pain and to optimize thumb and hand function through education, orthosis prescription, joint protection and activity modification principles, exercise therapy, and the use of assistive devices. This can be supplemented with pain medication and steroid injections [20–22]. When conservative treatment is no longer effective, surgical treatment may be indicated. Several surgical options are available. Joint-sparing options are joint denervation, lipofilling and temporary joint distraction. More invasive options include joint resection procedures such as trapeziectomy (with or without ligament reconstruction (LR) or tendon interposition (TI) or both (LRTI). Total joint arthroplasty using a prosthesis can be offered if the STT joint is not involved. The final surgical salvage procedure is trapeziometacarpal arthrodesis. The trapeziectomy and arthroplasty procedures are widely used and have been shown to be effective in reducing pain on mid- and longer term [23–26]. However, both procedures have their benefits and drawbacks.

Trapeziectomy

The resection of the trapezium as a surgical treatment for TMJ OA was early on described by Gervis as a method to relieve pain and improve function in patients with TMJ OA [27]. Since metacarpal subsidence and abutment of the base of the metacarpal onto the trapezoid or scaphoid appeared to cause recurrent pain in some cases, ligament reconstruction and tendon interposition (LRTI) have been added in an attempt to improve stability and reduce pain. Unfortunately, these procedures do not always prevent metacarpal subsidence (Figure 4) [28]. Mean subsidence of approximately 5 millimeters can be expected, independent of the surgical technique. This has been found to stabilize after one year and is weakly associated with pain or poor functional or unsatisfying outcomes [29–32]. When metacarpal subsidence progresses to impingement on the scaphoid or trapezoid causing discomfort or pain, revision surgery may be indicated [32–34].



Trapeziectomy with subsidence of the first metacarpal



Subsidence of the first metacarpal with abutment on trapezoideum and scaphoid

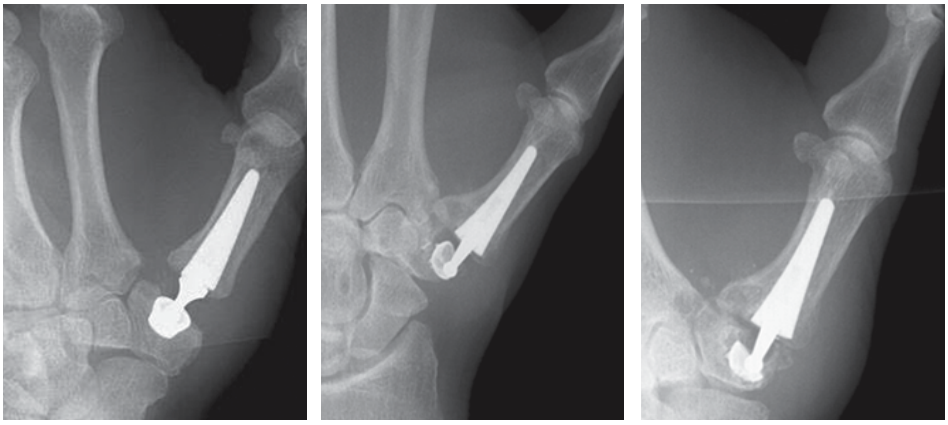


Abutment of the first metacarpal on trapezoideum and Z-deformity

Figure 4. Trapeziectomy and common complications

Total joint arthroplasty

In an effort to relieve pain and to restore normal stability and mobility at the TMJ, De la Caffiniere introduced in 1974 an implant based on the ball and socket design of the total hip implant [35]. Subsequently, other implants have been developed by various manufacturers. These aimed to reduce problems encountered following this early generations of TMJ prostheses, such as implant loosening, dislocation and wear and to improve the implant survival. Development went from primary stabilization with cement to uncemented parts aiming for secondary osseointegration, different component materials, modular necks and heads of different sizes and orientations to improve stability, and from single to dual mobility cups aimed to further prevent dislocation and loosening by reducing friction-induced stress at the bone-implant interface and facilitate exchange of implant parts in case of wear [28,36,37]. As TJA only addresses the TMJ, it is only feasible in patients without clinically symptomatic scaphotrapeziotrapezoid (STT) OA [38]. Complications of TJA are implant loosening or dislocation (Figure 5) [24,28]. The incidence has been reduced with improvement of implant design and the 10-year survival of modern implants is currently reported in a range of 85% to 95% [39,40].



Total joint arthroplasty | Cup dislocation | Cup loosening

Figure 5. TJA and common complications

Comparison of surgical procedures

Several recent systematic reviews and meta-analyses have focused on trying to identify which surgical procedure for treatment of trapeziometacarpal osteoarthritis is superior [41–44]. These reviews concluded that current evidence is low and high-level evidence comparing TJA with trapeziectomy is lacking, as only one randomized controlled trial (RCT) comparing TJA with trapeziectomy with LRTI was available for analysis [45]. TJA repeatedly showed quicker recovery and better (key)pinch strength but is accompanied by a higher complication risk than trapeziectomy. However, no clinically significant differences have thus far been found, and comparative studies are inconsistent on outcomes and complication risk [42–44]. Since there is a lot of heterogeneity in definitions and description of type and onset of complications, comparison across studies remains difficult.

When compared with trapeziectomy, the thumb biomechanics after TJA align more closely with the normal anatomical situation. The thumb column length is restored or preserved, hereby correcting metacarpophalangeal hyperextension and preventing or correcting a z-deformity. This is thought to result in better strength, range of motion and it is even speculated that this potentially leads to better functional outcomes [29,46–48].

However, patient reported outcome measurements (PROMs), used in the context of hand conditions, only partially address the functional aspects that are important to patients. For example, the ability to perform leisure activities, driving a car, or social and emotional aspects of the thumb problem are commonly not addressed in PROMs [49].

In addition, the importance, satisfaction and the meaning patients assign to their ability to perform different activities, can vary greatly between individuals [50].

It is currently still unknown whether patients experience differences in outcomes between trapeziectomy and TJA in daily life, resulting in a clinical equipoise concerning the most effective surgical intervention. Therefore, one of the aims of this thesis was to investigate whether TJA shows superior functional outcomes compared with trapeziectomy 1 year after surgery in a randomized and double anonymized clinical trial. As it was expected that not all complications were present after 1 year, we also aimed to investigate in the same study population the effectiveness and safety of the interventions on the mid-term of 5-years. Additionally, another aim was to explore the patients' perspectives to get better and deeper insights into their experiences and perspectives beyond the PROMs. This was investigated in a qualitative study by interviewing patients who underwent bilateral TMC surgery, trapeziectomy and TJA, addressing all ICF levels regarding possible differences on longer term and in what way the used PROM (Michigan Hand Outcome Questionnaire) reflected these perspectives.

Postoperative care

Trapeziectomy

As with any surgical procedure, effective postoperative care is crucial for optimal results. In general, after both procedures postoperative care consists of an immobilization period followed by rehabilitation supervised by a hand therapist, guided by the phases of wound healing and biomechanical principles. Postoperative care regimes after trapeziectomy procedures have been frequently subject of research.

However, systematic reviews concluded that there is no consensus in the postoperative care protocols and as a result, a wide practice variation exists [51,52]. The most commonly reported immobilization duration was 4 weeks however, a wide range existed from 2 to 12 weeks, as well as many differences in the recommended type of immobilization (semirigid or rigid). It was found that immobilization times longer than 6 weeks and rigid orthotic devices provided no additional benefit over earlier immobilization and semirigid orthotic devices. Two studies investigated postoperative regimes in trapeziectomy procedures and compared early mobilization (2 weeks cast followed by a soft neoprene orthosis for 4 weeks and activity as tolerated) to longer immobilization (cast or thumb spica splint for 6 weeks) and concluded an EAM regime was found safe and effective [53,54].

Wouters et al. identified 3 rehabilitation phases after trapeziectomy procedures: the acute postoperative phase (range 0-6 weeks), the unloaded phase (range 1-12 weeks) and the functional phase (range 3 weeks - 6 months) [51]. Considerable variation also exists in this context as when to start rehabilitation (range 1-6 weeks), and which form of rehabilitation is used (supervised hand therapy, self-rehabilitation or virtual options) [52]. Both reviews concluded that there was a lack of evidence comparing therapy regimens. Consequently is has been found that home based video assisted therapy was noninferior to in person hand therapy for upper extremity function after TMJ soft tissue arthroplasty [55].

Total joint arthroplasty

In TMJ TJA, the most efficient and safe way of immobilization and duration as well as effectiveness of supervised rehabilitation has not been investigated in comparative studies. In the only three systematic reviews regarding postoperative care after TMJ surgery, just three publications concerning TJA were included [56] and in later updates TJA was excluded (for unknown reasons) [51,52]. In another systematic review, which aimed to update the available evidence for the use of TJA, postoperative rehabilitation protocols were part of the data-extraction protocol but were not further reported on due to limited information in the original studies [24].

To ensure implant osseointegration, an immobilization period of 3 or 4 weeks after TJA is often recommended by prosthesis manufacturers, since bone-implant integration is improved when optimal clinical conditions are provided in the postoperative period. This includes promoting physiological interactions between the attached soft tissues and bone while minimizing stress on the operated side and preventing mechanical overloading and ensuring adequate blood flow [57]. Nevertheless, it is well established that aging negatively impacts bone conditions, with bone density loss in an unloaded limb being more pronounced in elderly patients [57], the population typically operated on for TMJ OA. The optimal balance between immobilization to promote wound healing, prevent micromotion and facilitate implant osseointegration and mitigating the adverse effects of immobilization is unclear. This leaves the most effective and safest method of immobilization, as well as its optimal duration, uncertain.

Multiple studies suggest that TJA can provide a quicker recovery and improved function in the short term when compared to trapeziectomy procedures [42–45,58–62]. Comparative studies assessing the effectiveness of supervised rehabilitation on the outcome are lacking, leaving the effectiveness of rehabilitation unknown [22,24,56]. Besides, the latest generation of prostheses does not come with a

guideline for supervised rehabilitation (Groupe Lepine, KeriMedical). The supporting evidence for this recommendation was obtained from retrospective case series in which patients were instructed to gradually resume their daily activities without doing prescribed exercises [63,64]. It is unknown whether these patients received information or education before or after the surgery, in order to set realistic expectations regarding the recovery period and results in the short-, mid- and long-term. As recommended previously, different types of postoperative care protocols within the same surgical procedure must be compared [22,51,65] and higher quality studies are needed to evaluate the effectiveness of supervised rehabilitation.

To get more insight into prescribed immobilization and rehabilitation regimes after TJA, the second part of this thesis aimed to summarize the available evidence, current practices and to identify knowledge gaps regarding immobilization and rehabilitation regimes with a scoping review design. Besides, as implant-related complications are the main drawback of TJA [42,44,59,66], addressing complications also must be part of the evaluation of the surgical procedure and postoperative care. Whereas comparison of complications across studies remained difficult in previous systematic reviews, we searched for the use of complication classifications and how complications were described within a scoping review aiming to provide recommendations for future studies. Consequently, we aimed to investigate the effectiveness of supervised rehabilitation comprising education, coaching and exercise therapy compared to education alone, in a quasi-experimental before-after trial.

Outline of this thesis

This thesis contains two parts: The first part focusses on the surgical management of trapeziometacarpal osteoarthritis comparing clinical and functional outcomes of trapeziectomy versus TJA on a quantitative as well as a qualitative level. In the second part the focus shifts to the TJA postoperative care investigating the current evidence of immobilization and rehabilitation regimes and the effectiveness of supervised rehabilitation.

Chapter 2 describes the results of the short-term outcomes of a randomized controlled trial comparing patient reported and clinical outcomes of trapeziectomy and TJA. **Chapter 3** reports the 5 year follow-up of this RCT with a focus on complications and survival. In **Chapter 4** this comparison is made from a patient perspective by applying a qualitative study.

Chapter 5 provides an overview of the available evidence of postoperative care protocols for immobilization and rehabilitation as well as complication classifications after TJA through a scoping review method. **Chapter 6** presents the findings of a quasi-experimental trial comparing clinical and functional outcomes of a supervised rehabilitation program to education alone after TJA. **Chapter 7** discusses the main findings and methodological considerations of these studies, followed by directions for future research/perspectives.

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PART I

SURGICAL MANAGEMENT OF TRAPEZIOMETACARPAL OSTEOARTHRITIS



CHAPTER 2

Total joint arthroplasty versus trapeziectomy in the treatment of trapeziometacarpal joint arthritis: a randomized controlled trial.

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This paper received an editor award in 2024 and was recognized in 2025 as top-cited paper published in the journal during 2022–2023.

ABSTRACT

The aim of this double- anonymized randomized controlled trial was to determine whether total joint arthroplasty has superior outcomes than trapeziectomy 1 year after surgery for trapeziometacarpal osteoarthritis. Sixty-two women aged 40 years and older, scheduled for surgery for stage II or III osteoarthritis of the trapeziometacarpal joint, were included and randomized to trapeziectomy or total joint arthroplasty. The primary outcome was the total score of the Michigan Hand Outcomes Questionnaire. Secondary outcomes were the Michigan Hand Outcomes Questionnaire subscale scores, Disability of the Arm, Shoulder and Hand Questionnaire, active range of motion, strength, return to work, patient satisfaction and complications. Data were collected at baseline and at 3 and 12 months. At 1 year we found no superiority of total joint arthroplasty over trapeziectomy regarding the total score of the Michigan Hand Outcomes Questionnaire. The total joint arthroplasty did show a significant advantage in strength and range of motion.

Level of evidence: Level I

INTRODUCTION

Trapeziometacarpal joint (TMJ) osteoarthritis (OA) is a common cause of pain and disability of the hands in postmenopausal women [1–4]. Its prevalence in the Dutch population ranges from 15 to 52% for women and it is positively correlated with age [5]. Numerous surgical techniques have been described for treatment of trapeziometacarpal osteoarthritis including trapeziectomy, trapeziectomy with ligament reconstruction with or without tendon interposition, arthrodesis and total joint arthroplasty (TJA).

All surgical procedures are effective in reducing preoperative complaints [6–10]. However, trapeziectomy can lead to thumb shortening owing to a collapse of the thumb metacarpal, causing pain by abutment to adjacent structures, or may lead to a Z-deformity of the thumb [11] requiring secondary surgery. Total joint arthroplasty is only feasible in patients without scaphotrapeziotrapezoid (STT) osteoarthritis, but may be complicated by implant loosening or dislocation [10]. An advantage of trapeziectomy is the low cost of the intervention. A prosthesis is more costly. However, it has been found to be the best way to restore the normal anatomy, potentially leading to better function, faster recovery, and preventing Z-deformity [11]. Current evidence is of low level and shows no superiority of one specific technique in outcomes such as pain, physical functioning and complications [12–14]. Although many cohort studies have been published, high level evidence comparing TJA with trapeziectomy is lacking. The aim of this randomized controlled trial was to determine whether TJA has better functional outcomes than trapeziectomy 1 year after treatment for stage II-III trapeziometacarpal osteoarthritis.

METHODS

Trial design

A double-anonymized randomized controlled trial was conducted at our centre. Participants were preoperatively assigned randomly to a group receiving either total joint arthroplasty or trapeziectomy. This 1-year outcomes study is part of an ongoing randomized controlled trial (RCT) with a 5-year follow-up. Recruitment started in January 2014 and ended in November 2018. The local medical ethical review board approved the study (NL47755.075.14). The clinical trial registration number is NCT02204488 (www.clinicaltrials.gov). This study followed the Consolidated Standards of Reporting Trials (CONSORT) reporting guidelines for randomised clinical trials [15].

Participants

Based on clinical and radiological findings, all participants were diagnosed with trapeziometacarpal osteoarthritis by a level 4 certified hand surgeon [16] at the outpatient clinic. When surgical treatment was indicated and agreed upon, and the patient met the inclusion criteria, patients were asked to consider participation in the study.

Women aged 40 years and older with symptomatic Eaton-Glickel [17] stage II or III osteoarthritis were included in this study. Exclusion criteria were previous operations for TMJ osteoarthritis at the same hand or secondary TMJ osteoarthritis as result of trauma, rheumatoid arthritis, systemic lupus erythematosus or gout, clinical signs of the STT arthritis, symptomatic carpal tunnel syndrome or De Quervain's tenovaginosis in the affected hand. Patients with neurological or other disorders of the affected hand that could influence postoperative recovery or who had insufficient knowledge of the Dutch language were also excluded. Participants provided written informed consent before participating in the study.

Surgical interventions

The surgical procedure of implantation of the uncemented semi-constrained (single mobility) Maïa prosthesis (Groupe Lepine, Genay, France) was carried out under general or regional anaesthesia by experienced (Level 4) surgeons. Prophylactic intravenous cefazolin (Mylan B.V., Bunschoten, The Netherlands) was administered preoperatively. A longitudinal incision was made dorsally over the trapeziometacarpal joint. After identification of the joint, a dorsal capsulotomy was performed. After resection of approximately 5 mm of the proximal end of the thumb metacarpal, the bone was progressively reamed to allow fitting of the metacarpal component. Osteophytes were removed. The central point of the trapezium was determined visually and marked with an awl, after which reaming for the spherical cup was carried out. The definitive 9 mm cup was put in place, after which the neck length was determined using various trial neck lengths. Alignment of the head with the cup could be adjusted by choosing a straight or off-set neck. After placement of the definitive metacarpal, trapezial and neck components the capsule and skin were closed.

The trapeziectomies were done under general or regional anaesthesia by experienced (Level 4) surgeons. A dorsal approach was used to obtain the same scar as in the prothesis group. A dorsal capsulotomy was carried out. After raising capsular and periosteal flaps from the trapezium, the trapezium was removed, after which the capsule and skin were closed. No specific capsular interpositions were done.

Postoperative care was the same in both groups; the thumb was immobilized in a plaster reinforced forearm bandage with the thumb in abduction, slight metacarpophalangeal (MCP) joint flexion and wrist extension. After 1 week the bandage was replaced with a circular forearm and thumb plaster cast for 3 more weeks (Figure 1). Immediately after cast removal, patients were referred to the department of hand therapy. Patients were seen by the hand therapist for supervised rehabilitation once a week in weeks 5 to 8 and once every 2 weeks in the following 4 weeks. This treatment was carried out by all-round certified hand therapists with more than 5 years of clinical experience using a standard protocol (Appendix I).



Figure 1. Cast immobilization (Courtesy: Elske Bonhof, published with permission of patient)

Outcomes

Preoperative measurements and assessments were conducted by one of three experienced certified hand therapists. They also informed the patients about the surgical procedures and postoperative rehabilitation. The assessors were certified hand therapists with more than 10 years of clinical experience, and they were unaware of the surgical procedure that had been done. Before the first measurement, a validation session took place to ensure the assessors made the measurements in the same way, according to a strict measurement protocol [18] to increase the reliability of the assessments [19]. Throughout the study, patients were measured by the same assessor to avoid potential measurement bias.

At baseline, sociodemographic characteristics were recorded. The primary outcome was hand function 1 year postoperatively, assessed by the total score of the

Michigan Hand Outcomes Questionnaire, Dutch Language Version (MHOQ-DLV; 0-100) [20–22]. Secondary outcomes were the MHOQ subscale scores, the Dutch language version of the Disability of the Arm, Shoulder and Hand Questionnaire (DASH-DLV), active range of motion, and grip and key pinch strengths (a mean of three measurements, taken at maximum efforts) in the involved hand. Return to work was assessed in weeks, with a self-designed questionnaire containing five questions: whether the patient did paid work; if not, was this because of the hand problem; how many hours a week the patient did paid work; the number of weeks to return to work after surgery; and the number of weeks until being fully employable again.

Satisfaction with the outcome and willingness to undergo the same procedure again was assessed using two questions scored on a numeric rating scale (NRS, 0-10). The number of patients with complications was recorded and the number requiring any revision surgery such as prosthesis revisions or secondary suspension tendonplasty after trapeziectomy. Complications requiring additional surgical procedures for De Quervain's tenovaginosis or carpal tunnel syndrome, were recorded separately.

Follow-up data were collected at 3 and 12 months after surgery. Radiological follow-up took place after 1 week and 1 year to examine the prosthesis position or any metacarpal bone collapse after trapeziectomy. Radiographs were examined for dislocation, osteolysis, prosthesis component displacement and STT osteoarthritis in the TJA group, and abutment and scaphotrapezoidal (ST) osteoarthritis in the trapeziectomy group.

Sample size calculation

Sample size calculation was based on equal numbers in each group with an alpha error of 0.05 and power of 0.90 to detect a difference of 15 points on the MHOQ total score. These assumptions resulted in 25 participants per study arm. When adding 10% for non-parametric analysis (n=27.5) and 10% extra patients taking potential loss to follow-up into account, the calculation resulted in 31 patients in each group.

Randomization

An online randomization tool (www.randomization.com) was used to develop a randomization scheme in a 1:1 ratio, in blocks of four and stratified for the surgeon. Allocation concealment was guaranteed by converting this randomization scheme to consecutive sealed opaque envelopes. For each new participant, an independent secretary opened the next envelope and scheduled the surgery

after baseline assessments had been done. Patients and the hand therapists making measurements and those involved in rehabilitation, were unaware of the randomization and not allowed access to the electronic patient files. To avoid measurement bias, hand therapists involved in the pre- and postoperative assessments were not involved in the postoperative rehabilitation. The study group allocation was disclosed 1 year after surgery, or earlier in the case of complications.

Statistical methods

Researchmanager® was used for data storage. This is a database that comprises the guidelines of Good Clinical Practice. Data were checked for errors, outliers and missing data. All variables were analysed for normal distribution by assessing the difference between mean, median and standard deviation, histograms and boxplots. For the MHOQ, the data for the affected side was analysed as a continuous variable. Normally distributed continuous variables are presented as means with standard deviation (SD) and as medians with first and third quartiles (IQR) if the distribution was non-parametric. Dichotomous and categorical data are described as frequencies with percentages.

Missing data analysis was done by inspection of matrix plots to identify the amount of and the patterns of missing values and also whether data were missing (completely) at random (MCAR). Little's MCAR test was used to check whether there was a relation between missing questionnaires and other variables. To verify equal randomization for baseline variables in both groups, between group differences were examined using the Fisher exact test (for binary data), and the unpaired *t*-test (for continuous data). An intention-to-treat analysis was carried out. To test the study hypothesis, a longitudinal covariance analysis with a generalized estimated equations (GEE) model was used for the primary outcome. Under the assumption that missing data are MCAR and not due to group allocation or treatment effect, this model estimates missing data values, thereby allowing the use of data from all participants, irrespective of whether they were measured at all time points. An exchangeable correlation structure is assumed. The overall effect of the model is reported as well as the model for interaction of group and time to determine the efficacy of the intervention. Secondary outcomes were analysed between groups for the outcome at 1 year using unpaired *t*-tests with a Bonferroni correction for multiple testing, Mann-Whitney U test or Fisher exact test, depending on the types of data. The threshold for significance was set at 0.05.

RESULTS

No significant or clinically relevant baseline differences were present between both groups (Table 1). The arthroplasty of two patients in the TJA group had to be converted to a trapeziectomy owing to fracturing of the trapezium during cup placement. According to the intention to treat principle, these patients were analysed in the TJA group. Another two patients in the TJA group did not return for follow-up assessment at 1 year. They returned later to have their contralateral trapeziometacarpal osteoarthritis treated. At that time, 14 to 18 months postoperatively, they stated that they had experienced no pain or limitations and had been satisfied with the results after 1 year. This information was retrieved from their medical files. Questionnaires were missing in 13% of the TJA group and in 10% of the trapeziectomy group. There was no relation between missing questionnaires and other variables. Little's MCAR test was not significant (p=0.34), confirming that the missing data were MCAR. A flowchart of the study is presented in Figure 2.

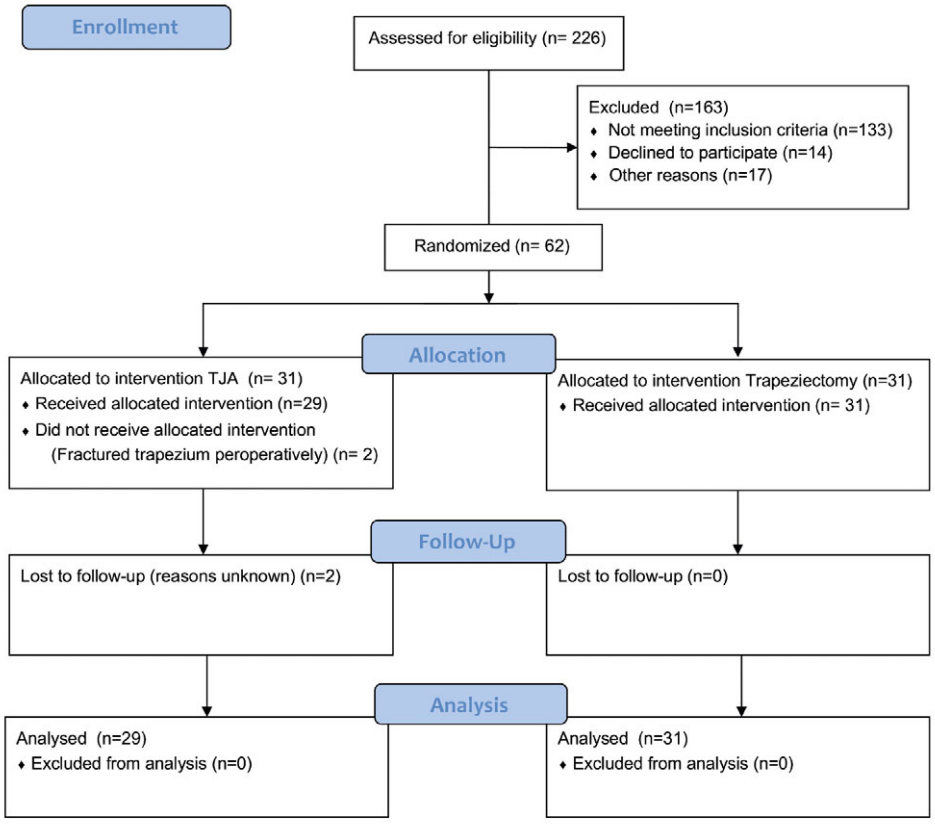


Figure 2. Flow Chart

Table 1. Baseline characteristics

Baseline characteristics	TJA *n*=31	Trapeziectomy *n*=31	*p*-value
Age	59 (6.5)	61 (8.5)	0.16*
Smoker, *n*	7	7	1 **
Diabetes mellitus present, *n*	2	2	1 **
Surgery on dominant hand, *n* (%)	13	14	1 **
Eaton and Glickel stage, *n*			1 **
II	13	12	
III	18	19	
MHOQ total score¥	49.9 (13.1)	44 (11.3)	0.065*

Data presented as mean (SD) unless otherwise specified; *Unpaired t-test; ** Fisher exact test; ¥MHOQ scores 0-100, a higher score represents a better hand function

Primary outcome

Raw MHOQ total (and sub scores) are presented in Table 2. Over time the mean MHOQ total score in the TJA group was higher than in the trapeziectomy group in the overall model (mean difference 8.5 points; 95% CI: -1.6 to 15.3; $p = 0.02$). In the model corrected for time the differences were neither statistically significant nor clinically relevant (Table 3). The odds for reaching the minimum clinically important difference (MCID) for the MHOQ at 3 months was higher for the TJA group (OR 5.3; 95% CI: 1.5 to 18.1; $p = 0.01$), however at 1 year it was not significantly higher in the TJA group (OR 1.60; 95% CI: 0.50 to 5.13; $p = 0.56$). The odds to reach the patient acceptable symptom state (PASS) [23] of 70 points on the MHOQ score at 3 months were higher in the TJA group (OR 7.06; 95% CI: 1.37 to 36.40; $p = 0.019$). At 1 year this difference diminished (OR 2.09; 95% CI: 0.68 to 6.43; $p = 0.26$).

Secondary outcomes

Median DASH scores were significantly better in the TJA group at 3 months and 12 months when compared to the trapeziectomy group (Table 4). A clinically relevant difference was only present at 3 months (median difference 18.3 points). MCP joint flexion of the operated thumb was significantly better in the TJA group at 3 months and at 12 months. MCP joint extension increased in the trapeziectomy group with a median difference of 5° at 3 months to 10° at 12 months. No such change was observed in the TJA group. No statistically significant, nor clinically relevant differences were found for grip-strength, palmar abduction, opposition, IP flexion and IP extension.

Pinch strength showed a clinically as well as a statistically significant difference at 3 months in favour of the TJA group, which remained clinically relevant at 12 months. Besides that, a clinically relevant decrease in mean pinch strength was observed in the trapeziectomy group, which was not seen in the TJA group (Table 4). Also, key-pinch strength was significantly higher in the TJA group at 3 months and at 12 months. Three-point pinch strength showed a clinically relevant positive difference for the TJA group at 3 months and 12 months.

Return to work

Fewer than 50% of the patients were employed at the baseline. Fifteen patients in the TJA group worked a median of 20.5 hours (Q1-Q3: 19 to 26.5) per week versus 15 patients in the trapeziectomy group working 23 (Q1-Q3:17 to 26.5) hours per week. The TJA group started working after a median of 6 (Q1-Q3: 1 to 10) weeks postoperatively, and the trapeziectomy group after 7 (Q1-Q3: 4.5 to 9) weeks ($p = 0.91$). After 3 months, five patients in the TJA group returned to their original work and six were doing modified work compared to three in the trapeziectomy group for original work ($p = 0.77$) and seven for modified work. After 1 year, eight patients in the TJA group had returned to their original work and three were doing modified work. In the trapeziectomy group this was five and four patients respectively.

Patient satisfaction

Patients were asked if they would consider having the surgery again under the same circumstances. At 3 months 21/26 patients in the TJA group responded with "yes" compared to 17/27 in the trapeziectomy group. At 1 year this was respectively 23/26 versus 17/27. There was no significant difference in satisfaction between the groups at 3 months (OR 2.0: 95% CI: 0.54 to 8.31; $p = 0.37$), or at 12 months (OR 4.38; 95% CI: 0.94 to 28.60; $p = 0.05$). Median satisfaction score (NRS 0 to 10) at 3 months was 7 (Q1-Q3: 6 to 8) for the TJA group, compared to 6 (Q1-Q3: 3 to 7.5) for the trapeziectomy group ($p = 0.03$). After 1 year the TJA group scored 7.5 (Q1-Q3: 6.3 to 8) compared to 6 (Q1-Q3: 6 to 8; $p = 0.06$) for the trapeziectomy group.

Table 2. Mean (SD) scores of the MHOQ-total and subscales (0-100)

	TJA			Trapeziectomy		
	Baseline	**3 months**	**1 year**	**Baseline**	**3 months**	**1 year**
MHOQ-total	49.9 (13.1)	63.4 (16.1)	75.3 (16.7)	44.0 (11.3)	53.1 (17.8)	66.4 (20.2)
Function	53.0 (15.5)	57.2 (11.9)	68.7 (14.3)	47.7 (12.5)	51.9 (16.6)	60.7 (16.2)
ADL	55.8 (21.7)	72.6 (18.1)	81.0 (18.3)	47.7 (19.4)	60.5 (23.3)	73.5 (24.0)
Work	44.7 (24.1)	51.9 (26.6)	71.7 (29.6)	37.3 (19.8)	38.9 (24.9)	59.1 (29.7)
Pain	32.5 (16.9)	59.1 (21.6)	69.8 (23.0)	28.2 (9.7)	47.2 (20.8)	59.6 (22.7)
Aesthetics	77.1 (16.7)	80.8 (17.7)	88.4 (13.5)	76.4 (24.6)	77.5 (22.7)	84.0 (16.3)
Satisfaction	36.1 (22.7)	58.8 (29.5)	72.1 (24.9)	26.4 (20.4)	42.3 (24.6)	61.4 (33.7)

MHOQ: Michigan hand outcomes questionnaire; TJA: total joint arthroplasty.

Table 3. Comparison of the total joint arthroplasty and trapeziectomy groups on the Michigan Hand Outcomes Questionnaire (MHOQ) scores based on Generalized Estimating Equations (GEE) analysis

	Overall Between groups		3-months Interaction group-time		12-months Interaction group-time	
	B (95% CI)	***p*-value**	**B (95% CI)**	***p*-value**	**B (95% CI)**	***p*-value**
MHOQ-total	8.5 (1.6 to 15.3)	**0.02**	5.5 (-2.4 to 13.4)	0.17	3.4 (-5.8 to 12.7)	0.46
Function	6.4 (1.0 to 11.8)	**0.02**	0.7 (-8.6 to 10.0)	0.89	3.6 (-5.7 to 13.0)	0.44
ADL	9.4 (0.7 to 18.2)	**0.04**	5.8 (-6.4 to 18.0)	0.35	-0.8 (-12.0 to10.3)	0.88
Work	11.0 (0.5 to 21.5)	**0.04**	7.2 (-5.5 to 19.9)	0.27	5.0 (-11.4 to 21.4)	0.55
Pain	8.6 (0.7 to 16.5)	**0.03**	8.7 (-1.9 to 19.4)	0.11	5.1 (-6.7 to 17.0)	0.40
Aesthetics	4.2 (-5.5 to 10.9)	0.53	2.3 (-7.4 to 12.0)	0.65	4.2 (-6.8 to 15.2)	0.45
Satisfaction	12.6 (2.4 to 22.9)	**0.02**	7.7 (-7.0 to 22.4)	0.30	3.0 (-12.4 to 18.4)	0.71

Statistically significant values shown in bold font. Analyses were performed by GEE models, with a group x time interaction term characterizing the intervention effect of interest. Beta coefficients represent the mean difference between groups with trapeziectomy as a reference group.
ADL: activities of daily living; CI: confidence interval; GEE: Generalized Estimation Equation; MHOQ: Michigan Hand Outcomes Questionnaire; TJA: total joint arthroplasty.

Table 4. Secondary outcomes

Outcome measure	Total joint arthroplasty group		
	Baseline *n*=31	**3 months *n*=29**	**12 months *n*=29**
DASH score (0-100), median (IQR)	37.5 (30.4 to 46.3)	18.3 (14.6 to 27.1)	15.0 (5.0 to 22.5)
Range of motion (°)			
MCP joint flexion	50 (10)	41 (11)	46 (13)
MCP joint extension, median (IQR)	-15 (-26 to -6.0)	-12 (-20 to 0)	-12 (-25 to 0)
IP joint flexion	64 (15)	60 (13)	63 (12)
IP joint extension, median (IQR)	-20 (-29 to -10)	-18 (-22 to -10)	-15 (-25 to -10)
Palmar abduction	40 (7)	35 (8)	37 (8)
Kapandji (0-10), median (IQR)	9 (9 to 10)	9 (8 to 10)	9 (9 to10)
Strength (kg)			
Grip	17.4 (8.4)	15.4 (7.4)	22.1 (7.7)
Pinch	3.4 (1.3)	3.5 (1.4)	4.4 (0.9)
Key pinch	4.9 (1.6)	4.7 (1.3)	6.0 (1.0)
Three-point pinch	4.3 (1.6)	3.9 (1.2)	5.1 (0.9)

Data are presented as mean (SD) or median (IQR) unless otherwise specified. Statistically significant values shown in bold font. Normally distributed Δ values between groups tested using unpaired t-tests. Mann–Whitney U tests were used for DASH, Kapandji and MCP extension. DASH: Disorders of Arm, Shoulder and Hand; IP interphalangeal; MCP: metacarpophalangeal; TJA, total joint arthroplasty.

Complications

Two TJAs had to be converted to trapeziectomy owing to a trapezium fracture which occurred during reaming. Three other patients had perioperative complications. In the trapeziectomy group a flexor carpi radialis injury occurred and was repaired. The patient noticed no adverse effects in her recovery. Another patient needed revision surgery after incomplete trapezium resection, requiring a ligament reconstruction and tendon interposition (LRTI). In the TJA group a patient had an injury of the extensor pollicis longus tendon. She eventually needed a tendon transfer after rupture of the initial repair. Twelve patients in the TJA group experienced complications within 1 year, compared to 16 patients in the trapeziectomy group (OR 0.60; 95% CI: 0.19 to 1.82; p = 0.44). In six TJA patients these complications were mild, and the symptoms resolved within 1 year; they included sensibility disturbance (n = 2), persisting pain (n = 2), superficial wound infection (n = 1) and mild complex regional pain syndrome (n = 1).

Revision surgery was required for six patients in the trapeziectomy group compared to one in the TJA group (OR 0.14; 95% CI: 0.003 to 1.30; p = 0.10). The trapeziectomy revisions were because of symptomatic metacarpal collapse. The indication for

Trapeziectomy group				
Baseline *n*=31	**3 months *n*=28**	**12 months *n*=22**	**Difference between groups at 3 months, Δ, (95% CI); *p*-value**	**Difference between groups at 12 months, Δ, (95% CI); *p*-value**
44.2 (35.2 to 57.5)	36.7 (29.6 to 45.4)	23.3 (12.9 to 36.7)	*p*=<**0.0001**	*p*=**0.03**
51 (11)	35 (9)	39 (12)	6.1 (0.7 to 11.5); *p*=**0.03**	6.7 (0.2 to 13.8); *p*=**0.04**
-9 (-20 to 0)	-17 (-20 to 0)	-22 (-27 to -12)	5; *p*=0.28	10; *p=0.03*
64 (12)	55 (13)	63 (11)	3.9 (-11.8 to 2.0); *p*=0.16	0.17 (-6.7 to 6.3); *p*=0.96
-20 (-30 to -15)	-15 (-20 to -10)	-22 (-26 to -5)	0.67	0.56
35 (8)	36 (8)	38 (8)	0.76 (-3.6 to 5.1), *p*=0.73	1.31 (-3.5 to 5.8); *p*=0.63
9 (8.8 to10)	9 (8 to 9)	9 (9 to10)	*p*=0.61	*p*=0.77
16.1 (6.7)	12.2 (5.7)	20.1 (7.4)	3.1 (0.4 to 6.6); *p*=0.08	2.0 (2.3 to 6.4); *p*=0.35
3.3 (1.2)	2.8 (1.1)	3.8 (1.3)	0.6 (0.0 to 1.2); *p*=**0.04**	0.6 (-0.1 to 1.2); *p*=0.08
4.7 (1.6)	3.5 (1.2)	4.8 (1.5)	1.2 (0.5 to1.9), *p*=<**0.001**	1.2 (0.4 to 1.9); *p*=**0.003**
4.4 (1.6)	3.2 (1.3)	4.5 (1.6)	0.7 (0.0 to1.3); *p*=**0.05**	0.6 (0.2 to 1.3); *p*=0.15

revision surgery was made in one case after 3 months and in the other five after 6 to 12 months. One of the two TJA patients whose implant procedure had to be converted to a trapeziectomy, also received an LRTI. Following the primary operation for TMJ OA some patients needed additional surgery for possibly associated conditions. Carpal tunnel release, trigger finger release, release of the first extensor compartment and MCP joint arthrodesis have been carried out in four patients in the trapeziectomy group. In the TJA group one patient needed a carpal tunnel release, the second patient had a trigger finger release together with a release of the first extensor compartment. Another patient had a MCP arthrodesis combined with a trigger finger release. Six trapeziectomy patients were treated with steroid injections for trigger thumb (*n* = 2), carpal tunnel syndrome (*n* = 1) and complaints related to scarring or adhesions (*n* = 3), compared to two TJA patients with injections for trigger thumb (*n* = 1) and extensor pollicis brevis tendinitis (*n* = 1).

Radiological follow-up showed metacarpal collapse (*n* = 8), abutment on adjacent structures (*n* = 9), with or without ST osteoarthritis (*n* = 5). The two TJA patients who were converted to trapeziectomy also showed radiological metacarpal collapse and

ST osteoarthritis, which was not obvious at the time of inclusion. No radiological abnormalities related to the prosthesis (e.g., cup loosening, dislocation) were found at 1 year.

DISCUSSION

The primary objective of this randomized controlled trial was to determine whether total joint arthroplasty has better results from the patient's perspective than trapeziectomy 1 year after treatment for TMJ osteoarthritis. We were unable to show superiority of total joint arthroplasty over trapeziectomy in daily hand function using the MHOQ. Despite the higher MHOQ scores in the TJA group, the differences were not statistically significant, nor clinically relevant, when corrected for time. Secondary outcomes such as pinch strength, key pinch strength and MCP flexion did show significantly better values for the TJA group. The TJA group also scored significantly higher on patient satisfaction at 3 months. The trapeziectomy group reaches the same satisfaction level at 1 year. Increased MCP extension was seen only in the trapeziectomy group and MCP flexion was better in the TJA group, suggesting that the TJA prevented a Z-collapse. This is consistent with the findings of Degeorge et al. [11]. Complications attributable to the type of surgery, requiring revision surgery, were only seen in the trapeziectomy group.

There are several limitations to our study. Assumptions that were made to calculate the sample size may have affected the internal validity of the study. The MCID for MHOQ total score examined at 1 year follow up is 17 points and the Smallest Detectable Change (SDC) is 11 points [23,24]. Since the registration of our study protocol in 2013, the use of the MHOQ as an outcome measure has increased and it has been found that high standard deviations of 17 points are common in TMJ osteoarthritis, even in large cohorts. As the variation between our groups is high, this may have led to an overestimation of the effect size. The high standard deviations that we found equalled the MCID, which makes it less easy to detect a clinically relevant difference between the groups. Therefore, it is questionable whether the MHOQ has sufficient discriminative ability to detect differences between groups treated for trapeziometacarpal osteoarthritis.

The immobilization protocol may also have affected the outcomes in our study. To avoid bias, we decided to immobilize patients in both groups for the same period of 4 weeks, which is commonly used after trapeziectomy. However, there is a wide variety in the duration of immobilization with a tendency towards

shorter immobilization periods [25–29]. Long immobilization may have negatively influenced the various grip strengths, activities of daily living and return to work. It remains unclear whether there is any benefit or increased risk associated with the duration of immobilization after the two surgical treatments.

The design of the prosthesis and the surgical technique that was used for TJA, might also have influenced the outcomes. We used a single mobility, semi-constrained prosthesis. The concept of dual mobility has subsequently been adopted after its successful use in hip joint replacements. Although dual mobility prostheses seem to have biomechanical advantages, the outcomes of single versus dual mobility prostheses in trapeziometacarpal TJA have not been reported. We determined the cup position without fluoroscopic support and reamed the trapezium without cannulated guidance. There were two trapezium fractures that may have been caused by this relatively uncontrolled positioning. Fluoroscopically guided cup positioning and cannulated reaming of the trapezium may lead to better biomechanical loading of the implant [30,31]. Earlier return to work would reduce overall costs for society and therefore mitigate the extra costs involved in using a prosthesis. We decided to assess only women, and only 50% were employed and the results are therefore difficult to interpret. Including working men would give a more complete picture.

The best available evidence for choosing between surgical options for the treatment of trapeziometacarpal joint arthritis are the systematic reviews performed by Wajon et al. [12] and Vermeulen et al. [13]. Recently Challoumas et al. [32] reported a meta-analysis of randomized studies that compared trapeziectomy with or without LRTI, arthrodesis and joint replacement. In this study, joint replacement had a 99% probability of being the best treatment modality for function and a 62% probability of being most effective for key pinch strength. However, only one randomized controlled trial was available for that review; it compared trapeziectomy and LRTI with joint replacement (Elektra) using the DASH score as the primary outcome measurement [33]. In comparison with our study, their study population was smaller, patients were aware of the surgical intervention and unfortunately the prosthesis used in this specific study has been abandoned owing to its poor durability [34]. There is only one retrospective cohort study comparing trapeziectomy and Maïa prosthesis, with a 9 year follow-up [35]. The MHOQ outcomes of this study are comparable to our own and the secondary outcomes indicate the same positive difference for pinch strength and MCP hyperextension. Better pinch and grip strength after TJA compared to trapeziectomy have been reported in several earlier studies [11,36,37].

Complications are a serious concern about using TJAs. However, implant failure appears to be less of an issue for modern implants [10]. Relatively large cohort studies of modern implants (Arpe, Ivory, Maïa) show that the ten-year survival is 85-95% [38]. The main concern after trapeziectomy is shortening of the thumb which may result in symptomatic abutment, pain and loss of strength, possibly causing a need for a secondary procedure. In this study we have noted a large number of patients receiving secondary surgery after trapeziectomy. The patients were dissatisfied with the primary treatment, mainly because of persisting pain at the base of the thumb metacarpal, which increased with loading. Radiographic examinations supported the diagnosis of metacarpal collapse as a cause of the persisting pain with increasing hyperextension deformity, suggesting collapse and signs of a Z-deformity. There was no indication in the records of these patients that conservative options had not been used, or that the operations were premature.

It is important to realize that the study aimed to compare the 'simple' trapeziectomy with a prosthesis, since there was no evidence supporting additional procedures in trapeziectomy [12,13,39]. We did no capsular interpositions, but we are unable to state whether the number of subsequent procedures would have been smaller if capsular interposition had been used. A last factor that might have influenced the outcomes of the trapeziectomy group is the surgical approach. We assumed no effect on outcome, so we chose the dorsal approach, for the purpose of avoiding awareness of study group allocation. However, recently Hamasaki et al. [40] have shown that the dorsal approach is largely inferior to trapeziectomy by an anterior approach in terms of treatment satisfaction and reducing the number of adverse events. This information was published after our study was designed.

Question remains whether the limited differences in outcome after a trapeziectomy justify the extra costs involved in using a prosthesis. The 5-year outcomes, which we hope to publish within 2 years, will focus on long-term complications and prosthesis survival. An analysis of relevant costs would be of interest in future research.

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Appendix 1 - Postoperative rehabilitation regimen

Treatment goals hand therapy

Main goal: Obtaining a stable, pain-free and functional thumb within three months postoperatively

Sub goals:

1. Improve active range of motion including prevention or correction CMC1 adduction and/or hyperextension MCP1 if necessary
2. Improve coordination and active stability
3. Improve strength
4. Improve functionality for patient specific goals (work, hobbies, sports)
5. Provide insight into the weight-bearing capacity of the prosthesis
6. Provide instruction of the principles of the load-capacity model

Week 1- 4 Postoperative

After the operation a plaster bandage is applied around thumb and wrist, with the thumb positioned in abduction and extension. One week postoperatively wound control takes place at the outpatient clinic of the hand surgeon. The plaster bandage is replaced by a circular plaster cast by the plaster technician for another three weeks. Four weeks postoperatively the cast is removed and subsequently hand therapy starts.

Week 4 - 7 Postoperative

Patient attends the hand therapy department once a week for 30 minutes
Improve active range of motion

a. Exercise therapy: pain-free, unlimited active motion without weight bearing to optimize wrist range of motion and thumb abduction, extension and opposition. Ten repetitions, 3-5 times a day
b. Splinting (only when indicated in case patient cannot avoid physically demanding activities or in case of CMC1 adduction or MCP1 hyperextension deformity. A custom made, thermoplastic short thumb spica splint is made including CMC1 and MCP1 without wrist involved. All joints are positioned in slight flexion to obtain a functional position of the thumb. Schedule of wearing during physical activities.
c. Edema control and (if necessary) managed with elastic bandage
d. Scar tissue massage

Improve coordination and active stability

a. Exercise therapy: pain-free, unloaded pinch exercises without collapsing the thumb. Gradually increasing from conscious use during exercises to unconscious use in daily activities. 3-5 times a day.

Oral information to give insight into the weight-bearing capacity of the prosthesis in order to avoid cup loosening.

Practical and ergonomic advice concerning the load-capacity model during the first weeks postoperative in order to avoid mechanic complications such as tendinopathies of the Abductor Pollicis Longus (APL) or cup loosening. Oral information is given and practical daily activities are stimulated depending on the patient needs.

Week 8 - 11 Postoperative

Patient attends the hand therapy department every two weeks, the visits will take 30 minutes.

a. Improve active stability and strength
b. Pain-free, gradually increasing isometric resistance exercises for pinch- and grip strength using exercise hand putty. Maximum repetitions until muscle fatigue occurs, once a day
c. Practical and ergonomic advice concerning load bearing and load bearing capacity during the third month postoperative. Oral information is given and practical daily activities are stimulated depending on the patient needs.
d. Functional exercises are incorporated to meet patient specific goals in work, hobbies or sports.

Week 12 Postoperative

Unrestricted functional use and discharge of hand therapy when therapy goals have been met satisfactory.

Chapter 3

Total joint arthroplasty versus trapeziectomy in the treatment of trapeziometacarpal joint arthritis: 5-year follow-up of a randomized controlled trial.

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J Hand Surg Eur Vol. 2025 Jul 14:17531934251357456.

ABSTRACT

This study presents 5-year results of a randomized controlled trial comparing total joint arthroplasty (TJA) and trapeziectomy for trapeziometacarpal joint osteoarthritis. Sixty-two women aged 40 and older scheduled for surgery were randomized. The primary outcome was daily hand function using the Michigan Hand Outcomes Questionnaire (MHOQ). Secondary outcomes included MHOQ subscales, range of motion, strength, satisfaction, complications, and survival. Follow-up data were available for 28 TJA and 26 trapeziectomy patients. At 5 years, TJA did not show superior patient reported outcomes on the MHOQ compared to trapeziectomy. Grip and tip pinch strength were not statistically significant or clinically relevant different. However, key pinch strength, satisfaction, and willingness to undergo the same treatment again favoured TJA. There was no statistically significant difference in revision rates between the groups. Five-year survival was 73% for trapeziectomy and 93% for TJA.

Level of evidence: I

INTRODUCTION

Several recent systematic reviews and meta-analyses have focused on identifying the best surgical procedure for treatment of trapeziometacarpal (TMC) osteoarthritis [1–4]. Total joint arthroplasty (TJA) repeatedly showed quicker recovery and better functional outcomes, specifically for tip- and key pinch strength, but with a higher complication risk. However, no clinically significant differences have thus far been found and studies are inconsistent on outcomes and complication risk when comparing TJA and trapeziectomy groups [2–4]. Furthermore, those reviews concluded that current evidence is low, as only one randomized controlled trial (RCT) on TJA was available for analysis. This trial with a 2-year follow-up showed no superiority of one specific technique [5].

We have previously described the 1-year outcomes of our double anonymized RCT comparing trapeziectomy with TJA for the treatment of Eaton and Glickel (E&G) stage II to III TMC osteoarthritis (OA) [6]. The TJA group showed higher Michigan Hand Outcomes Questionnaire (MHOQ) scores at 1 year, however, the mean difference of 3.4 points (95%CI 5.8 to 12.7, p=0.46) was not statistically significant, nor clinically relevant. Several secondary outcomes did show significantly and clinically relevant better values for the arthroplasty group. These included tip pinch strength, key pinch strength and metacarpophalangeal (MCP) joint flexion. An increase in MCP joint extension was only seen in the trapeziectomy group and better MCP joint flexion was measured in the arthroplasty group. This could be related to an imbalance of the thumb musculature. The prosthesis seems to have a preventive effect on the development of Z-deformity. The aim of the present study was to describe the 5-years follow-up of this study population, including mid-term complications and survival.

METHODS

A double anonymized RCT was conducted from 2014, with 62 participants randomly assigned to a group receiving either TJA or trapeziectomy. A detailed description of the methods had been published previously [6]. This paragraph briefly summarizes these methods and further elaborates on the additional methods used for the mid- term analysis.

Concealment of allocation was disclosed 1 year after surgery, or earlier in the case of complications. At the 5-year follow-up, patients and the examiners, were aware of the performed intervention.

Surgical interventions

The implant used for joint replacement was the uncemented semi-constrained (single mobility) Maïa prosthesis (Groupe Lepine, Genay, France). The trapeziectomies were carried out through a dorsal approach, to obtain the same scar as the participants in the prosthesis group to support the double anonymized study design. In the latter group, no additional interpositions, suspensions or temporary K-wire transfixation were done.

Outcomes

The primary outcome was hand function assessed by the total score of the MHOQ (MHOQ-Dutch Language Version; 0 to 100) [7–9]. Secondary outcomes were the MHOQ subscale scores, the active range of motion in degrees of the TMC joint, MCP joint and interphalangeal joint of the thumb, and the grip and pinch strengths of the treated hand. Tip pinch strength was assessed between the tip of the thumb and tip of the index finger, between the tips of the thumb, index and middle finger for three point pinch and key pinch (lateral pinch) with the thumb placed on the radial side of the index finger. Satisfaction with the outcome and willingness to undergo the same procedure again was assessed using two questions scored on a numeric rating scale (NRS, ranging between 0 and 10).

The number of patients with complications was recorded as well as the survival of the achieved surgical result and the number requiring any revision surgery, such as prosthesis revisions or secondary tendon suspensionplasty after trapeziectomy. Complications requiring additional surgical procedures, such as for de Quervain's tenosynovitis or carpal tunnel syndrome, were also recorded.

These data were collected preoperatively, at 3 months and at 1 and 5 years after surgery. Questionnaires were sent to the patients via a secured online data management portal. For the clinical examination and radiographs patients attended the hospital. Clinical examination was conducted by two experienced certified hand therapists. Radiographs with posteroanterior and peritrapezial view were examined by an experienced surgeon for dislocation, osteolysis, prosthesis component displacement and scaphotrapeziotrapezoidal (STT) joint OA in the TJA group, and for abutment with bony contact between the first metacarpal and scaphoid or trapezoid and scaphotrapezoidal (ST) joint OA in the trapeziectomy group. The 5-year follow-up assessments coincided with the COVID pandemic. This contributed to deferred and missing clinical measurements and radiographs. To reduce the number of patients lost to follow-up, participants with missing questionnaires were called to reconsider completing the questionnaires.

Statistical methods

Data were checked for errors, outliers and missing data. All variables were analysed for normal distribution by assessing the differences between mean, median and standard deviations (SD), histograms, quantile-quantile plots and boxplots. For the MHOQ, the data for the affected side was analysed as a continuous variable. Normally distributed continuous variables are presented as means with SD and as medians with interquartile ranges (IQR) if the distribution was non-parametric. Dichotomous and categorical data are described as frequencies with percentages.

An analysis of missing data was conducted by an inspection of matrix plots to identify the amount of and the patterns of missing values and determined whether data were missing (completely) at random (MCAR). Little's MCAR test was used to check whether there was a relation between missing questionnaires and other variables. Additionally to this, a non-responder analysis for the MHOQ at 5 years was performed to assess whether differences existed between responders and non-responders in important variables.

To test the primary study hypothesis, a linear mixed model analysis with a random intercept and fixed slope was used with a variance component covariance matrix to account for correlations between the measurements. With multiple measurements of the same individuals, a simple t-test can overestimate the effect, since correlations between the measurements and time are not taken into account. A mixed effects model can account for this and furthermore the model estimates missing data values, thereby allowing the use of data from all participants, irrespective of whether they are measured at all time points. The crude effect of the model is reported as well as the model with interaction between groups and time for all timepoints, to analyse how the effect changes over time. Results are reported as regression coefficients (beta). Beta coefficients represent the mean difference in MHOQ scores for the TJA group when compared to trapeziectomy group (that is coded as reference group in the analysis). A negative score represents a worse outcome. Furthermore, the change in MHOQ total score from baseline to 5 years was used to assess whether patients reached the minimally clinical important difference (MCID) of 17 points [9].

Secondary outcomes were analysed using unpaired t-tests, Mann-Whitney U test or Fisher exact test, depending on the types of data and presented as change scores between groups or odds ratio for Fisher exact test. When a significant effect and/or clinically relevant difference, exceeding the smallest detectable change for strength (1 kg for key pinch and 1.2 kg for pinch strength as defined by Ziv et al.

[10] was observed, this was further explored using linear mixed model analysis to assess the longitudinal relationship and interaction with time.

A Kaplan Meier curve was plotted to describe time to revision surgery at 5 years in both groups. An event was defined as failure of TJA or trapeziectomy when it required surgical revision. For the prosthesis group this could be implant revision, replacement or removal followed by trapeziectomy. For the trapeziectomy group this could be additional soft tissue procedures. Censoring of the patient occurred at the time of dropout of the study due to decease or withdrawal from participation. In the latter case, the date on which the patient was last seen by the surgeon or hand therapist for the operated thumb was taken as dropout date. To calculate a hazard ratio for revision surgery, a Cox proportional hazard regression analysis adjusted for randomization was performed. For all analyses test assumptions were evaluated and met and there was adhered to the intention to treat analysis. The threshold for significance was set at $p \leq 0.05$. A descriptive sensitivity analyses was carried out to explore the characteristics of the revision surgery patients from the trapeziectomy group to patients in this group without revision surgery.

RESULTS

No significant or clinically relevant differences were identified between both groups for all baseline characteristics; age, smoking, diabetes, surgery on the dominant hand, E&G stage and MHOQ baseline score [6]. At 5-years follow-up (mean 60 months, SD: 2.3, range: 57 to 69), 28 patients in the TJA group and 26 in the trapeziectomy group were available. Two participants in the trapeziectomy group declined further participation due to dissatisfaction with the outcome, they both had revision surgery. A flowchart of the study with number of available questionnaires and clinical examinations is presented in Figure 1. There was no relation between missing questionnaires and other variables. Little's MCAR test was not significant ($p=0.12$), confirming that the missing data were missing completely at random. The non-responder analysis showed no significant differences between responders and non-responders (Supplemental Table S1).

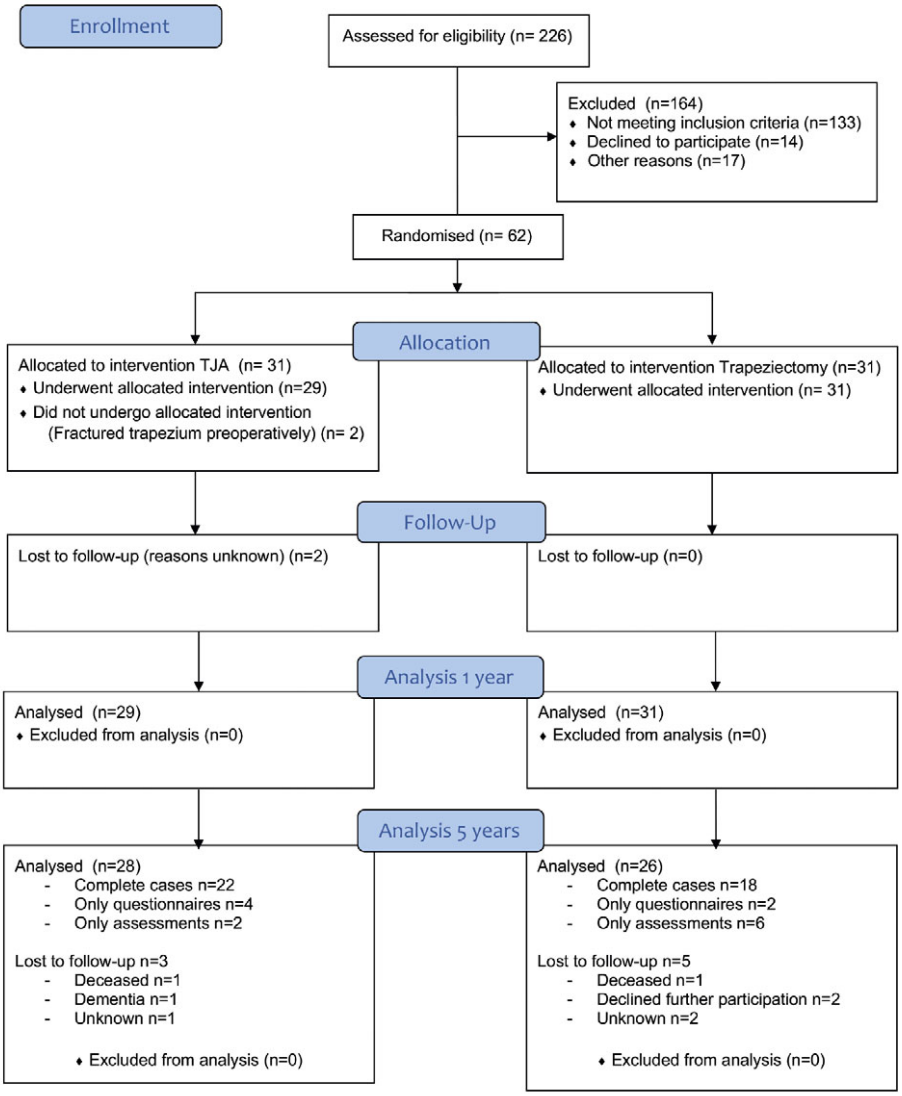


Figure 1. Flow chart

Primary outcome

Table 1 shows median MHOQ scores at 5 years per group. At 5 years, the mean MHOQ total score in the TJA group was higher than in the trapeziectomy group (Beta 5.9 points; 95% CI: -2.8 to 14.6; p=0.18). In the model corrected for time, the TJA group showed at 5 years a difference of -0.3 points for the MHOQ total score (95% CI -9.8 to 9.2, p= 0.95). (Supplemental table S2). The table shows no statistically significant nor clinically relevant differences in MHOQ scores.

Comparison of the beta coefficients over time indicates a faster recovery for the TJA group at 3 months, this difference diminished by 1 year to no difference between the groups at 5 years. Twenty-four patients in the TJA group improved on MHOQ score, compared to 17 patients in the trapeziectomy group. Eighteen patients in the TJA group and 13 patients in the trapeziectomy group reached the MCID (p=0.26) (Figure 2).

Table 1. Median (Q1 to Q3) scores of the MHOQ total and subscales (0-100) of the trapeziectomy and the TJA group at 5 years

	Trapeziectomy	**TJA**
	n=20	**n=26**
MHOQ-total	75 (53 to 90)	78 (60 to 91)
Function	68 (50 to 76)	73 (60 to 75)
ADL	80 (68 to 90)	91 (69 to 96)
Work	55 (34 to 91)	75 (51 to 100)
Pain	63 (34 to 91)	73 (55 to 94)
Aesthetics	94 (75 to 100)	91 (77 to 94)
Satisfaction	77 (46 to 96)	75 (47 to 95)

MHOQ: Michigan hand outcomes questionnaire; TJA: total joint arthroplasty.

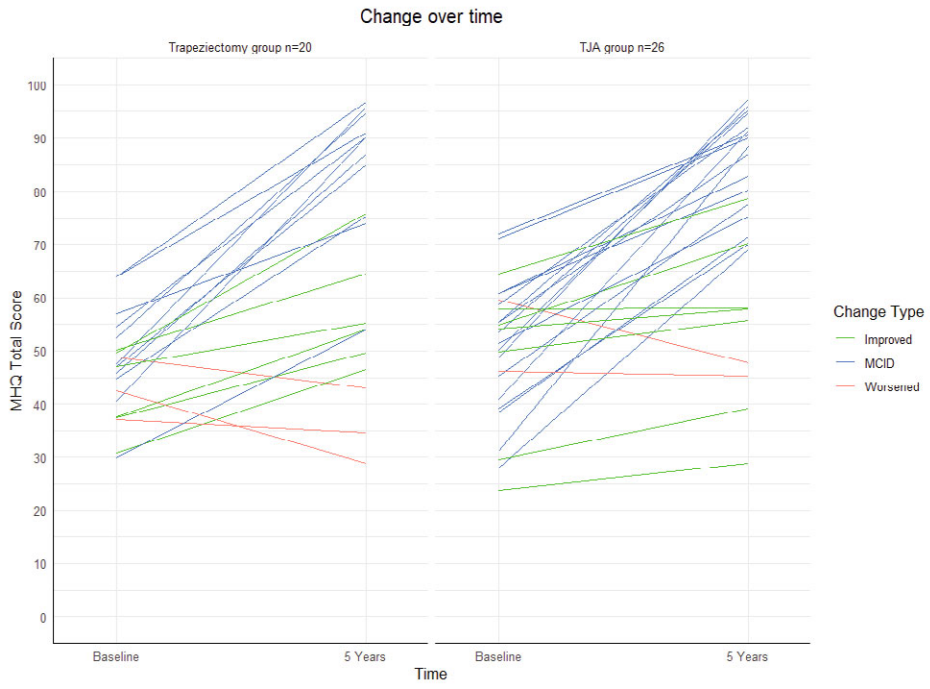


Figure 2. Spaghetti plot showing change in Michigan Hand Outcome Questionnaire (MHOQ) score from baseline to 5 years for the total joint arthroplasty (TJA) group (n=26) and the trapeziectomy group (n=20).

Secondary outcomes

MCP joint (hyper)extension, as part of a z-deformity, worsened over time in the trapeziectomy group and median MCP joint extension was 17 degrees more when compared to the TJA group. Tip pinch and key pinch strength showed a significant difference in favor of the TJA group (Table 2). The maximum strength was reached at 1 year postoperatively (Figure 3a, 3b). Despite the fact that the t-tests showed a statistically significant better tip pinch- and key pinch strength in favor of the TJA group at 5 years, the wide confidence intervals indicate a small effect as also shown by the overlapping standard deviations.

This is confirmed by the mixed model analysis, which showed that the outcome with the model for interaction for time did not remain significant for tip pinch strength at 5 years (Beta 0.68; 95% CI: –0.04 to 1.39; p=0.06). The effect for key pinch strength remained significant at 5 years (Beta 0.38; 95% CI: 0.10 to 0.66: p=0.01). Median satisfaction with the outcome at 5 years was 9 (IQR: 8 to 10) for the TJA group, compared to 7 (IQR: 5 to 9) for the trapeziectomy group (p=0.05). Patients were asked if they would consider having the surgery again under the same circumstances. In the TJA group 22 of 26 patients responded with 'yes' compared to 11 of 20 in the trapeziectomy group (Odds ratio: 0.23; 95% CI: 0.04 to 1.05; p=0.05).

Complications and survival

Radiological follow-up at 5 years revealed in the TJA group one patient with asymptomatic cup displacement. Despite this, she had excellent thumb function. There were no cases of osteolysis or loosening of the distal component. One patient had radiological signs of progressive STT joint OA, with no accompanying complaints. In the trapeziectomy group the radiographs of two patients suggested abutment of the first metacarpal and the scaphoid, without accompanying symptoms. Asymptomatic ST joint OA was radiographically visible in four patients. Two TJA patients underwent revision surgery during follow-up. One patient had a cup dislocation 3 years after arthroplasty. Radiography showed an angulated cup position. After 2 years of recurrent dislocations, she was treated with a trapeziectomy. One of the two patients who had a peroperative conversion from TJA to trapeziectomy needed revision surgery with a ligament reconstruction and tendon interposition (LRTI). Six patients in the trapeziectomy group suffered from symptomatic abutment necessitating LRTI. Most revision surgeries occurred within the first postoperative year with a median time of 12.5 months (IQR: 8.8 to 43) (Figure 4). Revision surgery patients in the trapeziectomy group suffered from more postoperative pain than the non-revision patients. (Supplemental table S3).

Survival at 5 years was 73% in the trapeziectomy group, versus 93% in the TJA group. TJA patients had a lower hazard of revision surgery compared to trapeziectomy patients, although this difference was not significant (Hazard ratio 0.33, 95% CI 0.07 to 1.63, p=0.17). Complications requiring additional surgical procedures, such as for de Quervain's tenosynovitis or carpal tunnel syndrome have not been necessary after the first year. Median time to associated surgery was 6 months (IQR: 5 to 8).

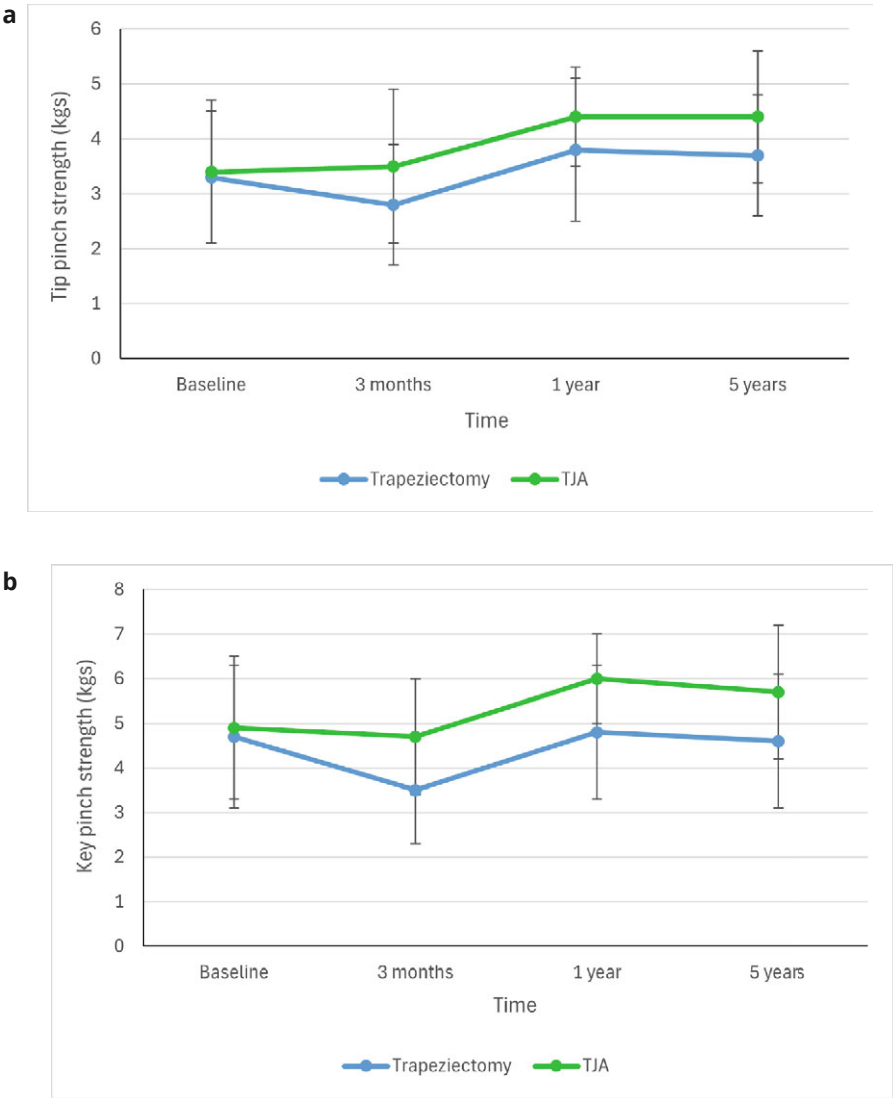


Figure 3. Tip pinch (a) and key pinch (b) strength over time in kilograms for each time point expressed in mean with standard deviation.

Table 2. Comparison of the trapeziectomy and total joint arthroplasty group for secondary outcomes at 5 years

Outcome measure	Trapeziectomy n=24	TJA n=24	Difference between groups at 5 yrs, (95%CI)	*p*-value
Range of motion (degrees)				
MCP joint flexion	40 (13)	44 (10)	4 (-11 to 3)	0.21
MCP joint extension	-20 (-27 to -8)	-3 (-21 to 6)	17	0.10
IP joint flexion	62 (15)	63 (11)	2 (-9 to 6)	0.66
IP joint extension	-17 (-20 to -12)	-14 (-21 to -2)	4	0.42
Palmar abduction	38 (6)	36 (5)	2 (-1 to 6)	0.17
Kapandji score (0 to 10)	9.5 (9 to 10)	10.0 (9 to 10)	0.5	0.80
Strength (kgs)				
Grip	17.9 (6.9)	20.1 (6.8)	2.2 (-6.2 to 1.8)	0.28
Tip pinch	3.7 (1.1)	4.4 (1.2)	0.6 (-1.4 to -0.01)	0.05
Key pinch	4.6 (1.5)	5.7 (1.5)	1.1 (-2.0 to -0.2)	0.01
Three point pinch	4.4 (1.4)	5.2 (1.8)	0.8 (0.0 to 1.3)	0.08

Data are presented as mean (SD) with 95% CI. MCP joint extension, IP joint extension and Kapandji score are presented as median (Q1 to Q3). MCP: metacarpophalangeal ; IP: interphalangeal.

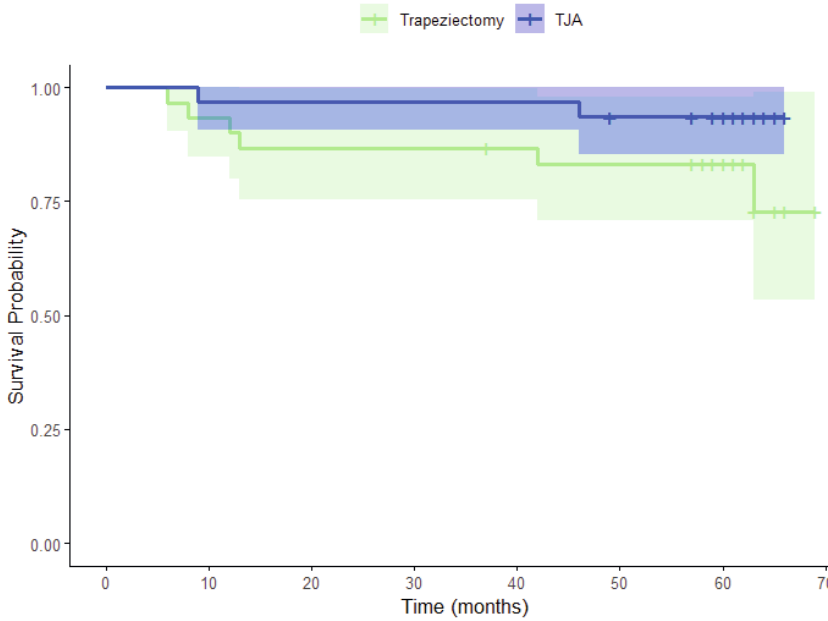


Figure 4. Kaplan Meier plot. Failure of total joint arthroplasty (TJA) or trapeziectomy requiring revision surgery. Censoring is indicated by the vertical marks and represents the time of dropout of the study due to decease or withdrawal from participation.

DISCUSSION

In this RCT, the patient reported functional outcome of total joint prosthesis in the treatment of TMC OA using the MHOQ was not superior to trapeziectomy at 5-year follow-up. This is in concordance with the results at 1 year [6]. The secondary outcomes that did show significant differences in favour of TJA were key pinch strength, patient satisfaction, willingness to undergo the same treatment again and a large median difference of 17 degrees was observed for MCP joint hyperextension.

Comparison of our primary outcome measure with other studies is difficult, since many studies used the Disabilities of Arm, Shoulder and Hand (DASH) questionnaire to evaluate patient rated outcomes. Moreover, because the DASH showed a ceiling effect within 1 year after TMC surgery, the DASH seems not responsive for the scope of our study. The only available study for comparison with MHOQ, with a long follow-up period, was a retrospective study with a 9-year follow-up comparing 48 TJA patients to 44 trapeziectomy with abductor pollicis longus suspension [11]. The mean MHOQ at 9 years was similar, with 81 (SD 4.5) points in the TJA group versus 80 (SD 4.4) in the trapeziectomy group. This is in concordance with our outcomes.

Latelise et al. [12] described thumb collapse and MCP joint hyperextension as the most relevant complications for trapeziectomy, and loosening, dislocation and periprosthetic ossification for TJA. MCP joint hyperextension, as seen as part of z-deformities, adversely affects pinch strength, but it has been shown to have no influence on pain or functional outcome [13–16]. Our findings are consistent with this literature as we found an increased MCP joint extension in the trapeziectomy group and enhanced keypinch strength in the TJA group without a significant difference in the MHOQ.

The revision incidence in the TJA group was comparable to the 4.3% described by Latelise et al. [12], however the 19% revision rate in our trapeziectomy group far exceeded the described rate of 2%. Our median time to subsequent procedures is lower than the 420 days (IQR: 248 to 804) for simple trapeziectomy as described by Lane et al. [17]. We currently lack a satisfactory explanation for the observed high revision incidence. In hindsight, waiting longer to allow for spontaneous pain relief could have decreased the amount of revision surgeries in the trapeziectomy group. We noticed improvement of MHOQ pain scores up to 1 year in this group. We acted on pain that we did not encounter in the TJA group, which might have led to a lower threshold for a revision surgery in the trapeziectomy group. This highlights the importance of informing trapeziectomy patients that postsurgical pain may take up

to a year to resolve and underscores the need for patience when considering revision surgery [18]. A 6-year follow-up study of 59 simple trapeziectomies showed only two patients had a conversion to LRTI because of persistent pain [19]. In a systematic review, focusing on outcomes and complications of trapeziectomies with a minimum of 5-year follow-up, 106 cases with simple trapeziectomy were included [20]. Overall, the results showed pain reduction and range of motion improvement in more than 90% of the satisfied patients. Metacarpal collapse occurred without any significant difference in studies using stabilization procedures compared to simple trapeziectomy. Dissatisfaction was often reported when patients required good hand strength or experienced complications. However, due to incomplete data, in mostly low level of evidence studies, the overall rate of complications remained unclear.

Cumulative survival rates of the MAIA implant of 93% at 5 years were reported by Toffoli and Teissier [21], which is in concordance to our results and equals the outcomes of other arthroplasties [22]. The 10-year survival of modern implants is reported in a range of 85% to 95% [23,24]. Lane et al. [17] reported the rate of revision procedures after primary TMC surgery to be 1.1% after simple trapeziectomy and 3.8% after arthroplasty. This is confirmed by the meta-analyses of Ganhewa et al. [25] which found that trapeziectomy has a lower rate of revision surgery compared with TJA, which differs from our results.

Limitations of our study have to be mentioned. First, our dropout was 14.5% for the primary outcome at 1 years and 26% at 5 years, which is comparable to dropout rates in other studies ranged from 10% at 1 year to 30% at 2 years [26-28]. The COVID pandemic is at least partially responsible for our dropout. This may have influenced the power of the study. As the sample size was initially determined for the primary outcome measure MHOQ at one year, we conducted a post hoc power calculation for the 5-year time point revealing a power of only 15.7%. This means that our results have to be interpreted with care. Second, most revision surgeries occurred within the first postoperative year, it is conceivable that a follow-up period of five years is insufficient to observe all potential complications associated with prostheses, as it is anticipated that a higher failure rate will be observed when the implant components approach the end of their expected lifespan [25]. Future research could be to study cost effectiveness, aiming to ascertain whether the trade-off of better strength and satisfaction with the outcome justifies the costs associated with TJA.

Acknowledgement

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Supplemental Table 1. Non responder analysis

	Responder n=46	**Non responder n=16**	***p*-value**
Randomization, Trapeziectomy/TJA, n	20 /26	11 / 5	0.146[b]
Age, years (mean, SD)	61 (7)	58 (9)	0.216[a]
Smoking, yes, n	9	5	0.489[b]
Dominant hand is surgery side, n	20	7	>0.99[b]
Eaton & Glickel stage OA, n II / III	II 19	II 6	>0.99[b]
	III 27	III 10	
MHOQ total score baseline (mean, SD)	48 (11)	43 (14)	0.150[a]
MHOQ total score 3 months (mean, SD)	57 (16)	54 (25)	0.623[a]
MHOQ total score 1 year (mean, SD)	69 (22)	69 (16)	0.991[a]
AROM/Strength assessment present at 5 years, yes, n	40	9	0.028[b]
MHOQ at 3 months missing, yes, n	5	4	0.219[b]
MHOQ at 1 year missing, yes, n	5	4	0.219[b]
Satisfaction at 1 year (median Q1-Q3)	7 (6-8)	9 (6-8)	0.164[c]
Revision surgery at 5 years, yes, n	4	4	0.19[b]
Surgery for associated conditions at 5 years, yes, n	5	4	0.22[b]

A non-responder is defined as a patient who did not complete the questionnaires at 5 years.
[a] Unpaired t-test. [b] Fisher exact test. [c] Mann Whitney-U test.
Abbreviations: TJA – total joint arthroplasty, OA – osteoarthritis, MHOQ – Michigan Hand Outcome Questionnaire, AROM – Active range of motion.

Supplemental Table 2. Comparison of the total joint arthroplasty and trapeziectomy groups on the Michigan Hand Outcomes Questionnaire (MHOQ) total and subscale scores

	Overall Between groups		3-months Interaction group-time		12-months Interaction group-time		5-years Interaction group-time	
	B (95% CI)	***p*-value**	**B (95% CI)**	***p*-value**	**B (95% CI)**	***p*-value**	**B (95% CI)**	***p*-value**
MHOQ-total	5.9 (-2.8 to 14.6)	0.18	6.0 (-3.0 to 15.)	0.19	3.6 (-5.5 to 12.6)	0.44	-0.3 (-9.8 to 9.2)	0.95
Function	5.3 (-2.2 to 12.7)	0.17	1.0 (-8.3 to 10.2)	0.84	3.6 (-5.7 to 13.0)	0.44	-1.4 (-11.2 to 8.4)	0.78
ADL	8.0 (-2.5 to 18.6)	0.14	6.2 (-4.5 to 16.9)	0.25	-1.0 (-11.8 to 9.7)	0.85	-1.6 (-12.9 to 9.8)	0.79
Work	7.4 (-6.0 to 20.8)	0.28	8.0 (-7.1 to 23.1)	0.30	5.8 (-9.4 to 21.0)	0.45	7.9 (-8.1 to 23.9)	0.33
Pain	4.3 (-6.3 to 14.9)	0.43	9.6 (-2.8 to 22.0)	0.13	5.8 (-6.7 to 18.3)	0.36	4.5 (-8.6 to 17.7)	0.50
Aesthetics	0.7 (-9.1 to 10.5)	0.89	2.5 (-7.9 to 12.8)	0.64	4.2 (-6.2 to 14.6)	0.43	2.3 (-8.7 to 13.3)	0.68
Satisfaction	9.8 (-3.5 to 23.1)	0.15	7.6 (-8.0 to 23.2)	0.34	2.2 (-13.5 to 17.9)	0.79	-8.1 (-24.6 to 8.4)	0.34

Analyses were performed by lineair mixed models with a random intercept and a group × time interaction term characterising the intervention effect of interest.
B: Beta coefficients represent the mean difference between groups with trapeziectomy as a reference group.
Abbreviation: ADL - activities of daily living.

Supplemental Table 3. Sensitivity analyses of revision surgery patients compared to non-revision surgery patients in the trapeziectomy group

	Trapeziectomy group n=25	**Trapeziectomy + revision surgery n=6**
Age, mean (range)	60.6 (47-77)	63 (53-77)
Smoking, n	6	1
Diabetes, n	1	1
E&G stage 2/3, n	9 (36) /16 (64)	3 (50) /3 (50)
Dominant hand involved, n	11	3
Paid work, n	12	2
MHOQ total scores		
Baseline	45	42
3 months	51	45
1 year	66	52
MHOQ pain		
Baseline	32	26
3 months	56	35
1 year	65	52
Baseline MCP joint extension, median Q1-Q3, degrees	-18 (-24 - 0)	-8 (-23 - 0)
Baseline MCP extension		
>20 degrees, n	5	2
>30 degrees, n	2	0
Δ median increase MCP joint extension, degrees		
3 months-baseline	4	0
1 year-baseline	10	11
Abutment MC1-scaphoid, n	0	5

Abbreviations: E&G – Eaton and Glickel stage, MHOQ – Michigan Hand Outcomes Questionnaire, MCP - Metacarpophalangeal

Chapter 4

Patients' perspectives of hand function after bilateral trapeziometacarpal surgery: trapeziectomy versus total joint arthroplasty. A qualitative thematic analysis.

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Submitted

ABSTRACT

Conclusive evidence as to whether total joint arthroplasty (TJA) with a prosthesis is better than trapeziectomy and how this should be measured, is still lacking. The aim of our study therefore was to explore patients' perspectives regarding possible differences in patients who underwent both procedures and in what way the Michigan Hand Outcome Questionnaire (MHOQ) reflected these perspectives. A qualitative study was designed according to a thematical codebook analysis in patients who had bilateral surgery (both trapeziectomy and TJA). Semi-structured interviews were conducted and coded, summarized and merged into themes.

Ten participants (7 females) were interviewed. Median time since trapeziectomy was 5.6 years (range 2.0 - 16.3) and for TJA 3.6 years (range 0.7 - 9.1). Four themes were identified: Surgery, General Functioning, Differences between surgical procedures and MHOQ. Irrespective of surgery type, participants reported that pain reduction had been achieved, though the majority continued to experience residual pain and loss of strength when performing heavy or forceful activities. The TJA hand was considered superior regarding strength and fine control. No relevant differences in activities and participation were mentioned. Recovery time after TJA was shorter than for trapeziectomy. Five participants preferred the trapeziectomy, three participants preferred TJA, and two had no preference. Substantial variability was observed in MHOQ total scores and not all differences between procedures experienced by participants were captured by the MHOQ.

INTRODUCTION

Several recent systematic reviews and meta-analyses tried to identify the best surgical procedure for treatment of trapeziometacarpal (TMC) osteoarthritis [1–6]. Total joint arthroplasty (TJA) repeatedly showed quicker recovery and better (key)pinch strength but without clinically significant differences in functional, patient reported, outcomes when compared to trapeziectomy. These findings were confirmed in the 5 year follow-up of our double blind randomized study comparing the outcomes between TJA and trapeziectomy [7]. In the latter study, the primary outcome concerned the Michigan Hand Outcomes Questionnaire (MHOQ). Remarkable were the large standard deviations in the participants' MHOQ scores, which also remained visible in longitudinal measurements in our study and in larger cohorts [8]. The large range even equaled the clinically relevant difference of the MHOQ. This suggests that the discriminatory power of the MHOQ may not be strong enough to demonstrate possible differences between these surgical procedures. It is known that patient reported outcome measurements (PROMs), used in the context of hand conditions, only partially address the functional aspects that are important to patients [9]. In addition, the importance, satisfaction and the meaning a patient assigns to the ability to perform different activities, can vary greatly between individuals [10].

The biomechanics after TJA align more closely to the original anatomical situation than following trapeziectomy, primarily due to restoration or preservation of the thumb column length, resulting in better strength and range of motion, and it has been speculated that this must also lead to better functional outcomes [11,12]. It is however unknown whether patients experience these differences in daily life. Therefore we aimed to explore patients' experiences and perspectives regarding the possible differences between the outcome of trapeziectomy and TJA for everyday hand function on all levels of the International Classification of Functioning, Disability and Health (ICF) in patients who underwent both procedures. In addition to this, we aimed to investigate in what way the MHOQ represented these patient perspectives.

METHODS

Design

A qualitative study was designed according to a thematical analysis with a deductive character using a codebook approach [13,14]. This study was conducted at the Isala Hospital, Zwolle, The Netherlands between September 2024 and December 2024. The institutional review board of the Medical Ethics Committees United (MEC-U)

in Nieuwegein, The Netherlands confirmed this study did not apply to the Medical Research Involving Human Subjects Act (WMO) and therefore a waiver for full medical ethical approval was provided (reference number W24.148). This study was preregistered at Open Science Framework on July 5th, 2024 (https://osf.io/xj9tg). All participants gave written informed consent prior to the interview. The COREQ reporting guideline was applied to report this study [15].

Reflexivity

Our setting is that of a major teaching hospital with 1250 beds. The multidisciplinary hand- and wrist expertise center employs nine hand surgeons, 13 hand therapists and three rehabilitation medicine doctors. Clinical research is continuously conducted with a special focus on surgical treatment of thumb base osteoarthritis. The principal investigator (EBJ) was an European certified hand therapist with more than 15 years of clinical experience, obtained a master in clinical epidemiology and was trained in qualitative research methods. This study was part of her PhD trajectory. The second researcher also was an experienced hand therapist (>10 years) and obtained a master in human movement sciences. The last author (CvdS) was a professor and consultant in rehabilitation medicine and experienced in qualitative research. In the participant information leaflet, information was given concerning the reasons and goal of the study and the involved researchers. To account for bias from a therapeutic relationship, participants who previously received hand therapy treatment from EBJ, were interviewed by BdJ.

Participant recruitment and sampling

Participants were identified using the electronic patient files based on diagnosis and surgical procedure codes. Inclusion criteria were adult patients with symptomatic thumb base osteoarthritis who had undergone bilateral surgery, TJA in one hand and trapeziectomy in the other hand. Participants were excluded if they had limitations or difficulties with the Dutch language or oral communication skills and/or psychiatric disorders interfering with the study goals. Participants eligible for inclusion were invited with a letter sent by post. If the participant decided to participate, a signed informed consent form was returned. Subsequently the researcher contacted the participant by telephone to schedule an interview appointment. When the signed consent form was not returned after two weeks, a single reminder letter was sent.

As usual in qualitative research, the sample size was not calculated in advance. The optimal sample size was considered to be reached when data saturation had taken place or when no more new codes were discovered. It was found that in

studies with relatively homogenous groups and narrowly defined objectives, saturation can be achieved in a range of 9 to 17 interviews [16]. The purposeful sampling method was used and to achieve maximum variation in the sample, participants with varied socio-demographic characteristics were invited with variation in gender, hand dominance, working versus retired population and participants who did or did not experience complications.

Data collection

Semi-structured interviews were conducted by two authors (EBJ and BdJ). As patient experience covers all the levels of the International Classification of Functioning, Disability and Health (ICF), we aimed to represent all these levels in the interview, covering body functions and structures, activities and participation, and environmental factors. Question were based on items of the MHOQ, that mainly represent body functions and activity in six domains (pain, function, aesthetics, activities of daily living, work and satisfaction) [17]. Additionally, the Disease Repercussion Profile (DRP) was selected as it is an individualized measure of perceived disadvantage from arthritis, representing an individual's problems on activity limitations and participation restrictions [18]. The six domains include impact on: day-to-day activities, social activities, finance and work, relationships, emotions and appearance.

To confirm completeness of the interview guide (Supplemental material S1) the literature was reviewed [9,19–22] and an experienced hand surgeon was asked to submit additional items of importance. Questions regarding any other hand issues affecting thumb function and awareness of patients' thumbs during daily activities were added.

The interview, the audio recording and transcription were pilot tested by the team to investigate the interview duration, the completeness of the topic list, whether questions had to be refined and to verify whether the software worked. Prior to the interview, participants were asked to complete the MHOQ, measuring both hands separately, in preparation for the interview questions regarding this questionnaire. The MHOQ scores were also used for detection of differences between both hands and comparison with the interview results. All interviews took place in a quiet room in the outpatient clinic of the hospital, except for one interview which was conducted online using videoconferencing. During the interviews, participants were encouraged to talk freely about all topics they concerned relevant in relation to the study aims. Photographs of participants' hands were taken to visualize any potential differences in thumb position during loaded (key)pinch (Supplemental Material S2).

Data analysis

For the thematic analysis, the six phase framework of Braun and Clarke [23] was followed.

1. Familiarization with the raw data was done by transcribing all audio recorded interviews by the two interviewers (EBJ and BdJ). Accuracy of the transcription was checked by the interviewers and consequently, transcribed interviews were sent to the participants to verify its accuracy.
2. When this was confirmed, data were transferred to ATLAS-TI (version 25.0.0.32864; Atlas.ti Scientific Software Development) for coding of the transcripts. Prespecified codes were assigned based on the interview guide. After three interviews the code 'control' was added as this emerged from the data and the code tree was modified to enable easier distinction between hand dominance and surgical procedure. Coding of the first two transcripts was performed independently by two researchers (EBJ and BdJ) and thereafter compared to validate the coding process and whether new codes should be added. Discrepancies in the coding were discussed with the team to obtain consensus. The subsequent interviews were independently coded by the principal investigator (EBJ) and verified by the second researcher (BdJ).
3. Codes were summarized and discussed with the research team and further combined and condensed. Consensus was reached for the final codes.
4. Possible themes were explored and discussed within the team.
5. Themes were defined and it was investigated whether codes could be combined within one theme. Leading to the definition of four themes: Surgery, General Functioning, Differences between surgical procedures and MHOQ.
6. The results were described in these themes and a table with quotes was added to elucidate the variation within the data. During the data collection and data analysis, a decision trail was kept to systematically administer the steps and the decisions taken during this process.

RESULTS

Thirty-one patients were detected by the search in the electronic patient files of which 19 met the inclusion criteria. Initially, 15 participants were invited, to prevent oversampling, of whom ten gave informed consent. Reasons for not willing to participate remained unknown since legislation precludes contacting participants without informed consent. The median duration of the interviews was 38 minutes (Q1 to Q3: 28 to 46). Analysis of the last three interviews did not result in elicitation of new information. Hence, sufficient data saturation was assumed after seven interviews

and inclusion was terminated. None of the participants made additional comments or corrections after the transcribed interview was sent to verify its accuracy. The median age of the participants was 66.5 years (range 53-72). Surgery of the dominant side was equally distributed between TJA and trapeziectomy (with or without ligament reconstruction and/or tendon interposition - LRTI) procedure (Table 1). Median time since surgery on the dominant hand was 4.9 years (range 2.0 - 9.1) and 3.6 years (range 0.7 - 16.3) for the non-dominant side. Median time since TJA surgery was 3.6 years (range 0.7 - 9.1) and 5.6 years (range 2.0 - 16.3) for trapeziectomy.

Theme 1: Surgery

All participants were unanimous about the reason for their surgeries: the increasing pain, leading to a loss of function and ultimately to limitations in daily life. Additionally, half of the participants preferred to discontinue wearing orthosis. All participants were generally satisfied with the reduced pain and improved functionality after surgery. The surgeries yielded benefits like a greater freedom in using their hands as they could perform activities painlessly again and wearing braces was not necessary anymore. Some participants also mentioned improvement in their quality of life as the former pain consumed energy or caused negative emotions. Joy in life was regained and they were less dependent on others. Quotes representing all themes are shown in Table 2.

Three patients experienced complications necessitating revision surgery (Table 1). One patient had revision surgery in both hands due to persistent pain after trapeziectomy and a recurrent prosthesis dislocation within one year post-surgery. One patient experienced a dislocation of the prosthesis head 3 days post-surgery after he bumped his thumb. After closed reposition failed, open reposition followed by 4 weeks cast immobilization was successful. The third patient experienced cup loosening 7 months post-surgery leading to removal of the prosthesis and a conversion to trapeziectomy with LRTI.

In general participants did not worry about potential complications or the longevity of the prosthesis. The majority said they did not think about it at all or even never considered it. Only two male participants adjusted their activities to preserve the prosthesis. Participants trusted there will be a solution when prosthesis failure would occur. Half of the participants would choose a trapeziectomy if they had to choose again between trapeziectomy or TJA (Table 1). Reasons for choosing were the use of body-own material instead of foreign material, a better range of motion, no risk of prosthesis dislocation and a more comfortable feeling and function. Three participants preferred a TJA for the improved range of motion and degree of control, as well as a more natural thumb position. Two participants had no preference as both hands were functioning well. All participants addressed the benefits and disadvantages of both procedures.

Half of them indicated that they do not feel comfortable making a statement about recommending either one of both procedures and would prefer to leave that to the doctor. They felt it to be important they can rely on the doctors' advice and their experience with both procedures. The other participants would recommend the procedure they preferred themselves but taking into account the faster recovery time after TJA, the risk of complications in both procedures and the strength and control needed, also depending on the type of occupation.

Regarding the aftercare the majority agreed that, however some in hindsight, hand therapy after TJA was not necessary although they recognized that a form of information is important to feel confident during the first months post-surgery. A minority preferred more guidance or repeated measurements. Some participants made recommendations for the surgeons and hand therapists to improve the healthcare process, all concerned communication. They would like to receive more information before surgery to set realistic expectations concerning risks and complications, expectations about time needed for recovery, residual pain and the survival time of the TJA. Also, practice variation between surgeons was mentioned in the process of shared decision making regarding the choice between trapeziectomy and TJA. Overall, the participants reported satisfaction with the process of care, the results and the healthcare providers.

Table 1. Participant characteristics

Partici-pant	Gender	Paid work	Dominant side	Procedure Dominant side	Time since surgery (yrs)	MHOQ total dominant side	Procedure non-dominant side	Time since surgery (yrs)	MHOQ total non-dominant side	Complications	Preferred surgery
1	M	Yes	Right	Trap+	4.3	79	TJA	2.2	81.83	None	TJA
2	F	Retired	Right	Trap	2.0	89.3	TJA	2.7	86.3	None	Trap
3	F	Yes	Right	TJA	6.0	67.2	Trap	6.7	68.6	None	No preference
4	M	Retired	Right	Trap	2.9	64.1	TJA	0.7	68.7	Cup dislocation > reposition	TJA
5	F	No	Left	TJA	4.0	84.83	Trap	3.5	84.83	None	Trap
6	F	Retired	Right	TJA	3.5	53.4	Trap+	7.9	52.3	Right: Cup loosening > trap Left: persisting pain > LRTI	TJA
7	F	Retired	Right	Trap+	5.6	94.7	TJA	3.6	88.4	None	Trap+
8	F	No	Right	Trap+	6.7	25.6	TJA	3.3	31.8	None	Trap+
9	F	Yes	Left	TJA	9.1	91.05	TJA	16.3	97.7	None	No preference
10	M	Yes	Right	TJA	5.5	91.11	TJA	6.4	91.05	Right: Cup loosening > trap+	Trap+

TJA = total joint arthroplasty; Trap = trapeziectomy; Trap+ refers to a trapeziectomy with an additional procedure such as ligament reconstruction and/or tendon interposition
Revision surgery and type is indicated with >
NB. Age has not been added to this Table because of participants' privacy protection

Table 2 Quotes

Theme	Quote
Surgery	
Reasons for surgery	I had so much pain and limitations at the time. Yes, doing nothing was not an option (p4)."
	"And yes, it does limit your life a bit. These are big words, but it's true (p5)."
	"I work without braces now. So that has been a really big improvement for me (p3)
Results of the surgery	"Well, I regained the freedom to use my hands normally again." (p6)
	"Well, much more, uh, well, joy in life, so to speak. The pain is gone. And yes, when you were at a party, you always had to wear those braces." (p7)
Complications	"But I think, you said it could collapse, but it seems to me that it's going to collapse."[trapeziectomy] (p4)
	"After about a month or so, it started that my thumb clicked strangely, because I could actually hear it." (p6)
	"I'm still scared of that, because if it happens again, it will take up to a year again. But it's more, uh, the fear that it might pop out rather than the actual pain." (p10)
Longevity prosthesis	With heavier work, really, yes. I leave that to someone else." (p4)
	"Let tomorrow take care of itself." (p9)
	"I haven't thought about that at all. I'm not concerned with it at all." (p1)
Preference surgery	Actually, I'm satisfied with both techniques, it doesn't matter to me whether the trapezium is removed or not." (p2)
	"I'm not really happy with the result, let me put it carefully, if I compare it so far with the left thumb (prosthesis)." (p4)
	"I have to say, the prosthesis works really well." (p1)
	"With one it's this, and with the other, I said, just go with the body-own material; I had the idea that, yeah, that would work right away, but here, something foreign material has been put in. And, yeah, I think I'd choose the trapeziectomy, just for the idea, you know." (p7)
Recommend surgery to others	"Maybe if you say someone wants to heal faster, I'd say, take the prosthesis, then you'll be a bit quicker back to being active with your hand." (p7)
	"Yeah, because if you, uh, have the bone removed and filled in, you'll be dealing with therapy for much longer. You'll be really busy for about a year. And you don't have that with the prosthesis side." (p9)
	"Well, I assume the surgeon can make a certain choice based on expertise, no, you should be able to fully trust that." (p5)
	"Yeah, with the prosthesis, you probably have more certainty that it's positioned well, and with the other surgery, you might have more of a chance that your thumb gets in a wrong position, I think, but I don't know, I really don't know." (p10)
Aftercare	"You don't get a cast, so I was really happy. Then at home, I thought, yeah, what if something happens in that area or if I bump it? So, I became a bit scared, let's say. But that didn't last long, it went well." (p1)
	"Therapy wasn't necessary at all for the prosthesis, but it went fantastic, it went well right away." (p10)

Theme	Quote
	"I was totally surprised when I came back for the thumb prosthesis to the hand clinic. I wanted some guidance because I was used to that from the other [trapeziectomy] hand. I thought, 'Well...' But I could just do everything based on pain. I had to switch my mindset a bit... But looking back, I didn't miss anything, and it was actually much faster." (p7)
General functioning and differences between procedures	
Body functions	
Pain	"I think the pain relief is really good for both hands. It's completely gone." (p1)
	"I had hoped to be rid of the pain, but that's just not the case, as the pain is getting worse on the right side [trapeziectomy]." (p4)
	Only with heavy strain, but the pain is practically gone, I think it's amazing." (p7)
Range of motion	It feels like there's more space in the trapeziectomy side and the prosthetic side just doesn't move any further." (p8)
	"Where the bone is out, it feels a bit looser, sometimes more unstable, but also a bit stiffer." (p4)
	"In essence, I can move both thumbs in all directions." (p3)
Strength, control and precision tasks	"You definitely have less strength with both thumbs, but I get the impression that you lose more with the trapeziectomy [dominant] hand than with the prosthesis." (p1, p4)
	"I think with the prosthesis it is somewhat a normal joint and that you can control it with your muscles if you want" (p4)
	"But I never force strength with my hands, I actually never do that. But I can't say it's a handicap." (p10)
Aesthetics	"It couldn't have been better, let me put it that way." (p10)
	When the prosthesis was in, it was straighter, and now there's no support at all [trapeziectomy]. On the trapeziectomy+ side, the position is much better." (p8)
Emotions	"They had already said beforehand, you won't get your own thumb back. So you can fight against it, or you can accept it." (p1)
	"I had hoped that I would have less pain. And since it's getting worse, I think, well, I don't know where this is going." (p4)
	"No, it's fine, I just keep going. I, uh, I'm not going to sit down and feel sorry for myself, because that doesn't help me either. I do everything with it and I take it into account, I try to keep it as much under control as possible." (p6)
Activities	
ADL, household tasks	"Mainly the heavy things, I do avoid that a bit." (p3)
	"Normally, you don't even think about it. Then you do things, and it works out for the most part." (p3)
	"And, well, actually everything goes well. I don't have anything I'd say I can't do or something like that." (p9)

Theme	Quote
Participation	
Occupation	In my work, I've been able to let go of things and say, 'I don't need to do that anymore.' So I don't really feel any limitations." (p3)
	"Cleaning, sweeping and up to my knees in the mud, that is my job, but you realize that sometimes it's difficult to screw screws, uh, to turn them. That can be a bit disappointing." (p1)
	"You can start exercising much sooner with the prosthesis. So, I might have been back to work a month earlier." (p1)
Leisure and sports	I just shouldn't overstrain it. If I do, I get called back." (p3)
	"I think it's amazing that I can work in my garden using with both hands again." (p7)
	"I'm just careful with my hands." (p10)
Social activities/ relations	"I consciously try to avoid giving too firm a handshake myself, but not going to the extremes"(p4)
	"I have grandchildren, a little one who comes running and jumps into your arms. I don't dare to do that with my hands." (p2)

Theme 2: General functioning

Body functions

The majority of the participants experienced a residual form of pain after strenuous activities described as a painful fatigue, cramps, stabbing pain or mild aching. One participant was completely pain free. Most participants still experienced some loss of strength in both hands with loss of grip and fatigue, specifically when performing strenuous tasks. They also reported that precision tasks could be difficult. These limitations affected their daily activities. The majority was generally satisfied with the appearance of their thumbs after surgery. Almost half of the participants reported having no emotional issues and believed that perceiving limitations is simply a matter of getting older and something that needs to be accepted.

Activities and participation

The vast majority reported still having difficulties with heavy or forceful activities during ADL or household tasks such as opening jars, bottles of packages, wringing out a cloth or lifting heavy objects. Seven participants reported the use of joint protection or ergonomic principles such as assistive devices, compensation strategies, such as alternating between left and right and/or distributing the load throughout the day, or asking for help. They stated being satisfied with the use of these coping strategies.

Four participants had paid work of whom two switched to less physically demanding work. Two individuals described difficulties with both hands in heavy tasks and fine motor activities during their work. Participants performing

computer work reported no issues or differences in executing their tasks with either hand. Two females had difficulties with heavy tasks during volunteer work, with the dominant hand often becoming sensitive first, regardless of the type of procedure. Forms of transportation as cycling or driving a car did not cause any problems in general. The participants engaged in various forms of sports. Half of the participants did not have limitations during leisure activities or sports. Some had to modify their activities due to other physical problems. Most tried to adjust their activities to avoid overloading of their hands and arms and emphasized the importance of balancing activities and rest. Half of the participants reported no major restrictions in social activities or maintaining relationships. They indicated that they can shake hands, hold their phones, and engage in activities with family and friends normally.

Theme 3: Differences between trapeziectomy and TJA

Body functions

Three participants did not experience a difference between both hands; one participant could not even remember on which side which procedure was done. Three others stated that pain occurred more in the trapeziectomy side and a single person reported increasing pain on the trapeziectomy side three year post-surgery. While approximately half of the participants reported no differences in joint mobility between both hands, two individuals indicated that the trapeziectomy side felt stiffer or felt somewhat looser. Conversely, two participants perceived the TJA side as being relatively stiffer.

The majority did not report a difference between both hands regarding control. However, half of the participants experienced better strength and fine motor performance skills in the TJA hand, regardless of whether this concerned the dominant or non-dominant side. Four people noticed shortening of the trapeziectomy thumb, but had no issues with it. Three people reported no aesthetic differences, two of whom had a trapeziectomy LRTI procedure. One participant found the trapeziectomy side to be unattractive due to the adducted position and sometimes hided the thumb in the presence of others. Another participant mentioned the adducted position of the TJA thumb as troublesome. A few participants experienced negative emotions due to unexpected increasing pain on the trapeziectomy side, concerns or fear about the dislocation risk of the TJA after heavy strain or being frustrated by their limitations and dependency on others. Regarding the postsurgical recovery process, all participants noticed a faster and easier recovery after TJA.

Activities and participation

Half of the participants did not experience differences between both hands. While the other half described differences during ADL or household activities due to pain, loss of control and grip or metacarpophalangeal (MCP) hyperextension in the trapeziectomy side. In the TJA side these participants sometimes experienced stabbing pain during strenuous activities, stiffness, or in one case the adduction position was restricting when washing hands or hair. One person reported being limited in all hobbies and sports because the dominant-trapeziectomy hand had always remained somewhat painful, and the pain, cramps and fatigue were increasingly present. One participant was afraid to resume sports due to concerns about TJA complications, but now has gained confidence to try it again. In a minority of the people, hand/thumb function somewhat affected social activities and relationships because they were cautious when lifting grandchildren, performing heavier caregiving tasks or shaking hands. In all these cases it concerned the dominant trapeziectomy side. Overall, it was stated that these limitations had no significant impact on their social interactions.

Theme 4: MHOQ

Most participants stated that the differences between both hands were sufficiently covered in the questionnaire and they did not miss items. Overall, the questionnaire was mentioned as 'standard'. Some participants found certain questions not relevant to themselves or their daily activities. Such as the aesthetics questions or questions regarding work when the participant was retired. One person mentioned difficulties in not being able to provide an explanation or to mark 'not applicable', and another person experienced difficulties to score the current hand function. Another person missed the possibility to specify the pain. Activities mentioned during the interview but not captured by the MHOQ were chopping vegetables or meat during cooking, wringing out a cloth, washing hands, writing, holding a media device and book, putting on jewellery, lifting heavy objects, lifting (grand)children and shaking hands. Substantial variability was observed in MHOQ total scores for the dominant hand as well as for the non-dominant hand without any differences between hands (Table 3). Analysing MHOQ scores per procedure revealed the same pattern. In two participants the MHOQ score seemed not consistent with their story. The interviewer administered the questionnaire again at the end of the interview, to get insight into possible reasons and to what extent re-completion would change the outcome. This resulted in a 50% higher total score. One participant acknowledged being not that attentive when completing the questionnaire and the other participant stated she did not understand the questions properly. MHOQ scores for the dominant hand and non-dominant hand were equal for participants who did not experience

differences between procedures. MHOQ subscales hand function and satisfaction scores differed in two participants who experienced differences between hands.

Table 3. Michigan Hand Outcome Questionnaire scores presented per procedure and per hand in median (Q1-Q3)

MHOQ score (0-100)	Trapeziectomy	TJA	Dominant hand	Non-dominant hand
Total score	82 (65 - 91)	84 (68 - 88)	82 (65 - 91)	84 (69 - 88)
Subscale satisfaction	75 (43 - 91)	83 (50 - 91)	79 (38 - 92)	81 (51 - 87)
Subscale ADL	88 (77 - 92)	86 (77 - 88)	89 (77 - 92)	86 (77 - 87)

DISCUSSION

This study reflects experiences of the current hand function, considering all aspects of daily life, of people who underwent bilateral TMC surgery and differences they experience between trapeziectomy and TJA. The majority of the participants experienced a residual form of pain and loss of strength during strenuous activities and only one participant was completely free of pain. Half of the participants experienced better strength and fine motor performance skills in the TJA hand, regardless of whether this concerned the dominant or non-dominant side. Half of the participants experienced some minor differences on activity and participation level without a significant impact on their social interactions.

Surgery

It is not surprising that all participants chose surgery because of increasing pain leading to limitations in daily life, since it is known that pain caused by TMC OA is associated with a negative impact on all ICF levels and interferes with daily life [21]. Prior to surgery, a non-surgical treatment is recommended including thumb orthoses [6]. An interesting finding was that participants also expressed the preference to discontinue wearing orthosis as a reason for surgery from an aesthetic and comfort point of view. This was not recognized as a patient motivation for surgery in the study of Gravas et al. [20], who identified reducing pain and/or improving function, activity or participation as ICF linked goals.

Participants acknowledged the benefits and disadvantages of both procedures and despite the absence of concern about potential complications or the longevity of the prosthesis, participants would appreciate more detailed preoperative counselling regarding all aspects of the surgery and rehabilitation duration. Reasons for choosing a procedure again, varied and were based on personal experience influenced by

factors such as functional outcomes, type of occupation as well as beliefs and feelings regarding the procedure and their current functioning. A shorter recovery time was recognized but did not lead to a greater preference for choosing TJA.

This was hypothesized by Nietlispach et al. [24] as a factor influencing a patient's decision to undergo TJA. In their study, comparing clinical and patient reported outcomes in 14 females who had both trapeziectomy and TJA, patients were generally satisfied with both procedures. However, more patients (n=10) preferred TJA over trapeziectomy, but reasons for these preferences were not listed.

General functioning

Some limitations on body functions level remained with heavy duty activities, leading to earlier fatigue and occasional pain despite significant pain reduction from surgery. On activity and participation levels these differences seldomly led to significant limitations. Residual pain during various activities was also recognized by other studies with pain scores on numeric rating scales during activities in a range of 1.0 to 2.5 after different TMC OA surgical procedures [22,24]. This emphasizes the importance of informing patients prior to surgery, regardless of surgical procedure, to expect some residual activity related pain and loss of strength, specifically during heavy or forceful activities.

Differences between trapeziectomy and TJA

Half of the participants experienced better strength and fine motor performance skills in the TJA hand, regardless of whether this concerned the dominant or non-dominant side, and half of the participants did not experience any differences on activity and participation level. Hand/thumb function somewhat affected social activities and relationships because they were cautious when lifting grandchildren, performing heavier caregiving tasks or shaking hands concerning the dominant trapeziectomy side or protecting the TJA side. The differences found depended on what hand function was required during occupational and recreational activities and the extent to which participants were able adapt the execution of activities.

Shortening of the trapeziectomy thumb, as commonly seen due to collapse of the first metacarpal, is an often reported complication in the literature [5] but it does not influence pain or functional outcome [25–28]. This was confirmed by our participants as they noticed the shortening without the experience of being problematic from an aesthetic or functional point of view.

As reported in many previous studies [1–4,11,24], all participants confirmed a faster and easier recovery after TJA compared to trapeziectomy. A qualitative study, addressing the duration of the recovery process after trapeziectomy with LRTI, concluded that patients were surprised about the long duration of this process and emphasized the importance of hand therapy in guiding patients' postoperative expectations and in rehabilitation [29]. The majority of our participants agreed that information and guidance after TJA is desirable but rehabilitation guided by a hand therapist is not necessary to regain function. The faster recovery and no specific need for a rehabilitation trajectory is a benefit of TJA over trapeziectomy from both the perspective of the patient and the health care provider.

MHOQ

Half of the participants experienced better strength and fine motor performance skills in the TJA hand, but the MHOQ scores did not reflect this. This suggests an underrepresentation of these items in the MHOQ, as only four of the 12 questions in the ADL subscale represent pinch or key pinch activities. The MHOQ pain subscale assesses frequency rather than pain intensity or pain provoking activities. Also, the pain subscale is not administered separately for both hands like the other MHOQ subscales. As a consequence, when comparing surgical procedures, differences based on specific pain inducing factors such as strenuous activities or fine motor skills and strength, cannot be captured. Despite the MHOQ is a validated instrument for the TMC OA population, showing an excellent responsiveness [30,31], the discriminatory power to detect differences between surgical groups seems insufficient as the MHOQ does not cover all relevant items as addressed by our participants. For this goal, a supplementary questionnaire representing activities requiring precision skills, (key)pinch strength and pain provoking activities is recommended. Finally, it is important to realise that MHOQ scores will be influenced by other health issues affecting hand function such as polyarthritis and by the ability to read and understand the questions or the amount of attention given to the many questions.

Methodological considerations

The study population is a precise reflection of our patient population regarding distribution of gender, age and number of people with paid work. Nevertheless, findings of a qualitative study are not meant to be generalized but rather used for getting better and deeper insights in participants' experiences and perspectives. Regarding the use of the MHOQ in our study, we have not administered the MHOQ pain and work subscales separately for both hands like the other MHOQ subscales, which may potentially have resulted in missed information.

To ensure trustworthiness of the data, credibility was established with the use of a purposive variated sample. Secondly, reliability was ensured by keeping a decision trail. To account for bias from a therapeutic relationship, participants who previously received hand therapy treatment from EBJ, were interviewed by BdJ. To prevent for researcher bias, triangulation methods were used when compiling the interview guide as well as when discussing codes, themes and interpretation of results with all authors with searching for falsification of results. Furthermore inclusion of representative quotations from the participants and photographs of their hands makes the interpretation transparent for the reader. Finally, a researcher not involved in this study, did a peer review to comment on the study and results.

Clinical relevance

From the patients perspectives, both procedures are eligible options because pain is reduced by the surgery, leading to satisfactory results despite some residual pain, loss of strength or fine motor skills. Limitations on body functions level, did not lead to limitations at activity and participation level. Possibly, activity modification and coping strategies could play a role in this. On the other side, participants did experience better strength and fine motor performance skills in the TJA hand, the rehabilitation duration was shorter and no specific guidance of hand therapists is needed. When patients have high occupational or recreational demands requiring (key)pinch strength and precision skills, TJA might be the better option. However, trapeziectomy always remains an effective solution, as was confirmed by our participants who preferred trapeziectomy over TJA in half of the cases.

Educating patients about the benefits and disadvantages of both procedures facilitates the shared decision making process. To set realistic expectations regarding the results in the short-, mid- and long-term, information should cover potential residual limitations in strength, pain, fine motor skills and performing strenuous tasks as well as potential complications and longevity of the TJA.

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Supplemental materials

Supplemental material S1. Interview guide

Supplemental material S2. Photographs of four participants' hands

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Supplemental Table S1. Interview Guide

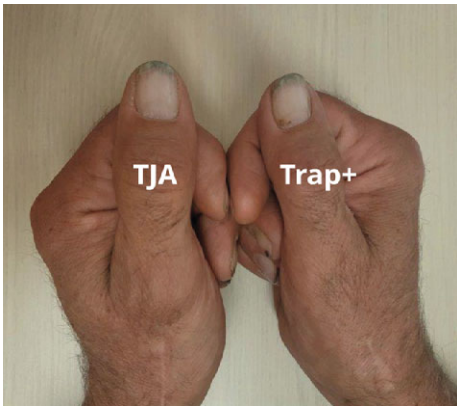
Main topic	Topics/ Questions
Introduction	Purpose and duration of the interview
Opening questions	What is your age?
	Which hand is your dominant hand?
	Do you remember which hand underwent which surgery and when? (for verification also retrieved from the medical record beforehand)
	Are there currently any other hand issues affecting thumb function (for instance tenosynovitis stenosans, carpal tunnel syndrome, poly-osteoarthritis)?
Transition question	For which reason did you choose surgery? Did it differ between both hands?
Key questions	*Every key question below is followed by the follow-up questions* *- Do you experience differences between the left and right thumb?* *- What does this difference entail?* *- Can you tell me more about these differences?* *- What does this difference mean for you?*
Daily tasks and self-care activities	How do your thumbs function in general/ daily life? Please tell me how you perform daily tasks and self-care activities (e.g., eating, brushing your teeth, tying shoelaces, walking with a mobility aid).
Household tasks	What household tasks do you do?
	Can you tell me how you perform household tasks (e.g., cooking, wringing, opening jars, cleaning, shopping)?
Occupation	What is your occupation? Are you still working? (do you perform paid work?) If no, why not? If yes, the same occupation as before the surgery? If working: Can you tell me about how you perform your job in relation to your hand function?
Leisure activities	Do you have hobbies, sports or other leisure activities? Can you tell me how you perform your leisure activities, such as sports and hobbies in relation to your hand function? Can you tell me if transportation is limited due to your hand function? (i.e. riding a car or bicycle or walking with a mobility aid) If yes, why?
Social activities	Can you tell me about the use of your hands during your social activities / maintaining relationships?
Aesthetics	Can you tell me what you think how your thumbs look?
Functions	Do you experience thumb pain nowadays? Can you tell me how you experience the strength of your thumbs? Can you tell me how you experience the range of motion of your thumbs? Can you tell me how you experience the control of your thumbs? Can you tell me how you experience performing precision tasks with your thumbs?
MHOQ	Are there items from the questionnaire you completed in advance of this interview that seem to be lacking? Are there important items you would like to add? Does the questionnaire represent the differences between both hands? Do you think items have to be added to make these differences clearer? Are there unnecessary items in the questionnaire?

Main topic	Topics/ Questions
Results of the surgery	What have the surgeries brought to you? Are you satisfied with the results of the surgeries? Why or why not? Is it related to complications you experienced? If you had to choose again, which surgery would you choose? Why would you choose this surgery? What is your view on the limited lifespan of the prosthesis? What do you think about the difference in aftercare between the two surgeries? What is your experience? Would you recommend the surgery to someone else? Reasons for why or why not?
Closing questions	Do you have any recommendations for us as healthcare providers? Is there anything else you would like to add that we haven't discussed yet?

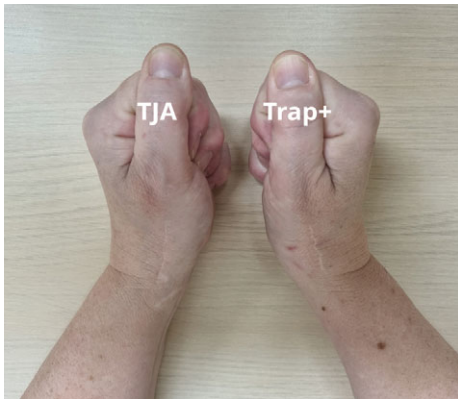
Supplemental materials S2. Photographs of four participants'hands

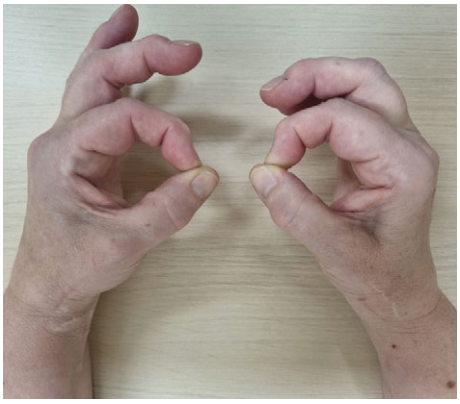
(Courtesy: Elske Bonhof, published with permission of patients)





Keypinch of a right-dominant male participant with trapeziectomy+ right and TJA left. He preferred TJA if he had to choose again.





Loaded keypinch (left) and pinch (right) of a right-dominant female participant with trapeziectomy+ right and TJA left. She preferred trapeziectomy+ if she had to choose again.



Loaded keypinch (left) and pinch (right) of a left-dominant female participant with TJA left and trapeziectomy right. She had no preference for a surgery if she had to choose again.



Loaded keypinch (left) and pinch (right) of a right-dominant female participant with trapeziectomy right and TJA left. She preferred trapeziectomy if she had to choose again.

TJA = Total joint arthroplasty; Trap = trapeziectomy; Trap+ = Trapeziectomy with tendon interposition ligament reconstruction

PART II

POSTOPERATIVE CARE AFTER TOTAL JOINT ARTHROPLASTY



Chapter 5

Immobilization, rehabilitation and complication classification after thumb trapeziometacarpal total joint arthroplasty. A scoping review.

Bonhof-Jansen EEDJ, Brink SM, van Uchelen JH, van der Sluis CK, Broekstra DC.

Hand Surg Rehabil. 2024 Dec;43(6):101783.

ABSTRACT

The best way of immobilization as well as effectiveness of rehabilitation for trapeziometacarpal (TMC) total joint arthroplasty (TJA) is unknown. We aimed to identify and describe the available evidence, practice variation and knowledge gaps regarding this topic. Literature was searched without restrictions. 123 studies were included, describing twenty-one prosthesis types. Reported immobilization types were cast (23%), splint (18%), compression bandage (10%), or combinations (26%). In 19%, immobilization time and type was not reported. Supervised rehabilitation (22%), self-rehabilitation (11%), functional use (11%), or customized rehabilitation (16%) were the rehabilitation forms reported. In 28% rehabilitation type was not described. Two (2%) studies used complication classifications, but time to complication was not described in 53 (43%). Multiple evidence gaps exist; lacking studies comparing types of immobilization protocols as well as rehabilitation regimens after TMC TJA. Currently there is no scientific evidence for any postoperative regime. This means that decision-making is based on clinical experience rather than evidence, explaining the wide practice variation.

INTRODUCTION

Total joint arthroplasty (TJA) of the trapeziometacarpal (TMC) joint with a ball and socket prosthesis has become an accepted surgical intervention for patients with debilitating osteoarthritis affecting the thumb base [1]. As with any surgical procedure, effective postoperative care is crucial for optimal results. However, in TMC TJA, the most efficient and safe way of immobilization and duration as well as effectiveness of supervised rehabilitation is investigated scarcely. In the only three systematic reviews regarding postoperative management after TMC surgery, just three publications concerning TJA were included [2] and in later updates TJA was excluded [3,4]. In another systematic review, aimed to update the available evidence for the use of TMC TJA, postoperative rehabilitation protocols were part of the data-extraction protocol but were not further reported on due to limited information in the original studies [1]. As implant-related complications are the main drawback of TMC TJA [5–8], addressing complications must be part of the evaluation, also when evaluating effectiveness of postoperative care. The purpose of this scoping review is twofold; (1) to identify and summarize the available evidence as well as practice variation regarding immobilization- and rehabilitation protocols and complication classifications used after TMC ball and socket prostheses, (2) to identify knowledge gaps.

METHODS

Protocol and registration

This review is conducted in accordance with the JBI methodology guidance for scoping reviews, using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses - Scoping Reviews (PRISMA-ScR) checklist [9,10]. The protocol was registered at OpenScience Framework on December 14th 2022. https://osf.io/ngtfh/?view_only=8fda936e22c247a98918834c6edbbb8f).

Eligibility criteria

Eligible studies were clinical studies concerning adult patients with thumb base osteoarthritis who underwent primary surgery with a ball and socket prosthesis. Full-text publications of clinical studies with at least one year follow-up containing information regarding postoperative immobilization and/or rehabilitation and/or complications were included. There were no restrictions regarding publication year, journal type, study design, level of evidence (LoE) and language. Articles were excluded when only an abstract was provided, it concerned clinical commentary,

an editorial note or letter to the editor, a conference abstract, posters, a qualitative study, a preliminary study, cadaveric studies, biomechanical studies, case reports or when full texts were unavailable. Exclusion also followed if articles concerned revision arthroplasty, trapeziectomy (including soft tissue procedures i.e. Weilby, LRTI), interposition arthroplasties (hemiarthroplasty, spacer implants, suture suspension), arthrodesis, osteotomy, combined surgery of the MCP-1 joint or other procedures than TJA. Publications were combined in the data-extraction table when these reported on long-term follow-up studies of the same study population in previously reported literature.

Information sources and search strategy

To avoid duplication with previous or upcoming reviews regarding this topic, a preliminary search was conducted on August 8th 2022 in Prospero, JBI Evidence synthesis, Open Science Framework registries as well as in Pubmed and Cochrane, this excluded suspicion of duplication.

The first search was intended to identify relevant keywords. Combined with words from search strings of previous relevant systematic reviews [3,4], the first author and a medical information specialist/librarian built a broad search string. This search strategy was adapted for all indexed databases (Appendix A). The literature search was undertaken by the first author across the following electronic databases on February 15th 2023: The Cochrane Library, Medline, EMBASE, CINAHL and PEDro. No filters were applied. The search was repeated on October 12th 2023 to identify new literature. The reference lists of relevant systematic reviews and the included studies were manually checked for additional relevant sources. Two reviewers (EBJ and SB) calibrated the selection and data extraction strategy by an independent pilot session with a sample of 19 articles. The results were compared for in- and exclusion criteria, the data extraction table and level of evidence checklist [11] to ensure a similar interpretation. Uncertainties were resolved through discussion and consensus, in consultation with an independent third reviewer (DB), leading to a clarification of the selection criteria. The calibration session resulted in improved agreement between the reviewers (unweighted Cohen's k before validation: k = 0.95 and after validation: k = 1.00) [12]. As during the calibration session the LoE table turned out to be insufficiently distinctive for our review, it was replaced by the modified Oxford table [13].

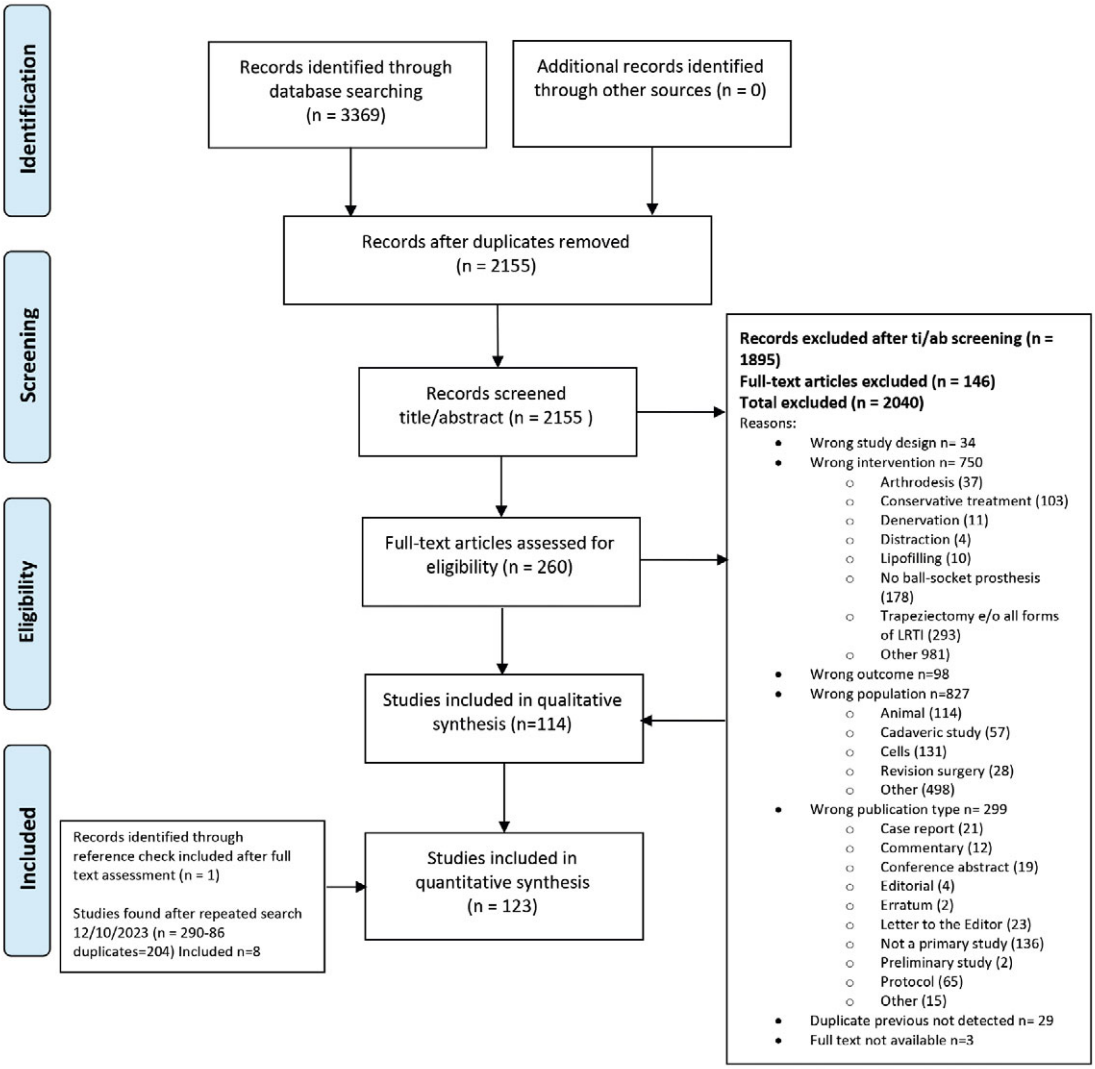


Figure 1. Flow chart

Selection of individual sources of evidence

Literature was uploaded from the electronic databases into the Rayyan application [14]. After de-duplication, articles were screened on title and abstract. If in doubt about meeting the inclusion criteria, the article was provisionally included for the full-text assessment round. Data from the included full-text articles was extracted in calibrated excel forms that were tested by the team before usage. Screening and data extraction was done blinded and in duplicate by the two reviewers. Disagreements between the reviewers during the selection procedure and data

extraction were resolved through discussion and consensus, if necessary with an independent reviewer with methodological background (DB) or with surgical background (JU). Where required, the authors of eligible studies published since 2013 were contacted by email to provide additional information or resolve any uncertainties, including one reminder mail. Publications describing multiple implant types with different immobilization or rehabilitation protocols, were described in the table with one line per implant. Additional analyses regarding studies with a high LoE and studies utilizing an early active motion (EAM) regime was performed. Furthermore, to make recommendations for future research, gaps in the existing literature were identified and interpreted [15].

RESULTS

Selection and characteristics of sources of evidence

The study selection process of search results is shown in Figure 1. Records identified through database searching yielded 3369 hits. Finally, 123 studies were included for quantitative synthesis. As ten studies reported on long-term follow-up of a previously described study population, we combined these in the data-extraction table (Appendix B). Twenty-one prosthesis types were described in a time frame of nearly 50 years (1974-2023) (Figure 2), containing 6695 patients of which 5198 females and 1069 males with a mean age of 60.3 (SD 4.2) years. In 18 studies (15%) gender was not described. Except from eight [16–23], all publications were from European origin, of which 42% from Belgium and France. The majority, 97/123 studies (79%), were classified as level 4 as they described case series. Five studies (4%) were ranked as LoE 1, concerning randomized controlled trials with implant types Elektra [24,25], MAIA [26], Moovis [27] and Touch [28]. Four of them were published in the last four years. Three studies [29–31] (2%) were level 2, prospective cohort studies, and 20 (16%) level 3, retrospective cohort studies. In 53 (43%) articles information was lacking for immobilization, rehabilitation or both. Twenty authors were approached, of whom ten responded and provided additional information. Furthermore, 10% of the studies contained inconsistencies regarding reported numbers of demographic variables in abstract, tables or text, or in the description of eligible patients versus included or analyzed patients, entailing uncertainties of precise numbers.

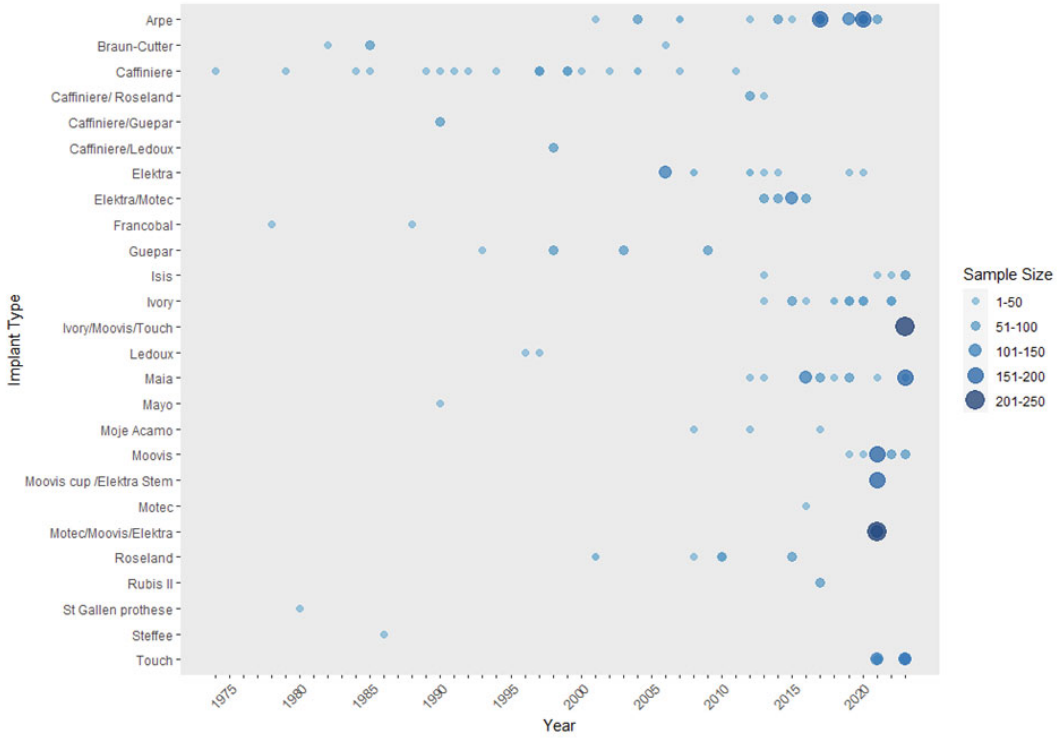


Figure 2. The Bubble chart represents the number of studies over the years per implant type. The size of each bubble is representative of the number of patients included in each study.

Immobilization protocols

Immobilization type was classified according to the degree of support of the thumb postoperatively. Identified immobilization types were cast (23%), splint (18%), compressive bandage (10%) or combined forms (25%). Of these combined forms, cast with additional usage of splint or brace was most common (19%), followed by the combination of compressive bandage with splint or brace (4%). In 23% of the studies immobilization type was not reported and in 19% immobilization time and type were unspecified (Table 1). The median total immobilization time (the sum of continuous and intermittent immobilization time) was 3 weeks (Q1 to Q3: 2.0 to 4.0). The median continuous immobilization time was 3 weeks (Q1 to Q3: 2.0 to 3.0). An additional intermittent immobilization period was applied in 37 (29%) studies in which in 5 studies the duration of this time was not reported. Median intermittent immobilization time was 3 weeks (Q1 to Q3: 2.0 to 4.0). As too many assumptions had to be made to summarize these findings in a concise table we refer to Appendix B for the overview of immobilization time per study. When a switch from continuous to intermittent immobilization was described, a

simultaneously switch of immobilization type was found in 27 studies. Prescription of intermittent splint or brace usage concerned removal only during exercises [17,32,33] or gradually reducing wear time for instance only during night time or when performing demanding activities [34–41]). In the remaining 26 studies criteria for weaning of the splint or brace were not described.

Table 1. Reported immobilization types

Immobilization type	Studies n (%)	Implant type	References
Cast	29 (23%)	Arpe, Beznoska, Braun-Cutter, Caffinière, Elektra, Isis, Ivory, Maia, Moje Acamo, Motec, Moovis, Touch	[18,19,24–26,31,54,59,69–89]
Splint	22 (18%)	Arpe, Braun-Cutter, Caffinière, Elektra, Guepar, Ivory, Maia, Moovis, Roseland, Rubis II, Touch	[17,21,27–29,34,36,40,53,75, 90–101]
Compressive bandage	12 (10%)	Caffinière, Ivory, Moovis, Roseland, Steffee, Touch	[42–44,47–49,51,52,59,102–104]
Combined	31 (25%)		[23,24,32,33,35,37–39,41,50, 58,79,105–123]
Of which:			
• Cast + splint/ brace	23 (19%)	Arpe, Caffinière, Elektra, Ivory, Maia, Moje Acamo, Motec, Moovis, Touch	[23,24,32,35,37–39,41,69,101, 104–109,112,114,115,117–120]
• Compressive bandage + splint/brace	5 (4%)	Caffinière, Isis, Ivory, Moovis, Roseland	[33,50,106,107,114]
• Divers	3 (2%)	Elektra, Touch	[58,115,117]
Unknown	29 (23%)	Arpe, Braun-Cutter, Caffinière, Elektra, Francobal, Guepar, Isis, Ivory, Ledoux, Maia, Mayo, Roseland, St Gallen	[16,20,46,124–148]

Rehabilitation protocols

Rehabilitation type was classified according to the degree of supervision or guidance the patients received. In 28% of the studies the rehabilitation type remained unclear (4%) or was not reported (24%). In the other studies, three types of rehabilitation could be extracted: supervised rehabilitation (22%; sessions supervised by a hand therapist, occupational- or physiotherapist), self-rehabilitation (11%; one time exercises prescribed by the surgeon or therapist or a leaflet, patients could perform exercises independently and unsupervised at home), functional use (11%; no exercises prescribed, patients were free to use the hand during activities guided by pain). In 16% of the studies these forms were individually prescribed (i.e. supervised rehabilitation only prescribed in case of delayed recovery or at the patient's request) (Table 2). Rehabilitation protocols were not added except for one study [26]. The median time patients were released to unrestricted activities

was 12 weeks (Q1 to Q3: 6.0 to 12.0) in studies concerning 13 prosthesis types. In three studies patients were encouraged to normal activities as soon as possible [42–44]. Time to unrestricted activities was not reported in 90 (73%) studies.As the majority of studies were classified as level 4, we conducted an additional analyses of high-level studies (LoE1 [n=5] and 2 [n=3]) [24–31]. These eight studies evaluated five different implant types, with six of the studies focusing on a single mobility implant. The variability in immobilization and rehabilitation protocols observed across the entire body of studies was also present in this subset. Additionally, we assessed the percentage of revision surgeries due to implant failures. One study, involving the Elektra TJA [25], reported a revision rate of 26.3%, while all other studies reported rates below 12%. Associated complications and their management were not consistently documented across all studies.

To gain more insight into the characteristics and complications reported in studies that described an EAM regime, we selected studies that used compressive bandage as immobilization type combined with functional use or individually prescribed rehabilitation. Eleven studies (LoE 3 [n=3], LoE 4 [n=8]), met these criteria [42–52]. Seven implant types of which cemented, uncemented single mobility and dual mobility were used. Time of total and continuous immobilization ranged from 0.7 to 2 weeks. Six studies prescribed functional use and five studies individually prescribed one of the rehabilitation types. Time to unrestricted activities was only reported by Tchuruckdichian [42–44], where patients were advised to resume their activities as soon as possible. The percentage of patients requiring revision surgery remained below the 12%. In five studies, the number of associated surgeries was not reported, preventing any preliminary conclusions about the effects of EAM or related complications.

Classification of complications

Complications were defined as all complications (implant related as well as associated conditions such as Quervain's tenosynovitis or trigger thumb) which occurred after surgery. Whether time to complication was described in each paper was recorded as well as the use of a classification system for the description of complications. Two complication classifications were found; one study [53] described a radiological standard scoring protocol for prosthetic complications and the second study [54] developed criteria to scale the implant performance based on range of motion, pain, DASH questionnaire and radiological outcome. Forty-two (34%) studies described time to complications and in 29 (23%) it was incomplete or inconclusive. Time to complication was not described in 53 (43%) of the studies.

Table 2. Reported rehabilitation types

Rehabilitation type	Studies n (%)	Implant type	References
Supervised rehabilitation	27 (22)	Arpe, Braun-Cutter, Caffinière, Elektra, Guepar, Ivory, Maia, Moje Acamo, Moovis, Motec, Roseland, Touch	[21,26,27,29,34,37,39,58,73,78,80, 90,93–95,100,106,114,115,117–119, 121–123,148,149]
Self rehabilitation	14 (11)	Beznoska, Elektra, Francobal, Guepar, Isis, Ivory, Maia, Moovis, Motec, Roseland, Rubis II	[24,40,41,77,79,81,88,96,112,113,130,132,141,143]
Unclear if supervised or self-rehabilitation	14 (11)	Arpe, Braun-Cutter, Caffinière, Elektra, Isis, Ledoux, Roseland	[17,23,32,38,71,74,75,84,85,92,97,102 ,103,145]
Functional use	14 (11)	Arpe, Caffinière, Elektra, Ivory, Maia, Moje Acamo Moovis, Motec Roseland, Steffee, Touch	[33,42–48,70,75,79,86,108,110]
Individually prescribed	20 (16)	Arpe, Braun-Cutter, Caffinière, Elektra, Isis, Ivory, Maia, Moovis, Roseland	[20,24,25,31,36,49–52,54,59,76,82,83, 99,101,116,120,125,133]
Unknown	34 (28)	Arpe, Caffinière, Elektra, Francobal, Guepar, Isis, Ledoux, Maia, Moje Acamo, Mayo, St Gallen, Touch	[16,18,28,30,35,53,69,89,91,97,98,104, 105, 107,109,111,124,126–129,131,134–138,140,142,144,146,147,150,151]

DISCUSSION

This scoping review showed a wide variation in postoperative policy between and within prostheses types and an inconclusive way of postoperative policy and complication description. Also, an evidence gap is confirmed for comparative studies regarding types of immobilization protocols as well as rehabilitation regimens after TMC TJA.

Immobilization and rehabilitation protocols

This review revealed that, in 23% of the studies, immobilization type was not reported while in 19% of the studies both immobilization time and type were unspecified. Rehabilitation type was not reported in 24% of the studies. Prosthesis manufacturers recommend an immobilization period to ensure implant osseointegration. However, due to the observed variety in immobilization protocols, regardless of LoE, the optimal type and duration seems undetermined. The success of osseointegration is multifactorial, as it depends on many different aspects such as biological, biomechanical, surgical and clinical variables and evolution of the

implant types [55]. Physiological disadvantages of immobilization are numerous, amongst others decreased bone density and joint mobility, muscle atrophy and reduction of vascular and lymphatic function. To overcome these disadvantages, EAM protocols have become more common within hand surgery and hand therapy, consisting of reduced immobilization time, less rigid immobilization and early initiation of active range of motion exercises [56,57]. This is also reflected in the immobilization or rehabilitation protocols that are used with the new implant generation: compressive or neoprene bandage usage instead of cast and/or functional use instead of supervised rehabilitation and return to activities as soon as possible [33,42–44,58,59]. However, these studies are all classified as LoE 3 and 4. As immobilization time, type of rehabilitation and time to release patients to unrestricted activities affects quality of life in the postoperative period, time needed to return to full activities and work as well as costs, these are important factors which need to be addressed when developing a rehabilitation program [60]. The choice of a rehabilitation program requires evidence based practice and expertise from the surgeon and the therapist, as well as the assessment of risk factors related to the patients pathology and the patient themselves, hereby considering all dimensions of the biopsychosocial model [61]. It was found that the type of aftercare after CMC soft tissue arthroplasty is also influenced by business related factors such as availability of hand therapists, years of surgical experience and geographical distance between patient and clinic [62].

Given that the design of TMC TJA shares similarities with hip TJA, it is conceivable to draw comparisons between their postoperative care protocols. Following uncemented total hip arthroplasty, studies indicate that no correlation exists between immediate unrestricted weight bearing and osseointegration failures, higher risks of femoral stem subsidence and surgical revision, when compared to partial weight bearing protocols. As also patient compliance and functional recovery was improved in these immediate unrestricted weight bearing protocols, these can be justified after hip TJA [63]. As the percentage of patients requiring revision surgery in the EAM studies (LoE 3 and 4) is comparable to the percentage in the LoE 1 and 2 studies and to the revision rate of 12.8% reported by Latelise [64] it warrants consideration to investigate an EAM regime after TMC TJA in comparative studiesComplications

As all factors mentioned above may influence the incidence and type of complications, it is a key to consider complications when developing studies addressing postoperative care regimens. Due to incomplete reporting of associated complications with their timing, (non)operative management and varying follow-

up durations, we were unable to make conclusions about effects of EAM or complications solely related to an immobilization or rehabilitation protocol. Our analysis was therefore limited to providing insights into the number of revision surgeries. A prespecified definition of possible complications will be helpful as a distinction has to be made between undesired subjective outcomes and objectifiable pathology [65]. The lack of patient-centered orientation is a limitation of the two classifications identified within this review, as the consequences and complication treatment are not part of these classifications. As no specific implant complication classification is available in the literature we recommend using the International Consortium for Health Outcomes Measurement (ICHOM) complication registration for wrist and hand conditions [66]. This may provide an unambiguous method of complication registration and enable comparison between studies. As this registration does not account for implant specific complications it could potentially be further developed by incorporating a list of such complications, for example as developed by national arthroplasty registries, where a distinction is made between types of implant specific and associated complications followed by severity and consequences from a patient perspective [67].

Strengths and limitations

The strength of this scoping review is underscored by the prior registration of its protocol, the systematic methodology and an extensive and repeated search without restrictions in year, language or design, providing a complete historical overview. Initially Google Scholar was added to the database searches, but it failed to produce reproducible results when using the same search string and results were limited to 1000 hits. Therefore we decided to omit this database search. The LoE table does not distinguish between prospectively, retrospectively or cross-sectionally collected data in studies without a comparative study arm. As such a LoE table does not exist, it resulted in mostly level 4 ratings. Furthermore, inconsistencies regarding reported numbers were frequently present in texts and tables and, although not directly a study limitation, this caused uncertainties of included versus analyzed patients, follow-up periods or gender. As in the last decade reporting guidelines warranted more complete reporting on studies, we noticed an increasing level of information in studies published in this period.

Knowledge gaps and recommendations for future research

A scoping review methodology aims to provide an overview of the evidence and identify knowledge gaps by using a systematic methodology and an extensive search, resulting in clear recommendations for future research. These are outlined in Table 3. Effectiveness of immobilization and rehabilitation is difficult to determine,

as it would be modified by multiple factors as prosthesis type, surgical experience, the surgery itself and the type and duration of immobilization as well as the rehabilitation protocol. To explore the trade-off between safe and (cost) effective postoperative care, future research should focus on high level evidence studies comparing different immobilization types and duration as well as rehabilitation regimens within the same prosthesis type with a focus on EAM regimes. When designing such studies, quality of osseointegration and complications need to be addressed systematically, as they could be influenced by early mobilization regimes. In this light, manufacturers should be challenged to provide surgeons and hand therapists with evidence based guidelines for aftercare. These has to be validated by independent reproduction studies to overcome industry bias, as it is known that sponsorship of studies by the manufacturing company can lead to more favorable outcomes [68].

CONCLUSION

This scoping review confirms an evidence gap in studies comparing types of immobilization protocols as well as rehabilitation regimens after TMC TJA and contributes to aggregated evidence. Currently there is no scientific evidence for any postoperative regime. Included studies were mainly of low quality of evidence, containing small samples, wide variation between and within prosthesis types and an inconclusive way of postoperative policy and complication description. Therefore decision-making is based on clinical experience rather than evidence which may explain the wide practice variation. High level comparative studies are needed to explore the trade-off between safe and (cost)effective protocols for immobilization as well as rehabilitation after TMC TJA.

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Table 3. Knowledge gaps of evidence with suggested research opportunities.

Research questions	Gaps in evidence [15]	Research opportunities	Future research questions
Which immobilization types are reported?	• Desired research findings do not exist • Practices are not covered by research • Evidence is missing from a body of research that could otherwise potentially answer the questions	Overall: Comparative studies within the same implant type. Criteria for type of immobilization; rigid for osseointegration or compressive bandage/ soft brace for reducing pain, swelling and provide support	Is an EAM regime a safe alternative after implantation of dual mobility prosthesis?
Which immobilization durations are reported?		Criteria for use of an intermittent immobilization period and time	Does an EAM regime result in fewer complications within the first 3 months postoperatively?
		Criteria for weaning of splint or brace	Does an EAM regime result in a faster RTW?
Which form of after care/ rehabilitation is prescribed?	• No evidence from primary studies is available	Criteria for rehabilitation form; when and what to prescribe?	Is supervised rehabilitation superior to self-rehabilitation or functional use?
		Time to release patients to unrestricted activities ADL, work, hobby, sport	What is a safe time to release patients to unrestricted activities ?
How are complications described and classified?	• Not much information is available concerning implant related complication classifications	Time to complication Classification to describe implant related and surgery related complications from a patient centred perspective	

ADL - Activities of Daily Living
EAM - Early active motion
RTW - Return to work

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Appendix A - Search strategy

Conducted on February 15, 2023, repeated on October 12, 2023.

Pubmed

("Carpometacarpal Joints"[Mesh] OR carpometacarpal[tiab] OR CMC[tiab] OR “basal joint”[tiab] OR “basilar joint”[tiab] OR ((thumb[tiab]) OR (base[tiab] *OR* basal[tiab] *OR* basil*[tiab])) OR trapezometacarpal[tiab] OR trapeziometacarpal[tiab] OR metacarpotrapezoid[tiab] OR TMC[tiab])
AND
("Arthroplasty, Replacement"[Mesh] OR “replacement arthroplast*”[tiab] OR implant*[tiab] OR prosthes*[tiab] OR “joint replacement*”[tiab] OR “joint arthroplast*”[tiab] OR TJA[tiab] OR "Trapezium Bone/surgery"[Mesh] OR "Carpometacarpal Joints/surgery"[Mesh])
1547 results 15022023 / 88 results 12102023

Cochrane

([mh "Carpometacarpal Joints"] OR carpometacarpal:ti,ab,kw OR CMC:ti,ab,kw OR "basal joint":ti,ab,kw OR "basilar joint":ti,ab,kw OR ((thumb:ti,ab,kw) AND (base:ti,ab,kw OR basal:ti,ab,kw OR basil*:ti,ab,kw)) OR trapezometacarpal:ti,ab,kw OR trapeziometacarpal:ti,ab,kw OR metacarpotrapezoid:ti,ab,kw OR TMC:ti,ab,kw)
AND
([mh "Arthroplasty, Replacement"] OR "replacement arthroplast*":ti,ab,kw OR implant*:ti,ab,kw OR prosthes*:ti,ab,kw OR "joint replacement*":ti,ab,kw OR "joint arthroplasty*":ti,ab,kw OR TJA:ti,ab,kw OR ([mh "Trapezium Bone"] *AND* [mh "Surgery"]) OR ([mh "Carpometacarpal Joints"] *AND* [mh "Surgery"]))
315 results 1502023 / 5 results 12102023

Embase

('carpometacarpal joint'/exp OR carpometacarpal:ti,ab,kw OR CMC:ti,ab,kw OR 'basal joint':ti,ab,kw OR 'basilar joint':ti,ab,kw OR ((thumb:ti,ab,kw) *AND* (base:ti,ab,kw *OR* basal:ti,ab,kw *OR* basil*:ti,ab,kw)) OR trapezometacarpal:ti,ab,kw OR trapeziometacarpal:ti,ab,kw OR metacarpotrapezoid:ti,ab,kw OR TMC:ti,ab,kw)
AND
('replacement arthroplasty'/exp OR 'replacement arthroplast*':ti,ab,kw OR implant*:ti,ab,kw OR prosthes*:ti,ab,kw OR 'joint replacement*':ti,ab,kw OR 'joint arthroplast*':ti,ab,kw OR TJA:ti,ab,kw OR ('trapezium bone'/exp *AND* 'surgery'/exp) OR ('carpometacarpal joint'/exp *AND* 'surgery'/exp))
1345 results 1502023 / 190 results 12102023

PeDRO
No results

CINAHL
((MH "Carpometacarpal Joints") OR (TI carpometacarpal OR AB carpometacarpal) OR (TI CMC OR AB CMC) OR (TI "basal joint" OR AB "basal joint") OR (TI "basilar joint" OR AB "basilar joint") OR (((TI thumb OR AB thumb)) *AND* ((TI base OR AB base) OR (TI basal OR AB basal) OR (TI basil* OR AB basil*))) OR (TI trapezometacarpal OR AB trapezometacarpal) OR (TI trapeziometacarpal OR AB trapeziometacarpal) OR (TI metacarpotrapezoid OR AB metacarpotrapezoid) OR (TI TMC OR AB TMC))
AND
((MH "Arthroplasty, Replacement+") OR (TI "replacement arthroplast*" OR AB "replacement arthroplast*") OR (TI implant* OR AB implant*) OR (TI prosthes* OR AB prosthes*) OR (TI "joint replacement*" OR AB "joint replacement*") OR (TI "joint arthroplast*" OR AB "joint arthroplast*") OR (TI TJA OR AB TJA) OR (MH "Trapezium Bone/surgery+") OR ((TI "trapezium bone*" OR AB "trapezium bone*") *AND* (TI surger* OR AB surger*)) OR ((MH "Carpometacarpal Joints") *AND* (TI surger* OR AB surger*)) OR ((TI "carpometacarpal joint*" OR AB "carpometacarpal joint*") *AND* (TI surger* OR AB surger*)))
162 results 1502023 / 7 results 12102023

Appendix B - Data extraction table

Author	Year	Country	LoE	Sample size (n)	Implant type	Implant characteristics
Alnot et al	1993	France	4	32	Guepar	cemented
Alnot et al	1998	France	3	79	Guepar	cemented
Amadio et al	1990	USA	3	10	Mayo implant	cemented
Amillo et al	2002	Spain	4	11	Caffiniere	cemented
Andrzejewski et al	2019	France	4	93	Maia	uncemented single mobility
Apard et al	2007	France	4	19	Arpe	uncemented single mobility
August et al	1984	UK	4	20	Caffiniere	cemented
Badia et al	2006	USA	4	25	Braun-Cutter	cemented
Boeckstijns et al	1989	Denmark	4	28	Caffiniere	cemented
Braun	1982	USA	4	29	Braun-Cutter	cemented
Braun	1985	USA	4	50	Braun-Cutter	cemented
Braun	1991	USA	4	NA	Braun-Cutter	cemented
Bricout et al	2016	France	4	139	Maia	uncemented single mobility
Brutus et al	2004	Belgium	4	54	Arpe	uncemented single mobility
Buffet et al	2022	France	4	19	Isis	uncemented
Caekebeke et al	2018	Belgium	4	35	Maia	uncemented single mobility
Caffiniere	1974/ 1979/ 1985/ 1991	France	4	10	Caffiniere	cemented
Cebrian-Gomez et al	2019	Spain	3	84	Ivory	uncemented single mobility
Chakrabarti et al / Johnston et al	1997/ 2011	UK	4	71/26	Caffiniere	cemented
Chiche et al	2023	France	4	157	Maia	uncemented single mobility
Chug et al	2014	Australia	4	14	Elektra	uncemented single mobility
Cootjans et al	2017	Belgium	4	156	Arpe	uncemented single mobility
Craik et al	2017	UK	3	83	Arpe	uncemented single mobility
De George et al	2018	France	3	NA	Maia	uncemented single mobility
De Jong et al	2023	The Netherlands	1	31	Maia	uncemented single mobility
De Smet et al	2004/ 2007	Belgium	4	40	Caffiniere	cemented

Immobilization total (weeks)	Immobilization continuous (weeks)	Immobilization intermittent (weeks)	Immobilization type	Rehabilitation type
NA	NA	NA	NA	NA
2,0	1,0	1,0	splint	supervised rehabilitation
NA	NA	NA	NA	NA
3,0	3,0	NA	splint	supervised rehabilitation
5,0	5,0	NA	cast	NA
4,0	2,0	2,0	cast/splint	NA
4.5	1.5	3,0	cast/splint	Unclear if (self) rehabilitation
1,0	1,0	NR	splint	Unclear if (self) rehabilitation
NA	NA	NA	NA	individually prescribed
1 to 3	1 to 3	NA	NA	individually prescribed
4,0	2,0	2,0	cast	supervised rehabilitation
1 to 3	1 to 3	NA	cast	
4,0	4,0	NA	splint	NA
3,0	3,0	NA	cast	functional use
NA	NA	NA	NA	NA
9,0	3,0	3,0	cast/splint	Unclear
2,0	2,0	NA	compressive bandage	unclear if (self) rehabilitation
6,0	3,0	4,0	compressive bandage /splint	supervised rehabilitation
NA	NA	NA	NA	NA
3,0	3,0	NA	NA	self rehabilitation
4,0	1,0	3,0	splint	supervised rehabilitation
3,0	3,0	NA	cast	Unclear if (self) rehabilitation
2,0	2,0	NA	splint	Unclear if (self) rehabilitation
3,0	3,0	0,0	cast	NA
4,0	4,0	0,0	cast	supervised rehabilitation
0,0	0,0	0,0	none	functional use

Author	Year	Country	LoE	Sample size (n)	Implant type	Implant characteristics
De Smet et al	2013	Belgium	3	23	Caffiniere/ Roseland	cemented
Dehl et al	2017	France	4	84	Rubis II	uncemented single mobility
Dodaro et al	1999	Italy	4	13	Caffiniere	cemented
Dreant et al	2019	France	4	25	Moovis	uncemented dual mobility
Dremstrup	2021	Denmark	4	168	Moovis cup (dual mobility) / Elektra Stem	uncemented dual mobility
Dumartinet-Gibaud et al	2020	France	4	63	Arpe	uncemented single mobility
Van der Eecken et al/ De Smet et al	2012 /2020	Belgium	4	29/50	Arpe	uncemented single mobility
Ehall et al	1990	Austria	4	11	Caffiniere	cemented
Erne et al	2018	Germany	3	39	Ivory	uncemented single mobility
Falkner et al	2023	Germany	4	52	Touch	uncemented dual mobility
Fauquette et al	2023	France	4	66	Isis	cemented and uncemented
Ferrari et al	1986	USA	4	38	Steffee	cemented
Filus et al	2023	Czech republic	4	48	Touch	uncemented dual mobility
Froschauer et al	2020	Austria	3	29	Elektra	uncemented single mobility
Froschauer et al	2020	Austria	3	29	Ivory	uncemented single mobility
Froschauer et al	2021	Austria	4	37	Touch	uncemented dual mobility
Gomez-Garrido et al	2019	Spain	4	137	Arpe	uncemented single mobility
Gonzalez-Espino et al	2021	Belgium	4	92	Touch	uncemented dual mobility
Goubau et al/ Vissers et al	2013 /2019	Belgium	4	22/24	Ivory	uncemented single mobility
Goubau et al	2015	Belgium	4	83*	Ivory	uncemented single mobility
Guardia et al	2010	France	4	68	Roseland	uncemented single mobility
Guggenheim et al	2000	Switzerland	4	40	Caffiniere	cemented
Guzzini et al	2023	Italy	1	68	Touch	uncemented dual mobility

Immobilization total (weeks)	Immobilization continuous (weeks)	Immobilization intermittent (weeks)	Immobilization type	Rehabilitation type
2,0	2,0	0,0	compressive bandage	functional use
3,0	3,0	NA	splint	self rehabilitation / individually prescribed
NR	NR	NA	compressive bandage/splint	NA
4,0	1,0	3,0	compressive bandage/splint	functional use
6,0	3,0	4,0	cast/ neoprene splint	functional use
NA	NA	NA	NA	NA
4 to 6	1 to 2	4,0	cast/splint	functional use / individually prescribed
2,0	2,0	0,0	compressive bandage	Unclear if (self) rehabilitation
6,0	2,0	4,0	cast/splint	functional use
7,0	1,0	6,0	cast/ brace	supervised rehabilitation
NA	NA	NA	NA	self rehabilitation
NR	NR	NA	compressive bandage	functional use
2,0	2,0	NA	cast	supervised rehabilitation
3,0	3,0	NA	splint	supervised rehabilitation
3,0	3,0	NA	splint	supervised rehabilitation
3,0	3,0	NA	splint	supervised rehabilitation
3,0	3,0	NA	cast	unclear if (self) rehabilitation
4,0	1,0	3,0	cast/splint	NA
7,0	3,0	4,0	cast/splint	self rehabilitation
7,0	3,0	4,0	cast/splint	self rehabilitation
4,0	0.3	4,0	compressive bandage/splint	supervised rehabilitation
NR	NR	NA	NA	individually prescribed
2,0	1,0	1,0	splint	Unclear

Author	Year	Country	LoE	Sample size (n)	Implant type	Implant characteristics
Hannula et al	1999	USA	4	33*	No name provided, design by author	uncemented single mobility
Hansen et al	2008	Denmark	4	16	Elektra	uncemented single mobility
Hansen et al	2013	Denmark	1	27*	Elektra	uncemented single mobility
Hansen et al	2013	Denmark	3	73	Elektra/Motec	uncemented single mobility
Hansen et al	2016	Denmark	4	59	Elektra/Motec	uncemented single mobility
Hansen et al	2008	Denmark	4	9	Moje Acamo	uncemented single mobility
Helbig et al	1988	Germany	4	47	Francobal	cemented
Hernández-Cortés et al	2012	Spain	4	19	Elektra	uncemented single mobility
Herren et al (low complication rate)/ Herren et al (short term recovery)	2023	Switzerland	4	101/147	Touch	uncemented dual mobility
Isselin	2001	France	4	45	Arpe	uncemented single mobility
Jacoulet	2007	France	4	29	Arpe	uncemented single mobility
Jager et al	2013	France	2	47	Maia	uncemented single mobility
Jurča et al	2016	Czech Republic	4	11	Beznoska	NA
Kaszap	2012	Germany	3	12	Moje Acamo	uncemented single mobility
Kirkeby et al	2021	Denmark	4	133	Motec/Moovis/ Elektra	cemented and uncemented
Kirkeby et al	2021	Denmark	4	222	Motec/Moovis/ Elektra	cemented and uncemented
Klahn et al	2012	Denmark	4	37	Elektra	uncemented single mobility
Klim et al	2023	Austria	1	82	Moovis	uncemented dual mobility
Kollig et al	2017	Germany	4	28	Moje Acamo	uncemented single mobility
Krukhaug et al	2014	Norway	4	82	Elektra/Motec	uncemented single mobility
Kubat et al	2012	Czech Republic	4	34	Maia	uncemented single mobility
Larsen et al	2015	Denmark	4	114	Elektra/Motec	cemented and uncemented
Lebrun et al	1996	France	4	56	onbekend	NA

Immobilization total (weeks)	Immobilization continuous (weeks)	Immobilization intermittent (weeks)	Immobilization type	Rehabilitation type
8,0	2,0	6,0	cast/splint	Unclear if (self) rehabilitation
3,0	3,0	NR	splint	Unclear if (self) rehabilitation
3,0	3,0	NA	cast	self rehabilitation / functional use
7,0	3,0	4,0	cast/ neoprene splint	self rehabilitation
3,0	3,0	NA	cast	self rehabilitation / functional use
3,0	3,0	NA	cast	functional use
NA	NA	NA	NA	NA
6,0	3,0	3,0	splint/ bandage	supervised rehabilitation
3,0	3,0	3,0	splint/soft brace	supervised rehabilitation
NA	NA		cast/ splint or brace	individually prescribed
3+	3,0	NR	cast/ splint	Unclear if (self) rehabilitation
3,0	3,0	NA	splint	supervised rehabilitation
2,0	2,0	NA	cast	self rehabilitation
3,0	3,0	NA	cast	supervised rehabilitation
3,0	3,0	NA	cast	functional use
6,0	3,0	3,0	cast/neoprene splint	self rehabilitation
6,0	3,0	3,0	cast/splint	supervised rehabilitation
6,0	6,0	NA	splint	supervised rehabilitation
18,0	6,0	12,0	cast/splint	supervised rehabilitation
NA	NA	NA	NA	NA
2,0	2,0	NA	cast	supervised rehabilitation
3,0	3,0	NA	cast	self rehabilitation
2,0	2,0	NA	compressive bandage	individually prescribed

Author	Year	Country	LoE	Sample size (n)	Implant type	Implant characteristics
Ledoux	1997	Belgium	4	24	Ledoux (cementless type, 1990)	uncemented single mobility
Lemoine et al	2009	France	4	68	Guepar	cemented
Lussiez et al	2021	Monaco/ France	4	107	Touch	uncemented dual mobility
Maes et al	2010	France	4	NA	Rubis II	uncemented single mobility
Martínez-Martínez et al	2015	Spain	2	15	Arpe	uncemented single mobility
Martin-Ferrero et al	2014 /2020 /2021	Spain	4	60/199/60	Arpe	uncemented single mobility
Martins et al	2020	France	4	46	Moovis	uncemented dual mobility
Masmejean et al	2003	France	4	60	Guepar	cemented
Moutet et al	1990	France	4	96	Caffiniere/ Guepar	cemented
Moutet et al	2001	France	4	24	Roseland	uncemented single mobility
Moya Aparicio	2000	Spain	4	17	Caffiniere	cemented
Nicholas et al	1992	Ireland	4	17	Caffiniere	cemented
Nonnemacher	1994	France	4	12	Caffiniere	cemented
Regnard et al	2006	France	4	100	Elektra	uncemented single mobility
Robles-Molina et al	2017	Spain	3	31	Arpe	uncemented single mobility
Sanchez-Crespo et al	2021	Spain	4	49	Isis	uncemented single mobility
Santos et al	2011	Portugal	3	18	NA	NA
Schuhl	2001	France	4	43	Roseland	uncemented single mobility
Seaourt et al	2021	France	3	48	Maia	uncemented single mobility
Semere et al	2015	France	4	51	Roseland	uncemented single mobility
Seng et al	2013	France	4	26	Isis	uncemented single mobility
Sondergaard et al	1991	Denmark	4	20	Caffiniere	cemented
Spaans et al	2016	Netherlands	4	20	Ivory	uncemented single mobility
Tchurukdichian et al	2020	France	4	88	Ivory	uncemented single mobility
Tchurukdichian et al	2023	France	3	211	Ivory/Moovis/ Touch	uncemented single and dual mobility

Immobilization total (weeks)	Immobilization continuous (weeks)	Immobilization intermittent (weeks)	Immobilization type	Rehabilitation type
NA	NA	NA	NA	NA
NA	NA	NA	NA	NA
7,0	3,0	4,0	splint	NA
2,0	2,0	NA	splint	self rehabilitation
3,0	3,0	NA	cast	individually prescribed
3,0	3,0	NA	cast	individually prescribed
4,0	4,0	NA	cast/splint	supervised rehabilitation
3,0	1,0	2,0	splint	self rehabilitation
0-4	0-4		NA	Unclear
1,0	1,0	NA	splint	Unclear if (self) rehabilitation
NA	NA	NA	NA	NA
1.5	1.5	NA	cast	Unclear if (self) rehabilitation
3,0	3,0	NA	splint	NA
3,0	3,0	NA	splint	individually prescribed
6,0	4,0	2,0	cast/splint	supervised rehabilitation
3,0	3,0	NA	cast	Unclear if (self) rehabilitation
2,0	2,0	NA	cast	NA
2 to 4	2 to 4	NA	unclear	self rehabilitation
4,0	4,0	NA	cast/splint	individually prescribed
4,0	4,0	NR	splint	supervised rehabilitation
0.3 to 2	0.3 to 2	NA	compressive bandage/splint	individually prescribed
NA	NA		NA	NA
4+	4+	NR	cast/splint	supervised rehabilitation
2,0	2,0	NA	compressive bandage	functional use
2,0	2,0	NA	compressive bandage	functional use

Author	Year	Country	LoE	Sample size (n)	Implant type	Implant characteristics
Tchurukdichian et al	2021	France	4	179	Moovis	uncemented dual mobility
Theyskens et al	2022 /Moovis cohort	Belgium	3	74	Moovis	uncemented dual mobility
Theyskens et al	2022 /Ivory cohort	Belgium	3	62	Ivory	uncemented single mobility
Thillemann et al	2016	Denmark	4	40	Motec	NA
Thomas	1978	Germany	4	8	Francobal	cemented
Thorkildsen et al	2019	Norway	1	19	Elektra	uncemented single mobility
Toffoli et al	2017	France	4	80	Maia	uncemented single mobility
Ulrich-Vinther et al	2008	Denmark	2	42	Elektra	uncemented single mobility
Van Cappelle et al	1999	Netherlands	4	63	Caffiniere	cemented
Vandenberghe et al	2013	Belgium	3	90*	Caffiniere/ Roseland	cemented
Vanmierlo et al	2022	Belgium	3	36	Ivory	uncemented single mobility
Wachtl et al	1996 /1998	Switzerland	4/3	34/84	Caffiniere/ Ledoux	cemented
Wyss et al	1980	Switzerland	4	12	St Gallen	NA
Závodský et al	2018	Czech Republic	4	40	Ivory	uncemented single mobility
Zollinger et al	2008	Netherlands	4	27	Roseland	uncemented single mobility
Zollinger et al	2010	Netherlands	4	34	Roseland	uncemented single mobility

Publications were combined in the data-extraction table when these reported on long-term follow-up studies of the same study population in previously reported literature.
* Precise number uncertain
NA Not applicable
NR Not reported

Immobilization total (weeks)	Immobilization continuous (weeks)	Immobilization intermittent (weeks)	Immobilization type	Rehabilitation type
2,0	2,0	NA	compressive bandage	functional use
NR	NR	NA	compressive bandage	individually prescribed
2,0	2,0	NA	cast	individually prescribed
6,0	2,0	4,0	cast/splint	supervised rehabilitation
NA	NA	NA	NA	self rehabilitation
6,0	6,0	0,0	cast	individually prescribed
3,0	3,0	NA	cast	functional use
3,0	3,0	NA	cast	Unclear
NA	NA	NA	NA	NA
2,0	2,0	NA	compressive bandage	Unclear
3,0	3,0	NA	cast	self rehabilitation
2,0	2,0	NA	NA	Unclear if (self) rehabilitation
NA	NA	NA	NA	NA
2,0	2,0	NA	NA	supervised rehabilitation
0.7	0.7	NA	compressive bandage	individually prescribed
0.7	0.7	NA	compressive bandage	individually prescribed

Chapter 6

Trapeziometacarpal total joint arthroplasty, with or without supervised hand rehabilitation: a quasi-experimental trial.

Bonhof-Jansen EEDJ, Brink SM, de Jong TR, van Uchelen JH, Bakker EW.

Hand Ther. 2025 Mar;30(1):34-45.

ABSTRACT

Introduction Aim of this study was to determine whether postoperative supervised rehabilitation improves functional outcomes after trapeziometacarpal (TMC) total joint arthroplasty (TJA), compared to education alone.

Method A quasi-experimental before-after trial included 31 women (≥40 years) per group diagnosed with trapeziometacarpal osteoarthritis who underwent TJA. A cohort (n=31) who was given education alone was compared to a cohort (n=31) who were subjected to supervised rehabilitation. Primary outcome was the difference in hand function three months postoperatively, measured by the Michigan Hand Outcomes Questionnaire (MHOQ). Other outcomes were the MHOQ subscale scores, the active range of motion, strength, time to return to work, satisfaction and complications.

Results Patients in the education group had a significantly higher median delta MHOQ score when compared to the rehabilitation group at 3 months (28.5 (20.5-31.3) versus 15.8 (1.9-21.1, p=<0.01)) and at 12 months 36.6 (26.8 - 47.2) versus 27.4 (14.5 - 33.0, p=0.01)). Only the secondary outcomes the MHOQ subscales hand function, ADL and satisfaction revealed significant differences in favor of the education group. The education method reduced the median number of hand therapy sessions with eight visits.

Conclusion The present study does not show a significant or clinically relevant benefit from supervised rehabilitation in terms of functional outcomes following TJA compared to education alone. Based on this, it seems safe to leave patients unsupervised in their recovery following TJA and to suffice with just education, however further exploration of effectiveness and safety of this intervention is recommend in larger trials.

INTRODUCTION

The trapeziometacarpal (TMC) joint is a common location of osteoarthritis (OA). The prevalence of radiologic TMC OA is approximately 35% in people of 55 year or older [1]. Pain and loss of hand function may be present, causing limitations in daily activities and a substantial reduction in quality of life [2]. When conservative treatment is no longer effective, trapeziectomy with or without ligamentous suspension, or total joint arthroplasty (TJA) with a prosthesis is commonly performed. Effective postoperative care is essential to achieve optimal outcomes [3-5]. However, there is a lack of evidence for the use of a specific rehabilitation protocol, resulting in a wide practice variation regarding the content of rehabilitation protocols after TMC arthroplasty in general, depending on surgical technique, availability of hand therapists and clinical expertise [3,4]. Specifically following TJA, comparative studies assessing the effectiveness of supervised rehabilitation on the outcome are lacking, leaving the effectiveness of rehabilitation unknown [5–7]. Besides, the latest generation of prosthesis , does not come with a guideline for supervised rehabilitation [8,9]. The supporting evidence for this recommendation was obtained from retrospective case series in which patients were instructed to gradually resume their daily activities without doing prescribed exercises [10,11]. Higher quality studies are needed to obtain stronger evidence of the optimal care following TMC TJA. As such, the aim of this study is to determine whether supervised postoperative rehabilitation leads to better functional outcomes 3 months after TMC TJA compared to education alone.

MATERIALS AND METHODS

Trial design

This quasi-experimental before-after trial compares a cohort of patients originating from a randomized controlled trial (RCT) (2014-2018) in which all participants received supervised hand therapy [12] to a prospectively enrolled cohort, which was formed from the same source population immediately following the trial, between September 2018 and November 2019. In the latter cohort, patients received education only, by a certified hand therapist.

The local medical ethical review board approved this study (number 180713). The trial was registered at the Netherlands Trial register, www.trialregister.nl (NL7654). This study followed the Consolidated Standards of Reporting Trials (CONSORT) reporting guidelines [13].

Participants

The study was conducted at the Hand and Wrist Center in the Isala hospital. Patients were referred from the outpatient clinic of the department of plastic surgery, after which TMC OA was diagnosed by level 4 certified hand surgeons [14]. Once surgical treatment with TJA was scheduled, the patient was referred to the hand therapy department. Women of 40 years and older, with symptomatic TMC OA (Eaton and Glickel stage II or III), were included if a TJA was done [15]. Exclusion criteria were surgery for TMC OA on the same hand in the past, secondary TMC OA following trauma, rheumatoid arthritis, systemic lupus erythematosus or gout. Patients with Quervain's tenosynovitis, symptomatic carpal tunnel syndrome (CTS), or neurological disorders on the affected side that could influence postoperative recovery, and patients with insufficient knowledge of the Dutch language were excluded also. An additional exclusion criterium for the education cohort was a previous contralateral TMC TJA, since experience with the procedure could reduce the need for coaching or rehabilitation. Participants provided written informed consent before participating in the study.



Figure 1. Cast immobilization (Courtesy: Elske Bonhof, published with permission of patient)

Interventions

The surgical procedure consisted of implantation of an uncemented semi-constrained single mobility prosthesis (MAIA, Groupe Lepine, Genay, France) [12]. Postoperatively, the thumb was immobilized in a forearm plaster cast with the TMC joint in slight extension, palmar abduction and opposition, slight flexion of the first metacarpophalangeal (MCP) joint and slight wrist extension (Figure 1). After 1 week the cast was removed and a circular plaster cast for another 3 weeks was applied. Immediately after cast removal, 4 weeks postoperatively, patients attended the hand therapist.

Education group

Education group patients received one education session preoperatively and one session 4 weeks postoperatively. Education consisted of oral information about the surgery, the expected recovery process and advice when and how to gradually resume daily activities. The standardized content in writing of the education session was handed over to the patients at the end of the first instruction. (Appendix 1). After removal of the cast the hand therapist checked whether the patient remembered and understood the preoperatively provided education and gave additional information if necessary. This check was done according to the 'repeat-back' method [16]. Patients were urged to contact the hand therapist in case of excessive pain or swelling which persisted despite taking rest. At the 3 months postoperative assessment time point, patients were asked for experienced problems and whether they had sought treatment elsewhere. In case of delayed or obstructed recovery, patients were offered the opportunity to undergo a customized treatment program depending on the patient's needs.

Supervised rehabilitation group

Patients in the supervised rehabilitation group received supervised rehabilitation for a period of approximately 2 months after cast removal. They attended the hand therapy department once a week from week 4 to 7 and once every 2 weeks in week 8 to 12. Treatment was carried out by experienced hand therapists following the local treatment guideline (Appendix 2). The educational content provided to both groups was identical. Advice about when to resume activities is primary based on perceived pain during activity and related to the osseointegration process in the first 6 to 8 weeks while patients are gradually resuming their daily activities to be allowed to resume full activity after 12 weeks.

Outcomes

At baseline, sociodemographic characteristics were recorded. Primary outcome was daily hand function 3 months postoperatively, measured by the total score of the Michigan Hand Outcomes Questionnaire (MHOQ; 0-100) [17,18]. The Minimal Clinically Important Difference (MCID) for MHOQ total score examined at one year follow up is 17 points and the Smallest Detectable Change (SDC) 11 points [19]. Secondary outcomes were the MHOQ subscale scores, the active range of motion of the thumb joints, and grip- and (key)pinch strength of the involved hand. Range of motion was measured using a Devore™ goniometer (North-Coast Medical Inc, Morgan Hill, USA) by the dorsal measurement method in degrees. Flexion was noted as a positive angle and hyperextension as a negative angle [20]. The palmar abduction of the thumb was measured in degrees with the Pollexograph

(Ipsen Pharmaceuticals, Hoofddorp) using the pollexograph-metacarpal active measurement method. Maximum opposition of the thumb was determined with the Kapandji score (0-10) [21].

Grip strength was measured in kilograms using a calibrated Baseline Jamar® handheld dynamometer (Fabrication Enterprises, White Plains, NY) in the second position. The pinch- and key pinch strength were measured in kilograms by a calibrated mechanical pinch gauge (Baseline, Fabrication Enterprises, White Plains, NY). Patients received standardized instructions for each grip and pinch test measurement and the average out of three maximum contractions was taken. Return to work was assessed with a questionnaire containing questions regarding type of employment, weekly working hours and the number of weeks until resuming original or modified work. Satisfaction with the outcome was assessed with one question scored on a 11 point (0-10) numeric rating scale. The number of extra contact moments with hand therapist or surgeon were also recorded. 'Extra' was defined as all the contact moments initiated by the patient except for the scheduled appointments according to the study protocol. The study of Bricout et al. was used to detect all possible complications related to the TJA [11]. All complications were registered and tabulated using the modified Clavien-Dindo Classification for hand surgery [22]. Data were collected at baseline, 3 and 12 months after surgery by three certified hand therapists with more than 10 years of clinical experience.

Blinding

As this study compares two consecutive cohorts, it was not possible to make patients and hand therapists unaware of the intervention. Participants were not able to see outcomes of previous assessments. To avoid measurement bias in the rehabilitation group, hand therapists involved in the pre-and postoperative assessments were not involved in the postoperative rehabilitation.

Sample size calculation

A previous study on CMC1 osteoarthritis showed patients who underwent surgery had a mean baseline MHOQ total score of 46 points (SD15) [23]. Three months postoperatively the total MHOQ score for the education only group is estimated at 64 (SD17) and for the hand therapy group 81 points (SD17). The MCID of 17 points is used as a significant difference between the groups [23].

An a priori sample size calculation showed that, with 28 patients in each group, a difference of 17 points on MHOQ could be detected with 1 primary endpoint, an alfa of 5% and a power of 80%, based on a two-sided unpaired t-test. Including

10% extra patients for taking potential loss into account, the calculation counts 31 patients in each group.

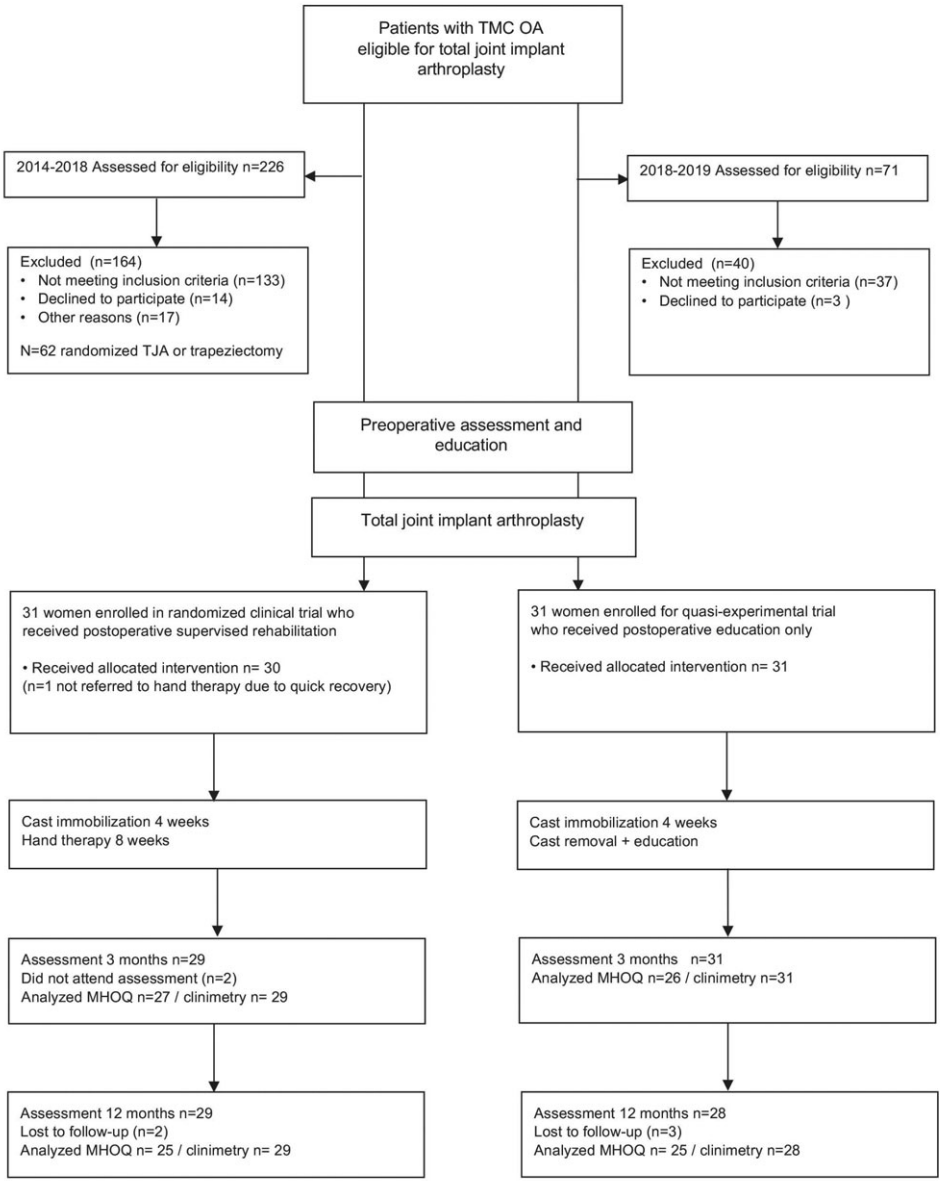


Figure 2. Flow chart

Statistical methods

The data were checked for errors, outliers and missing data. All variables were analyzed for normal distribution. Continuous variables are presented as means with standard deviation (SD) in a normal distribution or as median with first and third quartiles (Q1-Q3) when non-normality of data is present. Dichotomous and categorical data are described as frequencies with percentages. Missing value analysis was conducted using non-responder analysis and matrix plot inspection to explore missing value patterns, aiming to assess whether the data were missing completely at random (MCAR), confirmed by Little's MCAR test.

To adjust for baseline differences, delta scores, representing the difference between a follow-up score minus the baseline score, are reported for MHOQ scores and Cochran-Mantel-Haenszel (CMH) analysis for confounding variables. Groups were analyzed according to complete cases using an intention to treat analysis. Unpaired t-tests with Bonferroni correction or Mann Whitney U test in case of non-parametric distribution were used to detect between-group differences for continuous variables. Fisher exact test was used for categorial variables. A p-value of < 0.05 was considered significant.

RESULTS

A flowchart of the study is presented in Figure 2. Table 1 presents baseline characteristics. One patient from the rehabilitation group was not referred to hand therapy due to a satisfactory natural recovery within six weeks. In two patients in this group the surgery had to be converted to trapeziectomy due to a trapezium fracture occurring during reaming for cup implantation. Six patients in the education group reached out to the hand therapist once, while three patients made contact two or three times before the scheduled assessment at 3 months. Reasons for contacting were feelings of insecurity and fear (n=4) for which advice and reassurance was given and check-up for one patient after a fall on operated hand. Other reasons for contacting included signs and symptoms of Quervain's tenosynovitis or CTS, for which advice and splinting was provided (n=2), as well as advice and self-rehabilitation exercises for MCP pain associated with thumb collapse deformity and finger stiffness (n=2), clinically diagnosed by the hand therapist. None of the patients sought advice or treatment elsewhere or switched to the supervised rehabilitation program.

Table 1. Baseline characteristics

Baseline characteristics	Supervised rehabilitation n = 31	Education alone n = 31	p-value
Age, mean years (SD)	58.6 ± 6.5	61.0 ± 8.5	0.21 *
Smoking, yes, n	7	1	0.05 †
Diabetes mellitus present, n	2	3	>0.999 †
Dominant hand is surgery side, n	13	15	0.79 †
Eaton & Glickel stage OA, n II / III	13 / 18	13 / 18	>0.999 †
MHOQ total score, mean (SD)	49.9 ± 13.1	42.5 ± 14.2	0.05*

MHOQ scores 0-100, a higher score represents a better hand function
* Unpaired t-test, † Fisher exact test

Table 2. Non responder analysis for primary outcome on MHOQ total score at three months

Baseline characteristics	Responder N= 55	Non responder N=7	p-value
Age, mean years (SD)	60 (7.28)	58 (8.89)	0.4 (95% CI -8.63 – 3.59)*
Smoking, yes, n	7 (12.73)	1 (14.29)	>0.99 (OR 0.87, 95% CI 0.08 - 45.93)
Diabetes mellitus present, n	4 (7.27)	1 (14.29)	0.46 (OR 0.48, 95% CI 0.04 - 26.99)
Dominant hand is surgery side, n	26 (47.27)	2 (28.57)	0.44 (OR 0.58, 95%CI 0.18 - 1.83)
Eaton & Glickel stage II / III, n (%)	25 / 30 (45.5 / 54.5)	1 / 6 (14.3 / 85.7)	0.22 (OR 0.20, 95%CI 0.004 - 1.86)
Group rehabilitation/ education, n (%)	27 / 28 (49.0 / 50.9)	4 / 3 (57.1 / 42.9)	>0.99 (OR 0.71, 95%CI 0.10 - 4.74)
MHOQ total score baseline, mean (SD)	46.9 (14.02)	39.2 (10.1)	0.29 (95%CI -25.38 - 10.05)*
MHOQ baseline present, yes (%)	53 (96.4%)	4 (57.1%)	**0.008** (OR 17.84, 95%CI 1.59 – 273.63)
AROM/strength present at 3 months, yes, n (%)	54 (98.2)	6 (85.7)	0.21 (OR 8.41, 95%CI 0.10 – 713.92)
	9 (16.36%)	1 (14.28%)	>0.99 (OR 1.17, 95%CI 0.12 – 59.0)
MHOQ 1 year present, yes (%)	51 (92.7%)	3 (42.9%)	**0.004** (OR 15.50, 95%CI 1.93 – 149.06)
AROM/strength present at 1 year, yes (%)	52 (94.5%)	5 (71.4%)	0.09 (OR 6.57, 95%CI 0.45 – 73.82)
Number of hand therapy visits, median	3 (Q1-Q3:0-8)	2 (Q1-Q3: 0-11)	0.92**

Responders are defined as patients with completed questionnaires at 3 months p-value derived from Fisher exact test unless specified with * for Unpaired t-test or ** for Mann-Whitney U test

Table 3. Primary outcome MHOQ and subscales

MHOQ	Supervised rehabilitation		Education alone			
	Δ 3 months - baseline n= 27	**Δ 12 months - baseline n=25**	**Δ 3 months - baseline n= 26**	**Δ 12 months - baseline n=25**	**Difference between groups at 3 months* p-value**	**Difference between groups at 12 months* p-value**
Total score	15.8 (1.9 - 21.1)	27.4 (14.5 - 33.0)	28.5 (20.5 - 31.3)	36.6 (26.8 - 47.2)	**<0.01**	**0.01**
Pain	25.0 (17.5 - 42.5)	35.0 (21.3 - 53.8)	25.0 (15.0 - 40.0)	40.0 (20.0 - 50.0)	0.79	0.83
Hand function	10.0 (0.0 - 12.5)	20.0 (1.3 - 28.8)	25.0 (12.5 - 35.0)	35.0 (20.0 - 45.0)	**<0.01**	**<0.01**
ADL	11.0 (4.1 - 25.0)	22.0 (13.8 - 33.3)	34.8 (22.8 - 52.5)	41.4 (22.9 - 60.7)	**<0.01**	**<0.01**
Work	5.0 (-2.5 - 25.0)	30.0 (6.3 - 45.0)	12.5 (0.0 - 28.8)	40.0 (20.0 - 75.0)	0.25	0.08
Aesthetics	0.1 (- 6.3 - 18.7)	9.4 (-4.7 - 18.7)	6.2 (0.0 - 28.1)	6.3 (0.0 - 37.5)	0.16	0.31
Satisfaction	25.0 (0.0 - 45.8)	43.8 (20.8 - 58.3)	41.7 (22.9 - 57.1)	45.8 (25.0 - 67.0)	**0.03**	0.43

MHOQ scores 0-100, a higher score presents a better hand function
Data are presented as delta scores (Δ) with median (Q1-Q3)
* Mann-Whitney U test

In each group ten questionnaires were missing. The total percentage missing questionnaires for the primary outcome was 10.7%. Little's MCAR test was non-significant (p=0.63), showing no relation between missing questionnaires and other variables. Table 2 shows no differences in other prognostic variables in responders versus non-responders. This findings confirm missing values were completely at random.

Patients in the education group had a significantly higher median delta score when compared to the rehabilitation group at 3 months (28.5 versus 15.8, p= <0.01) and at 12 months (36.6 versus 27.4, p=0.01) (Table 3). The MHOQ subscales hand function, ADL and satisfaction showed significant differences in favor of the education group. The CMH test showed patients in both groups improved at MHOQ total score independent of smoking (3 months p=0.62, 12 months p=0.64). Figure 3 shows the individual changes of MHOQ total score and whether patients reached the MCID at three months. Raw MHOQ scores are available in the supplementary table (Appendix 3). Between group differences were not found at 3 and 12 months for range of motion and strength (Table 4).

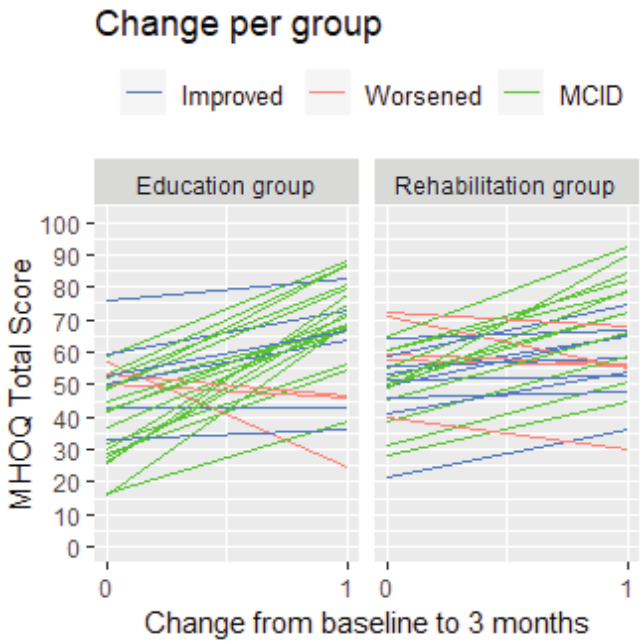


Figure 3. Change plot of individual MHOQ scores over time per group.
The plot represents individual change per group on MHOQ score from baseline to 3 months after surgery. Red lines denote patients who worsened on MHOQ score after surgery. Blue lines represents patients who improved on MHOQ score and green lines patients who reached the MCID of the MHOQ.

Less than 50% of the patients were employed at the time of surgery. Prior to surgery, 15 patients in the rehabilitation group worked a median of 20.5 hours (19 - 26.5) per week versus 13 patients in the education only group, working 24 (16 - 25) hours per week. The rehabilitation group started working after a median of 6 (1.0-10.0) weeks postoperatively, and the education group after 8.0 (2.5-8.0) weeks. After 3 months five patients in the rehabilitation group returned to their original work and six were doing modified work compared to eight and four in the education group.

Complications occurred in both groups, involving the dominant hand in 5 patients from the rehabilitation group versus 10 in the education group. Median time to complications was 2 months (range 1-12) in the rehabilitation group compared to 3.5 (range 1-10) in the education group. No significant differences were found regarding the total number of complications between both groups at 3 months (OR 3.15, 95% CI 0.77 - 15.77, p=0.13), and 12 months (OR 0.55, 95%CI 0.15 - 1.94, p= 0.40). Revision surgery was required in one patient in the rehabilitation group and two patients in the education group at 12 months (Table 5). Surgery for associated complications, among which CTS, TVS or Quervain's tenosynovitis was necessary in 3 rehabilitation patients and 7 patients from the education group, with a median time to surgery of respectively 4 (range 2-6) versus 8 (4-15) months. At 3 months, the education group scored a median satisfaction (NRS 0-10) of 8.0 (7.0-9.25), while the rehabilitation group scored 7.0 (6.0-8.0) (p=0.08). After 1 year, this was 7.5 (6.3-8.0) points for the rehabilitation group and 8.0 (8.0-10.0) points for the education group (p=0.03).

At 3 months 21 patients in the rehabilitation group and 27 in the education group would consider having the surgery again under the same circumstances. There was no significant difference between the groups at 3 months (OR 0.16, 95% CI 0.003 - 1.59, p=0.09), nor at 12 months (p=>0.99). The education method reduced the number of hand therapy sessions and surgeon consults with a median of respectively eight visits (p=<0.001) and two (p=<0.001), saving approximately four hours of health care professional time.

Table 4. Secondary outcomes

Outcome measure	Supervised rehabilitation		Education alone			
	Δ 3 months – baseline n=29	**Δ 12 months – baseline n=29**	**Δ 3 months – baseline n=31**	**Δ 12 months – baseline n=28**	**Difference between groups at 3 months p-value***	**Difference between groups at 12 months p-value***
Extension MCP joint (dgr)	0.0 (-6.0 -16.0)	0.0 (-2.0 – 15.0)	0.0 (-8.0 -5.0)	1.0 (-6.3 – 10.0)	0.41	0.59
Flexion MCP joint (dgr)	-9.0 (-14.0 - -4.0)	-2.0 (-15.0 -3.0)	-5.0 (-11.5 - -2.5)	-1.5 (-5.3 – 5.0)	0.25	0.28
Kapandji score (0-10)	0.0 (-1.0 – 0.0)	0.0 (0.0 - 1.0)	0.0 (-1.0 – 0.0)	0.0 (-1.0 – 0.0)	0.79	0.74
Palmar abduction (dgr)	-4.0 (-6.0 – 2.0)	0.0 (-4.0 – 4.0)	0.0 (-2.0 – 4.0)	4.0 (-2.5 – 6.0)	0.08	0.14
Grip strength (kgs)	-1.6 (-5.0 – 2.0)	3.4 (1.0 – 7.8)	5.4 (1.7 – 10.0)	5.4 (1.7 – 10.0)	0.67	0.43
Pinch strength (kgs)	0.0 (-1.0 – 1.2)	0.9 (0.1 – 1.6)	0.2 (-0.3 – 0.8)	0.8 (0.0 – 1.2)	0.67	0.37
Key pinch strength (kgs)	0.0 (-1.4 – 0.7)	1.0 (1.2 – 1.9)	0.0 (-0.6 – 0.7)	1.3 (-0.2 – 2.0)	0.85	0.73
Extra visits handtherapist †	8.0 (6.0 - 10.0)		(0.0 -1.0)		**<0.001**	
Extra visits surgeon†	2.0 (0.5 - 4.0)		0.0 (0.0 – 1.0)		**<0.001**	

Data are presented as median (Q1-Q3). The delta (Δ) scores represents the difference between follow-up and baseline.
* Difference in delta scores between groups using Mann-Whitney U test.
† Median (Q1-Q3) visits in each group at three months post-surgery.

Table 5. Complications

Grade	Definition	Supervised Rehabilitation (n=12)	Education (n=15)
I	Any deviation from the normal treatment course without the need for surgical, endoscopic and radiological interventions. Acceptable therapeutic regimens are: extra analgesics and additional hand therapy/ splinting/ cast. This grade incudes e.g.: tendinitis, scar tenderness, temporary sensory disturbances, etc.	Sensibility disturbance (n=2) Pain (n=2)	Sensibility disturbance (n=1) Carpal tunnel syndrome (n=1)
II	Any deviation from the normal treatment course requiring antibiotics, steroid injections or other pharmacological treatment not listed in Grade I. Also included are wound infections and hematoma's not needing anesthesia.	Superficial wound infection requiring antibiotics (n=1) Tendinitis EPB or FPL requiring corticosteroid injection (n=2)	Corticosteroid injection required for: Tenosynovitis first extensor compartment requiring (n=2) for which n=1 combined with splint Carpal tunnel syndrome (n=1) Pain combined with splint (n=1)
III	Any deviation from the normal treatment course requiring surgical, endoscopic or radiological intervention. Also, this includes tendinitis, scar tenderness, persistent pain, etc. not responding to conservative therapy, drugs or injections.		
A	Minor surgical intervention under local anesthesia (e.g. irritating K wire, suture removal subcutaneously)		
B	Major surgical intervention under regional or general anesthesia (e.g. repeat surgery, tenolysis, neurolysis, nerve repair or surgery for tendon rupture, breaking of plate, non-union, initial prosthesis failure)	CTR (n=1) TFR dig 1 + MCP1 artrodesis (n=1) TFR dig 1 + Release first extensor compartment (n=1) LRTI (after perioperative trapezium fracture > trapeziectomy) (n=1)	CTR (n=4) of which n=1 combined with UNE release MCP1 artrodesis (n=1) Release 1st ext comp (n=2) of which n=1 combined with RSN neurolysis Cup loosening and luxation > trapeziectomy (n=2)
C	Complex Regional Pain Syndrome, diagnosed using Budapest* criteria, independent of the initiated treatment	Mild CRPS, symptoms resolved within one year (n=1)	

ICHOM Complications in Hand and Wrist conditions (ICHAW), modified and derived from Clavien-Dindo 2009.

DISCUSSION

The main objective was to determine whether postoperative supervised rehabilitation improves functional outcomes after TMC TJA, compared to education alone. We could not find clinical and statistical evidence that supervised rehabilitation is beneficial in improving functional outcomes at 3 and 12 months. Supervised rehabilitation aims to improve hand function by, amongst other, coaching, AROM and strength exercises. Although the rehabilitation program is usually completed by 3 months, the natural course of total recovery often takes approximately 1 year [23–28]. Reduction of pain is usually achieved within three months when pain caused by the surgery itself has subsided [29]. When pain diminishes, functional hand use during daily activities may be adequate for increasing AROM and strength, potentially explaining why no between group differences were found on these variables. In recent years, early active motion protocols have become more common, leading to reduced immobilization time, less rigid immobilization and early initiation of active range of motion [30,31]. However, there remains a wide practice variation with on one hand publications reporting TJA aftercare with self-rehabilitation or functional use without prescription of supervised rehabilitation [32–38] while other studies still prescribe supervised rehabilitation [39–41]. Comparative studies concerning type and duration of postoperative rehabilitation after TMC TJA are lacking [5–7]. One study described two different types of postoperative care where patients with trapeziectomy with tendon interposition were referred to hand therapy and patients with TJA were allowed to unlimited use [25]. Since this study did not control for selection bias and compared two different surgical interventions as well, the effectiveness of supervised rehabilitation cannot be determined. The evidence to gradually resume daily activities without supervised rehabilitation was obtained mostly from retrospective cohort studies [10,11,29,42,43]. However, outcomes for AROM and strength are consistent with our findings [10,11,27,29,42] as well as MHOQ scores [44,45].

It remains unclear whether a causal relationship exists between the number of grade 3 complications and the lack of formal hand therapy in the education group. TVS, CTS and Quervain's tenosynovitis are common associated complications after TJA [35]. The number of patients as well as the median time to complications and the time to surgery for associated complications is larger compared to the rehabilitation group, however there is an overlap between the ranges in both groups. Notably, CTS was more prevalent in the education group (n=6). Except for one patient, these symptoms developed within 2 to 3 months postoperatively, a period during which patients increase their physical activity. As the development of complications is multifactorial, the number of reoperations could be attributable to the intervention

but also under influence of persistent swelling, disuse or overuse or even a mental or social context [46]. CTS occurred in one frailty elderly patient, bilaterally in one case and in another patient CTS was atypically and combined with ulnar neuropathy symptoms. The patient who underwent MCP arthrodesis was already symptomatic with an unstable MCP joint before TJA. As a preventative measure the provision of comprehensive patient education on the symptoms of possible complications and the appropriate responses, firstly by adjustments of activity level and secondly by consultation of the hand therapist may help to prevent such complications.

Study strengths and limitations

This study is a first attempt to compare postoperative protocols after TMC TJA surgery. A non-randomized design was used because the supervised rehabilitation cohort from the RCT had already been enrolled, so high quality data were available for comparison with the education group. To mitigate the limitations of non-randomized studies, we controlled for selection bias and confounding by indication in the education cohort, by enrolling consecutive patients meeting the inclusion criteria and giving the total TJA population this education method.

Assumptions that were made to calculate the sample size could have led to a threat of the internal validity. Firstly, because the MCID for the MHOQ in TMC OA [19] is established for the one-year follow-up and might not be sensitive enough for the primary outcome at 3 months or to detect between group differences. London et al. determined the MCID between eight and thirteen points after 3 months in nontraumatic conditions among which OA [47]. Since the MCID for surgically treated TMC OA was not calculated specifically for 3 months, we used the one-year MCID established for the postsurgical TMC OA population. Secondly, because of high known standard deviations of seventeen points on the MHOQ scores [19,23], variation between groups were high which could have led to an overestimation of the effect size. These factors influence the power of our study; the effect size remains small, either because no differences exist or because the groups were too small in hindsight, resulting in a greater chance of a type II error. A post-hoc sample size calculation shows that, with the found difference on the primary outcome and a power of 80%, 171 patients had to be included in each group. It also should be noted that results are not extrapolatable to trapeziectomy with or without soft tissue arthroplasties. Multiple studies suggests that TJA can provide a quicker recovery, thereby demanding less intensive rehabilitation, and improved function in the short term when compared to trapeziectomy with or without soft tissue arthroplasty [45,48–56]. Furthermore, in TJA the osseointegration time needs to be taken into account. These differences complicate direct comparison of their rehabilitation protocols.

As recommended in previous studies, different types of postoperative care protocols within the same surgical procedure must be compared in studies [57–59]. This trial contributes to structured research into the effectiveness of supervised rehabilitation and the transparency of rehabilitation protocols after TMC TJA and may help to determine the optimal postoperative care and reduce practice variation. As supervised rehabilitation potentially has no benefit to education alone after TMC TJA, the latter can yield a patient benefit and may be an efficient and cost saving alternative. It would be of future interest to reproduce this study in a larger non-inferiority trial and to explore whether the number of complications will reduce when patients are provided with comprehensive education on the symptoms of possible complications and the appropriate responses. Development of a prediction model for postoperative course after TJA will enable individually tailored patient care.

CONCLUSION

The present study does not show a significant or clinically relevant benefit from supervised rehabilitation in terms of functional outcomes following TJA compared to education alone. Based on this, it seems safe to leave patients unsupervised in their recovery following TJA and to suffice with just education, however further exploration of effectiveness and safety of this intervention is recommend in larger trials.

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Appendix 1 - Information leaflet education only group

What is osteoarthritis of the thumb base?

Osteoarthritis, in other words 'joint wear' is a disease of the joints. In joints the bony endings are covered with cartilage, to ensure smooth and painless movements of the bones. In cases of osteoarthritis (degenerative arthritis) cartilage degenerates causing the bones to rub together. This causes pain and finally the joint is ruined.



Figure 1. Osteoarthritis of the thumb base (Courtesy: Isala Hand-Wrist Center)

In the hand osteoarthritis often occurs in the joint at the thumb base. The shape of this joint allows the thumb to move into many directions, so we can grasp objects between our thumb and fingers. As the osteoarthritis worsens the slightest movements cause pain. Strength diminishes, the joint starts swelling and tends to luxate. Finally, joint mobility gets restricted.

Woman more often develop this disease. Mostly the onset is from the age of forty. Former lesions of this joint (such as fractures and sprains) increase the chance of developing osteoarthritis in a later stage.
The first symptom of osteoarthritis of the thumb base is pain when the thumb is in major grip and in a precision grip while grabbing objects between thumb and

fingers, such as opening of jars, opening of car doors and turning of keys. Pain can be provoked by heavy loading and weather circumstances (temperature and humidity).

Prior to the operation

Prior to the operation a hand therapist (a specialised physiotherapist or occupational therapist) will assess your hand function. Measurements will be made for mobility and strength of your hand and thumb. Besides that, you will be informed about the post-operative period and you will get advices on what you can do and what you should not do.

The operation

During the operation the thumb joint will be replaced by an artificial joint, a prosthesis. This will prevent grinding of the bones resulting in less pain. The mobility will be preserved as much as possible. The aim of the operation is relief of pain so you can use your hand better.

The operation is performed during an outpatient procedure and will be performed under local anaesthesia of the arm or under general anaesthesia. During the operation the plastic surgeon will replace the base of the thumb by a prothesis. The base of the metacarpal bone is removed to insert the shaft of the prothesis. Next a small cup will be shaved in the carpal bone to host the head of the prothesis. Together a new mobile joint is realised.





After the operation

A period of four weeks rest in plaster cast

After the operation a plaster cast is applied around your thumb and wrist, One week after the operation you will return to the outpatient clinic for wound control. The plaster bandage is replaced by a plaster cast in order to rest the operation site so the prothesis can get embedded. The plaster will stay for three weeks. It is important to prevent swelling of the hand by keeping the hand well elevated. Smoking is discouraged because this narrows blood vessels leading to a negative impact on tissue repair. After four weeks the cast is removed. You will be referred to a hand therapist who will guide you for further recovery.

Start moving but without force

After removal of the cast the hand therapist instructs you to start moving the joints so you can use your thumb properly again. In the beginning your wrist and thumb may feel stiff and probably be swollen, but by exercising this will be gone within a few weeks. The operation will have lessened your original pain complaints, however you may experience post-operative pain. This will diminish gradually.

As it takes six to eight weeks for the in-growth of the prosthesis no force should be applied to the thumb during the first six to eight weeks. This means you cannot stress the thumb heavily. So do not use power grips and do not perform heavy activities such as mangling, carrying bags etcetera.

You can use your hand in light daily activities such as dressing, brushing your teeth, holding a knife or fork etcetera. Also, long lasting minor stress (handling a smartphone or a book) can cause problems. We do not advise you to exercise with a ball or a sponge because this often leads to complaints in the field of overcharge. Weight bearing on thumb and prosthesis should be done with caution and gradually. During the first six weeks postoperative you may not drive a car nor ride a bicycle.

After three months you are able to perform most of your activities

The major part of recovery is reached in the first three months after the operation; after that recovery still continuous gradually. After about three months you will be able to perform most of your activities.

Taking into account possible complaints you can resume your daily activities step by step. Strength (and sometimes also mobility of the thumb) is not yet fully regained after three months but will do so in the first year postoperative. Often people

still experience some pain in this timeframe in the thumb base area. This is a well-known phenomenon, that will, with progressive activities, disappear after six months. The end results of recovery will be reached after about one year.

Consult your hand therapist in case of sudden increase of (pain) complaints not subsiding by rest in one week. In case you have a question after reading this hand-out please contact your hand therapist.

Appendix 2 - Supervised rehabilitation regimen standard care group

Treatment goals hand therapy

Main goal:
Obtaining a stable, pain-free and functional thumb within three months postoperatively

Sub goals:

1. Improve active range of motion including prevention or correction CMC1 adduction and/or hyperextension MCP1 if necessary
2. Improve coordination and active stability
3. Improve strength
4. Improve functionality for patient specific goals (work, hobbies, sports)
5. Provide insight into the weight-bearing capacity of the prosthesis
6. Provide instruction of the principles of the load-capacity model

Week 1- 4 Postoperative

After the operation a plaster bandage is applied around thumb and wrist, with the thumb positioned in abduction and extension. One week postoperatively wound control takes place at the outpatient clinic of the hand surgeon. The plaster bandage is replaced by a circular plaster cast by the plaster technician for another three weeks. Four weeks postoperatively the cast is removed and subsequently hand therapy starts.

Week 4 - 7 Postoperative

Patient attends the hand therapy department once a week for 30 minutes
Improve active range of motion

a. Exercise therapy: pain-free, unlimited active motion without weight bearing to optimize wrist range of motion and thumb abduction, extension and opposition. Ten repetitions, 3-5 times a day
b. Splinting (only when indicated in case patient cannot avoid physically demanding activities or in case of CMC1 adduction or MCP1 hyperextension deformity. A custom made, thermoplastic short thumb spica splint is made including CMC1 and MCP1 without wrist involved. All joints are positioned in slight flexion to obtain a functional position of the thumb. Schedule of wearing during physical activities.
c. Edema control and (if necessary) managed with elastic bandage
d. Scar tissue massage

Improve coordination and active stability

a. Exercise therapy: pain-free, unloaded pinch exercises without collapsing the thumb.

Gradually increasing from conscious use during exercises to unconscious use in daily activities. 3-5 times a day.

Oral information to give insight into the weight-bearing capacity of the prosthesis in order to avoid cup loosening.

Practical and ergonomic advice concerning the load-capacity model during the first weeks postoperative in order to avoid mechanic complications such as tendinopathies of the Abductor Pollicis Longus (APL) or prosthesis loosening. Oral information is given and practical daily activities are stimulated depending on the patient needs.

Week 8 - 11 Postoperative

Patient attends the hand therapy department every two weeks, the visits will take 30 minutes.

Improve active stability and strength

Pain-free, gradually increasing isometric resistance exercises for pinch- and grip strength using exercise hand putty. Maximum repetitions until muscle fatigue occurs, once a day.

Practical and ergonomic advice concerning load bearing and load bearing capacity during the third month postoperative. Oral information is given and practical daily activities are stimulated depending on the patient needs.

Functional exercises are incorporated to meet patient specific goals in work, hobbies or sports.

Week 12 Postoperative

Unrestricted functional use and discharge of hand therapy when therapy goals have been met satisfactory.

Appendix 3

Appendix 3. Supplementary table. Raw MHOQ scores

MHOQ	Supervised rehabilitation			Education alone		
	Baseline n=30	3 months n=27	12 months n=26	Baseline n=27	3 months n=28	12 months n=28
Total score	49.9 (13.1)	63.4 (16.1)	75.3 (16.7)	42.5 (14.2)	68.4 (16.8)	78.0 (18.1)
Pain	32.5 (16.9)	59.1 (21.6)	69.8 (23.0)	29.1 (13.3)	57.1 (21.0)	68.2 (23.8)
Hand function	53.0 (15.5)	57.2 (11.9)	68.7 (14.3)	42.6 (16.9)	64.6 (21.9)	73.2 (21.2)
ADL	55.8 (21.7)	72.6 (18.1)	81.0 (18.3)	39.7 (22.4)	75.5 (17.6)	78.5 (22.3)
Work	44.7 (24.1)	51.9 (26.6)	71.7 (29.6)	37.6 (25.9)	50.9 (27.2)	77.7 (27.5)
Aesthetics	77.1 (16.6)	80.8 (17.7)	88.4 (13.5)	71.8 (23.5)	87.5 (15.7)	89.5 (18.0)
Satisfaction	36.1 (22.7)	58.8 (29.5)	72.1 (24.9)	33.9 (20.2)	74.4 (23.8)	80.9 (22.5)

MHOQ scores 0-100, a higher score presents a better function or less pain
Data are presented as mean (SD)

Should you actually do hand exercises?

Commentary on an article by Patrick C. Barrett, MD, et al.: “Provision of a Home-Based Video-Assisted Therapy Program Is Noninferior to In-Person Hand Therapy After Thumb Carpometacarpal Arthroplasty” and on commentary David Ring: “No Difference in How I Work with a Hand Therapist, Got It. But Can I Do the Exercises on My Own?”

Bonhof-Jansen EDJ, Brink SM.

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Our compliments for this well designed study. It is important to reflect on our clinical practice and to challenge current rehabilitation programs even when they have not been proven safe and effective yet. Evaluation through high-quality studies is essential to optimize postoperative care and hand therapy rehabilitation programs. Perhaps more importantly, such studies will enable colleagues to confidently implement these findings into their clinical practice. Until now, no scientific evidence has been available to support any specific postoperative regimen following trapeziometacarpal joint arthroplasty [1,2]. The literature describes various rehabilitation approaches, including supervised rehabilitation, self-rehabilitation, functional use and individually prescribed rehabilitation, but a clear consensus is lacking [2].

As David Ring wrote in his commentary: "There are many benefits to keeping things simple. In addition to more limited use of resources and lower exposure of patients to greater out-of-pocket costs, keeping the exercises simple encourages agency, which is an important aspect of good health. I would like to see a study that compares these simple, independent exercises with virtual, therapist-guided exercises" [3]. We would even like to take it a step further.

We recently published an article in which we studied whether a postoperative supervised rehabilitation program improves functional outcomes after trapeziometacarpal implant arthroplasty, compared to education alone [4]. This latter group received written and oral education preoperatively as well as postoperatively without prescribing exercises but promoting functional use. We found no significant or clinically relevant benefit from supervised rehabilitation in terms of patient reported functional outcomes compared to education alone. And patients in the education group were more satisfied. However, in the education group, psychologically factors as feelings of fear and insecurity or overloading led patients back to the hand therapist in eight cases. In both groups complications like carpal tunnel syndrome or tenosynovitis stenosans occurred.

David Ring emphasizes the importance of psychologically factors that influence postoperative recovery and proposes mindset exercises alongside with physical exercises [3]. We observed that using comprehensive patient education and managing expectations regarding the time needed for postoperative recovery, when and how to resume daily activities, hobbies and work and what to do when recovery is delayed or obstructed, enhances patients self-management. This is supported by the work of de Ridder et al. showing that satisfaction with treatment results is influenced by patient's experience with healthcare delivery, illness

perception and treatment expectations [5]. And as a preventative measure, we now add comprehensive patient education on the symptoms of possible complications and the appropriate responses, firstly by adjustments of activity level and secondly by consultation of the hand therapist.

We think it is crucial that safety of rehabilitation programs also is addressed. Therefore, complications have to be taking into account when designing such studies, to get insight into possible drawbacks of the rehabilitation program. As the development of complications is multifactorial, it will be hard to assign complications solely to a rehabilitation program. As they could be attributable to the intervention but also under influence of persistent swelling, disuse, overuse, a psychological and/or social context. When we are able to identify these factors, ideally prior to surgery, we would be able to tailor the rehabilitation program depending on the needs of an individual patient without overuse of rehabilitation staff or costs.

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Chapter 7

GENERAL DISCUSSION

The first part of this thesis, comprising chapters two, three and four, focussed on the outcome of the surgical management of trapeziometacarpal osteoarthritis. It investigated by means of a randomized clinical trial whether TJA is superior to trapeziectomy in terms of functional outcomes on the short (1 year) and mid-term (5 years). A qualitative study gave insight into the patient's perspectives comparing the two surgeries on the longer term. In the second part, containing chapters five and six, the focus shifted to postoperative care after TJA. It explored the current evidence on immobilization and rehabilitation regimes and on the use of complication classifications by means of a scoping review. The effectiveness of supervised rehabilitation was investigated in a quasi-experimental trial.

This final chapter summarizes the main findings (7.1), reflects on methodological considerations (7.2), addresses the clinical implications of the results (7.3) and provides recommendations for future research (7.4). The subsequent paragraphs are organized around the two parts of the thesis; surgical management and postoperative care after TJA. The thesis is finalized with a general conclusion (7.5).

7.1 DISCUSSION AND MAIN FINDINGS

SURGICAL MANAGEMENT

The research in **Chapter 2, 3 and 4** revealed no superiority for TJA over trapeziectomy in terms of patient reported functional outcome using the MHOQ as well as from the patients' perspectives. Both procedures were found to be good options for patients with grade II-III OA, since pain is reduced by the surgery, leading to satisfactory results despite some residual pain, loss of strength or fine motor skills. Benefits of TJA are a better key pinch strength and fine motor performance skills and a shorter recovery time after surgery. There was no statistically significant difference in revision rates between the groups. Based on these mid-term (5 years) results, we conclude that both procedures are safe and effective treatments for TMJ OA. Although we are unable to make robust statements regarding these findings due to a lack of power, partially resulting from a reduced number of follow up visits due to COVID, our results are in line with previous studies reporting a better thumb strength and shorter recovery time after TJA [1–6]. Hence, our results provide guidance for shared decision-making when considering surgery. However, the question remains whether the limited differences in outcomes between both procedures justifies the extra costs involved in using a prosthesis. Future cost-effectiveness studies on this topic may help to determine which procedure should be advocated.

Thumb strength

A relevant question in the context of daily activities is whether the improved (key) pinch strength following TJA provides a functional benefit. The mean pinch (3.7 kgs, SD 1.1) and key pinch strength (4.5 kgs, SD 1.5) in our trapeziectomy group appears sufficient for many daily tasks since it has been found that (key)pinch strength required for daily activities ranges from 2.3 - 3.2 kgs [7,8]. However, Hock et al [9] discovered that more than 3.5 kgs of pinch force was used by females to open several types of food containers and a stronger key pinch makes opening packages easier [10].

Pinch strength is negatively affected by MCP hyperextension, as seen as part of z-deformities, but it has been shown to have no influence on pain or functional outcome [2,11–13]. This is consistent with our findings: an increased MCP joint extension in the trapeziectomy group was observed and lower (key)pinch strength compared to the TJA group, without a significant difference in the MHOQ. In a systematic review of trapeziectomy procedures with a 5-year follow-up, 106 cases

with simple trapeziectomy were included. Overall, the results showed pain reduction and range of motion improvement in more than 90% of the satisfied patients. However, dissatisfaction with trapeziectomy procedures was often reported by patients who required good hand strength or experienced complications [14].

Complications

In our RCT **(Chapter 2 and 3)** we did not find statistically significant differences in revision rates between the trapeziectomy and TJA group. The most complications in our study occurred in the first postoperative year. In the context of complications, the question arises which factors are associated with complications necessitating revision surgery and whether this could be influenced.

After trapeziectomy, metacarpal subsidence has been found to stabilize after one year and is weakly associated with pain or poor functional or unsatisfying outcomes [2,11,12,15]. However, when metacarpal subsidence progresses to impingement on the scaphoid or trapezoid causing discomfort or pain, revision surgery may be indicated [15–17]. Revision surgery for subsidence is performed in 2% to 5% of the patients [16,18–20]. The revision rate of 19.4% in our trapeziectomy group far exceeded this, with a slightly less median time to revision surgery (12.5 months, IQR 8.8 to 43) than the 14 months (IQR 8.3 to 26.8) as described by Lane et al. [21] for simple trapeziectomy. Surgery rates for associated conditions as carpal tunnel syndrome, trigger finger and Quervain's tenosynovitis were comparable.

Patients in our trapeziectomy group who underwent revision surgery suffered more from pain in the first year than the non-revision patients in this group. Recovery of pain can take up to 1 year and metacarpal impingement is a common cause for persisting pain [17,22]. This highlights the importance of informing patients who consider to undergo a trapeziectomy that postsurgical pain may take up to a year to resolve. It also underscores the need for patience when considering revision surgery [17]. However, patients expectations, experiences and perceptions after thumb base surgery show wide variations [23] and psychological factors such as distress and pain catastrophizing may also contribute to experienced pain [24].

Our TJA revision rate was 6.5%. Revision rates after TJA of up to 12.8% have been reported for the older generation of implants, with a mean time to revision surgery of 4 years, mainly for loosening, dislocation and cup wear [18]. However, in the same study a lower prevalence of loosening, dislocation and wear was found for the newer implant generation, reducing the revision surgery rate to 4.3%, which is comparable to our results. Maling et al. systematically reviewed the literature for

outcomes of dual mobility implants and included 13 studies describing outcomes of 1,421 prostheses [25]. After a follow-up ranging from 1 to 5 years, 0.6% dislocations and a 2% revision rate including for dislocation, infection, loosening, polyethylene wear and trapezial fracture were reported. Despite the broad range of follow-up times and the low level of evidence of included studies, the revision rate appears to approach that of trapeziectomy and may potentially hereby reduce the earlier reported high complication risk associated with TJA. Currently, the 10-year survival of modern TMJ prostheses is in the range from 85% to 95% [26,27]. As modern implants have less complications [18,25,28], meta-analyses including older implants may thus lead to an overestimated complication rate.

POSTOPERATIVE CARE AFTER TJA

We found no scientific evidence for any postoperative regime following TJA (**Chapter 5**). This means that at the start of our studies, decision-making was based on clinical experience rather than on scientific evidence. Identified knowledge gaps from our review can be translated into research opportunities addressing postoperative care and are outlined in the section future research directions.

Our scoping review revealed a wide variation in postoperative policies between and in prostheses types. Also, inconclusive ways of postoperative policies and complication descriptions were found. An evidence gap was confirmed for comparative studies regarding types of immobilization protocols as well as rehabilitation regimens after TMC TJA. We furthermore found that not all patients received supervised hand therapy, and that postoperative care was limited in some studies to the advice to use the hand during activities guided by pain, or hand therapy was only prescribed on indication. This variability in clinical practice raised the question whether supervised rehabilitation yields better outcomes. We subsequently investigated this in **Chapter 6** using a quasi-experimental before-after trial. The results did not show a significant or clinically relevant benefit of supervised rehabilitation in terms of functional outcomes following TJA compared to education alone. Based on this, it seems safe to leave patients unsupervised in their recovery following TJA and to suffice with just education. However further exploration of effectiveness and safety of this intervention is recommended in larger trials.

7.2 METHODOLOGICAL CONSIDERATIONS

Study Design and Population

In **Chapter 2** and **3** a randomized, double anonymized, clinical trial design was used representing the highest level of evidence for clinical studies. A potential limitation of randomized controlled trials is a strictly selected study population, which may limit the external validity and generalizability of the findings to the broader population. This may also apply for our RCT, as well as for the quasi-experimental trial in **Chapter 6**, as we included only women. Reasons for this were that women represent nearly 75% of our surgical population and that we aimed to minimize heterogeneity in the sample. Our results were consistent with the findings of other RCT's which included both men and women as well as with systematic reviews comparing trapeziectomy procedures to TJA [29–31]. This suggests that the potential limitation of including only women did not affect the conclusions.

Loss to follow-up

As the primary outcome of the RCT in **Chapter 2** and **3** was the MHOQ at 1 year, the sample size was calculated taking this time frame into account. Although we added 10% extra to account for potential loss to follow-up, we could not foresee the cancelled follow-up assessments due to the COVID pandemic and the loss to follow-up increasing to 26% at 5 years. Thus, when studying mid-term results at 5 years, it must be taken into account that the loss to follow-up might increase from 10% to 25-30% as also occurred in other studies [30,32,33]. This resulted in a post hoc power of only 15.7% for the 5-year time point, meaning that our mid-term results have to be interpreted with care.

Outcome measures: clinical relevance

Several remarks can be made regarding the primary outcome MHOQ, used as a substitute for daily hand function. Firstly, since the registration of the study protocol of the RCT in **Chapter 2** and **3** in 2013, the role of patient reported outcomes and the use of the MHOQ has increased. A minimally clinical important difference (MCID) of 17 points for the MHOQ total score was established for TMJ surgery for the 1-year follow-up [34]. It was reported that high standard deviations of 17 points are common in TMJ OA [22,34], reflecting a large variability within the samples. The high standard deviations for the MHOQ total score (range 11 to 20) that we found equalled the minimally clinical important difference, which makes it less easy to detect a clinically relevant difference between the groups. This may have influenced the power of our studies; either because no differences existed or because the groups were in hindsight too small, resulting in a greater chance of a type II error.

Secondly, if a difference does not exist or the MHOQ is not sensitive enough to detect a possible difference, increasing the sample size may still not lead to significant results. Large distributions in MHOQ scores were also found in a study comparing nearly 800 patients who underwent trapeziectomy with various forms of tendon plasty, without any difference found between these surgical techniques [22]. These findings suggest that patients do not experience any differences in daily functioning measured with the MHOQ between the surgical treatments, as all procedures will give pain reduction and functional improvement. This is consistent with the quantitative and qualitative findings in this thesis. Although differences on body functions level were found in our RCT as well as reported by the patients in our qualitative study, these did not lead to limitations at activity and participation level according to the interviewed patients. Possibly, activity modification and coping strategies could play a role in this.

We have also used the Disability of Arm, Shoulder, Hand Questionnaire as a second PROM to enable comparison with previous studies. While the MHOQ is hand specific, the DASH evaluates the upper extremity in general but also addresses participation level. However, the DASH showed a ceiling effect within 1 year post surgery and therefore was not responsive for the scope of our study.

Outcome measures: Validity

The MHOQ is a validated instrument for the TMJ OA population, showing an excellent responsiveness [34,35]. Despite this, and considering all remarks above, the question raised whether the MHOQ has sufficient discriminative ability to detect differences between groups treated for TMJ OA. It is known that many PROMs used in the context of hand injuries or -conditions, only partially address the functional aspects that are important to patients [36]. The patients studied in **Chapter 4** disclosed that the MHOQ does not cover all items relevant to them. The MHOQ pain subscale assesses frequency rather than pain intensity or pain provoking activities. As a consequence, when comparing surgical procedures, differences based on specific pain inducing factors, such as strenuous activities or fine motor skills and strength, may not be captured. In the context of the RCT studies in **Chapter 2** and **3**, where a better key pinch strength was found for TJA, it must be noted that only 4 of the 12 questions in the MHOQ ADL subscale refer to (key)pinch activities (pick up a coin, turn a key in a lock, button a shirt/blouse and tie shoelaces/knots). Hence, when using the MHOQ as a substitute for daily hand function after TMJ surgery, it can be questioned whether and to what extent this outcome is associated with (key) pinch strength and fine motor skills. For this goal, a supplementary questionnaire or adjustment of the MHOQ is recommended representing activities requiring precision skills, (key)pinch strength and pain provoking activities.

Finally, some studies concluded that MCP joint hyperextension with reduced thumb strength does not influence functional outcome [2,11–13]. The question arises whether the conclusions drawn in these studies are justified. Functional outcomes were assessed using different measures; in two studies, no patient reported outcome measure (PROM) was used. Instead, functional outcomes were defined as range of motion, strength and pain, hence only representing the ICF body function level. One study employed the Quick Disabilities of the Arm, Shoulder and Hand (QDASH) questionnaire [2]. Reissner et al. used the MHOQ and found no correlation between the degree of metacarpal subluxation or proximal migration with the MHOQ score or key pinch strength [13]. Range of motion or strength are not similar to the construct of functional outcome, but were used as a substitute estimate. In addition to this, we found that the MHOQ does not capture all functional limitations experienced by patients and (key) pinch activities are underrepresented. Therefore, the validity of the conclusions of the studies on MCP joint hyperextension and functional outcome may be limited by the choice of the measurement instruments.

Time horizon

Although most revision surgeries in our cohort occurred within the first postoperative year, it is conceivable that a follow-up period of 5 years may be insufficient to capture all long term problems associated with prostheses. When the implant components approach the end of their expected lifespan, which is in between 10 and 20 years, it is anticipated that a higher failure rate will be observed [37].

Conducting a RCT with a follow-up period of 5 years took 10 years to complete. This made our study design challenging, and required a lot of patience and perseverance from everyone involved. It is questionable whether longer follow-up is possible and ethically justified. There is a limited possibility for national multicentre studies on TJA, primarily due to the absence of reimbursement for TJA and hereby a lack of collaboration of partners with comparable expertise. Large international prospective databases such as compiled in arthroplasty registry databases may partially compensate for this drawback as well as making raw data available through open access. It is predicted that the value of evidence generated with real-world data will be established in the near future [38].

7.3 CLINICAL IMPLICATIONS

The impact of TMJ OA on daily life functioning is profound, because the thumb plays a crucial role in hand function. Especially tasks involving precision grip become more difficult, ultimately leading to a reduced quality of life [10,39–41]. A trend analysis predicted that the number of people in the Netherlands with OA will double between 2022 and 2050 [42], herewith becoming the most common chronic condition partly due to aging of the population. Although these analyses were pertained to osteoarthritis in general and did not specifically address TMC OA, logically this trend can also be applied to this joint. This urges investigation into the most (cost)-effective way of treating TMJ OA.

SURGICAL MANAGEMENT

Our results provide guidance for shared decision-making and patient education when considering the benefits and risks of either procedure. From the patients' perspective, both TJA and trapeziectomy procedures are eligible options, because pain is reduced by the surgery, leading to satisfactory results despite some residual pain, loss of strength or fine motor skills. Limitations on body functions level, did not lead to limitations on activity and participation level. It is possible that activity modification and coping mechanisms contribute to maintaining functioning in daily life, despite diminished thumb strength or precision skills. Participants from our qualitative study preferred trapeziectomy over TJA in half of the cases. In 3 of the 5 cases this comprised trapeziectomy with additional soft tissue arthroplasty, which may have prevented metacarpal subsidence. Reasons for choosing a procedure again, varied and were based on personal experience influenced by factors such as functional outcomes, type of occupation as well as beliefs and feelings regarding the procedure and their current functioning.

It has been found that the mean time to return to work is faster after TJA (1.5 months) than after trapeziectomy (2.8 months) [6]. Patients who are unable to perform their work due to pain and impaired function with a necessity for a timely return to work, could benefit from TJA, because recovery after TJA takes less time without the need for supervised rehabilitation.

This also applies to patients performing occupational or recreational activities requiring substantial (key)pinch strength and precision skills. It has been found that type of occupation and gender showed no significant higher complication risk

for manual workers than for office workers following TJA. However, in men below the age of 50 years, there might be a risk for accelerated prosthesis wear [43]. Time to return to work following TMJ surgery is also influenced by occupational requirements, being shorter for individuals with light physical occupations compared to those with heavy physical occupations. Additionally, when the dominant hand was operated on the time to return to work also increased [44,45].

Furthermore, as is suggested that TJA is able to correct preoperative MCP joint hyperextension [46], the severity of metacarpal collapse can also be taken into account. These considerations highlight the need for a comprehensive preoperative assessment capturing the daily functional demands related to thumb strength and precision skills.

POSTOPERATIVE CARE AFTER TJA

Educating patients about the benefits and risks of both procedures supports the shared decision-making process. Participants in the qualitative study, presented in **Chapter 4**, emphasized the importance of receiving preoperative information about outcomes, potential complications, and recovery time. This aligns with findings by de Ridder et al., who highlighted that patient satisfaction with treatment outcomes can be influenced by improving treatment expectations and their overall healthcare experience [47]. To help set realistic expectations for short-, mid-, and long-term results, preoperative information should include expected recovery time, potential residual limitations in strength and fine motor skills, pain and the ability to perform strenuous tasks, possible complications and the long-term durability of TJA.

Supervised rehabilitation providing exercises after TJA is not necessary when proper patient education is provided. Based on our experience with the education method since 2018, we can confidently state that it adequately meets the needs of most patients. Nevertheless, there will always be patients who require or desire more intensive support, also emphasizing the need for personalized care.

This study contributes to reducing the burden on both the healthcare system and patients, as the number of hand therapy sessions and surgeon consults were reduced with a median of respectively eight and two visits, saving approximately 4 hours of health care professional time. The results have already been incorporated into our local care pathway. Since TJA is not a commonly refunded treatment option in the Netherlands, the generalizability of this change in postoperative patient care is not

expected to be incorporated nation widely. Despite this, our patient brochure, which outlines the complete trajectory, including postoperative protocol, is publicly available on the Isala website (https://www.isala.nl/patientenfolders/8286-gewrichtsvervangende-operatie-bij-artrose-in-de-duimbasis/). We share our knowledge with other hospitals in the Netherlands that are implementing TJA and our postoperative guidelines are also disseminated more broadly through the prosthesis distributor.

7.4 FUTURE RESEARCH DIRECTIONS

SURGICAL MANAGEMENT

Now that with the new generation of implants the complication risk decreases and survival increases, an important next step is to study cost effectiveness, aiming to ascertain whether the trade-off of better strength and reduced recovery time justifies the higher costs associated with TJA. When studying cost-effectiveness it is recommended using a societal perspective rather than a healthcare perspective as time to return to work may be of importance when comparing trapeziectomy and TJA.

Throughout our studies we observed that comparison of complications with other studies was challenging due to the lack of an unambiguous definition for revision surgeries and associated surgeries and a comprehensive classification for TJA related complications or reporting guideline. Incomplete reporting of associated complications with their onset and management occurred frequently. An inconclusive way of complication descriptions hampers pooling of data in future meta-analyses or individual patient data analyses, preventing conclusions concerning safety of the intervention.

Additionally, independent research is recommended to minimize the risk of industry bias as it is known that sponsorship of studies by the manufacturing company can lead to more favourable outcomes [48].

In the past 5 years, only 3 RCTs have been published comparing trapeziectomy with TJA [29,30,49], as well as one additional RCT in 2019 [31], in contrast to 11 systematic reviews including TJA [18,25,28,50–57]. This substantial volume of systematic reviews contributes little to the existing body of evidence as they all included the same clinical studies. Individual patient data analysis from RCT's may enhance comparability between studies, analyse subgroups and pooling of data hereby increasing the strength for decision making [58].

Outcome measures

More research is warranted for which primary outcome to choose when comparing surgical procedures in TMJ OA in clinical studies. First, it would be of interest to investigate the amount of association of thumb strength with the MHOQ three months postoperatively. As it is important to incorporate the patient perspective and functional outcomes relevant to them, we recommend adjustment of the MHOQ or searching for a supplementary questionnaire representing activities requiring precision skills, (key)pinch strength and pain provoking activities. An alternative may be the Patient Reported Outcomes Measurement System-Upper Extremity (PROMIS-UE), consisting of 46 items enabling the use of short forms in fixed subsets of items from the itembank [59]. Oud et al. developed a custom short form representing 25 items assessing ADL function, including (key) pinch activities [60]. Although MHOQ and PROMIS-UE were found to be highly reliable for assessing ADL performance [35,61] the test-retest reliability of the PROMIS-UE showed a better distinguishment between persons with different levels of ADL performance in a non-surgical population wearing hand orthoses [60].

Another option might be the use of the patient specific function scale (PSFS) to assess individual problems on the activity and participation level. Van Kooij et al. found that the PSFS scores showed good content and discriminative validity in non-surgically treated patients with TMC OA [62]. Furthermore, responsiveness and construct validity indicated that the PSFS measures a unique construct different from the MHOQ.

When looking beyond the PROMs, many performance based outcomes are available for testing activities of daily living in a standardized manner, such as the Arthritis Hand Function Test (AHFT), the Sequential Occupational Dexterity Assessment (SODA), the Jebsen-Taylor Hand Function Test or the Sollerman test of hand function. These tests could be used additionally to PROMs, although measurement properties have not been established for all instruments and these tests also have their own limitations [63–65].

POSTOPERATIVE CARE AFTER TJA

Immobilization

The complete lack of comparative studies investigating shorter duration and less rigid immobilization after TJA warrants further investigation. To overcome the disadvantages of immobilization, early active motion (EAM) protocols may accelerate functional recovery, reduce stiffness and improve overall outcomes by promoting

circulation and enhancing neuromuscular control. These regimes are characterized by a reduced immobilization time, less rigid immobilization and early initiation of active range of motion. EAM regimes with a short immobilization duration and non-rigid material have been found safe and effective in RCT's conducted in trapeziectomy procedures [66,67]. Future research should address whether an EAM regime is safe when considering osseointegration and complications and whether it leads to a faster return to work. More specifically, the most optimal type and duration of immobilization needs to be determined, including criteria for the type of immobilization, the use of an intermittent immobilization period, for weaning from splint or brace and finally, time to release patients to unrestricted activities. Future prospective studies should also incorporate economic analyses comparing immobilization versus EAM protocols.

Rehabilitation

We recommend conducting a replication study which may confirm the effectiveness and safety of the education intervention in a larger sample. In order to predict outcome and to identify patients' needs during the recovery period it would be of interest to search for factors contributing to satisfactory functional outcomes after trapeziectomy and TJA.

7.5 GENERAL CONCLUSION

We found no superiority for TJA over trapeziectomy in terms of patient reported functional outcome using the MHOQ as well as from the patients' perspectives. Both procedures were found to be eligible options since pain is reduced by the surgery, leading to satisfactory results despite some residual pain, loss of strength or fine motor skills. Regarding postoperative care, our scoping review showed a wide variation without scientific evidence for any postoperative regime and an inconclusive way of postoperative policy and complication description. Consequently, in our quasi-experimental trial supervised rehabilitation showed no relevant benefit in functional outcomes following TJA, compared to education alone. These findings indicate that it seems safe to leave patients unsupervised in their recovery following TJA and to suffice with just education.

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Summary
Samenvatting

SUMMARY

Osteoarthritis of the thumb base is a common cause of pain and weakness in the thumb, leading to hand disability. The prevalence of osteoarthritis increases with age and is approximately twice as common in women compared to men. Because the thumb plays a crucial role in hand function, especially in tasks involving precision grip, the impact of TMC OA on the patients' daily life can be profound and it can cause limitations in all daily activities, including personal care, household chores, occupational tasks, and hobbies, ultimately reducing quality of life.

Treatment typically starts with non-surgical management as a first step. The aims are to reduce pain and to optimize thumb and hand function through education, orthosis prescription, joint protection and activity modification principles, exercise therapy, and the use of assistive devices. This can be supplemented with pain medication and steroid injections. When conservative treatment is no longer effective, surgical treatment may be indicated. The two most common surgical procedures are removal of the trapezium bone (trapeziectomy) and total joint arthroplasty with a prosthesis (TJA). Several systematic reviews and meta-analyses have focused on trying to identify which surgical procedure for treatment of trapeziometacarpal osteoarthritis is superior. These reviews concluded that current evidence is low and high-level evidence comparing TJA with trapeziectomy is lacking. Consequently, definitive conclusions regarding the optimal surgical treatment remain elusive.

SURGICAL MANAGEMENT

The research in **Chapter 2, 3 and 4** revealed no superiority for TJA over trapeziectomy in terms of patient reported functional outcome using the MHOQ as well as from the patients' perspectives. The secondary outcomes that did show significant or clinically relevant differences in favour of TJA were key pinch strength, metacarpal phalangeal joint (hyper)extension, patient satisfaction and willingness to undergo the same treatment again.

Both procedures were found to be good options for patients with grade II-III osteoarthritis, since pain is reduced by the surgery, leading to satisfactory results despite some residual pain, loss of strength or fine motor skills. Benefits of TJA are a better key pinch strength and fine motor performance skills and a shorter recovery time after surgery. There was no statistically significant difference in revision rates between the groups. Based on these mid-term (5 years) results,

we conclude that both procedures are safe and effective treatments for TMJ OA. Although we are unable to make robust statements regarding these findings due to a lack of power, partially resulting from a reduced number of follow up visits due to COVID, our results are in line with previous studies reporting a better thumb strength and shorter recovery time after TJA. Hence, our results provide guidance for shared decision-making when considering surgery. However, the question remains whether the limited differences in outcomes between both procedures justifies the extra costs involved in using a prosthesis. Future cost-effectiveness studies on this topic may help to determine which procedure should be advocated. More research is also warranted for which primary outcome to choose when comparing surgical procedures in thumb base osteoarthritis in clinical studies.

POSTOPERATIVE CARE AFTER TJA

We found no scientific evidence for any postoperative regime following TJA (**Chapter 5**). This means that at the start of our studies, decision-making was based on clinical experience rather than on scientific evidence. Our scoping review revealed a wide variation in postoperative policies between and in prostheses types. Also, inconclusive ways of postoperative policies and complication descriptions were found. An evidence gap was confirmed for comparative studies regarding types of immobilization protocols as well as rehabilitation regimens after thumb base TJA. Future research should address whether an early active mobilization regime is safe compared to immobilization when considering osseointegration and complications and whether it leads to a faster return to work.

We furthermore found that not all patients received supervised hand therapy, and that postoperative care was limited in some studies to the advice to use the hand during activities guided by pain, or hand therapy was only prescribed on indication. This variability in clinical practice raised the question whether supervised rehabilitation yields better outcomes.

We subsequently investigated this in **Chapter 6** using a quasi-experimental before-after trial. The results did not show a significant or clinically relevant benefit of supervised rehabilitation in terms of functional outcomes following TJA compared to education alone. Based on this, it seems safe to leave patients unsupervised in their recovery following TJA and to suffice with just education. However further exploration of effectiveness and safety of this intervention is recommended in larger trials.

SAMENVATTING PROEFSCHRIFT

Artrose van de duimbasis is een veel voorkomende oorzaak van pijn en krachtsverlies van de duim. De kans op artrose neemt toe met het stijgen van de leeftijd en komt bij vrouwen twee keer zo vaak voor als bij mannen. De duim heeft een cruciale rol in de hand functie, met name bij activiteiten waarbij precisie of kracht vereist is. Dit zorgt ervoor dat de impact van duimbasis artrose op het dagelijks leven groot kan zijn, omdat het de dagelijkse verzorging, huishouden, werk- en hobby activiteiten kan beïnvloeden en kan uiteindelijk hiermee een verminderde kwaliteit van leven geven.

De behandeling bestaat uit voorlichting over artrose met adviezen over gewrichtsbescherming en hulpmiddelen, het aanpassen van activiteiten, spalktherapie en oefentherapie. Dit kan worden aangevuld met pijn medicatie en steroid injecties. Wanneer dit onvoldoende helpt om de pijn en beperkingen te verminderen is chirurgie geïndiceerd. De twee meest voorkomende operaties zijn het verwijderen van het trapezium botje (trapezectomie) of het plaatsen van een gewrichtsvervangende prothese. Verschillende systematische reviews en meta-analyses hebben getracht te onderzoeken welke van deze twee ingrepen het beste is voor de chirurgische behandeling van duimbasisartrose. Deze onderzoeken concludeerden dat het huidige wetenschappelijke bewijs niveau laag is en dat gerandomiseerde studies die deze twee procedures vergelijken, ontbreken. Daarom kunnen er geen definitieve conclusies over de meest optimale chirurgische behandeling getrokken worden.

CHIRURGISCHE BEHANDELING

De onderzoeken in dit proefschrift (**hoofdstuk 2, 3 en 4**) hebben geen superioriteit aangetoond van de prothese ten opzichte van trapezectomie wat betreft patiënt-gerapporteerde functionele uitkomsten, zowel volgens de patient gerapporteerde vragenlijst MHOQ als vanuit het perspectief van de patiënten zelf. De uitkomsten die wel significante en/of klinisch relevante verschillen in het voordeel van de prothese lieten zien, waren de kracht van de sleutelgreep, de mate van (hyper)extensie van het MCP-gewricht, patiënttevredenheid en de bereidheid om dezelfde behandeling opnieuw te ondergaan.

Beide procedures bleken geschikte opties voor patiënten met graad II-III artrose, aangezien de pijn vermindert door de operatie, wat leidt tot bevredigende resultaten ondanks enige restpijn, verlies van kracht of fijne motoriek. De voordelen

van de prothese zijn een krachtigere sleutelgreep, een betere fijne motoriek en een kortere herstelperiode na de operatie. Er werd geen statistisch significant verschil in heroperaties tussen de groepen vastgesteld.

Op basis van deze middellange termijn resultaten (5 jaar) concluderen we dat beide procedures veilige en effectieve behandelingen zijn voor duimbasisartrose. Hoewel we geen harde uitspraken kunnen doen vanwege een gebrek aan statistische power, mede veroorzaakt door een verminderde aantal follow-up bezoeken als gevolg van COVID, zijn onze resultaten in lijn met eerdere studies die een sterkere duimkracht en een kortere herstelperiode na een prothese rapporteren. Onze bevindingen bieden daarom richtlijnen voor gezamenlijke besluitvorming bij het overwegen van een chirurgische ingreep. Desalniettemin blijft de vraag of de beperkte verschillen in uitkomsten tussen beide procedures de extra kosten van een prothese rechtvaardigen. Toekomstige kosteneffectiviteitsstudies kunnen helpen bepalen welke procedure moet worden aanbevolen. Verder onderzoek is ook nodig om te bepalen welke primaire uitkomstmaat geschikt is bij het vergelijken van chirurgische procedures voor duimbasisartrose in klinische studies.

POSTOPERATIEVE ZORG NA EEN PROTHESE

Er werd geen wetenschappelijk bewijs gevonden voor een specifiek postoperatief regime na een prothese (**hoofdstuk 5**). Dit betekent dat besluitvorming aan het begin van onze studies voornamelijk gebaseerd was op klinische ervaring in plaats van wetenschappelijk bewijs. Onze scoping review toonde aanzienlijke variatie in postoperatief beleid, zowel tussen als binnen verschillende typen prothesen. Bovendien bleken postoperatieve richtlijnen en beschrijvingen van complicaties inconsistent en onvoldoende onderbouwd. Vergelijkende studies ontbreken met betrekking tot immobilisatieprotocollen en revalidatieregimes na een prothese. Toekomstig onderzoek moet zich richten op de vraag of een vroege actieve mobilisatie veilig is vergeleken met immobilisatie, met betrekking tot osseo-integratie en complicaties, en of het leidt tot een snellere terugkeer naar werk.

Daarnaast werd vastgesteld dat niet alle patiënten handtherapie ontvingen, en dat postoperatieve zorg in sommige studies beperkt bleef tot het advies om de hand te gebruiken tijdens activiteiten op basis van pijn, of dat handtherapie alleen op indicatie werd voorgeschreven. Deze praktijkvariatie roept de vraag op of gesuperviseerde handtherapie betere uitkomsten oplevert. Deze vraag werd onderzocht in **hoofdstuk 6** middels een quasi-experimentele studie. De resultaten

toonden geen significante of klinisch relevante voordelen van gesuperviseerde handtherapie ten opzichte van enkel educatie in termen van functionele uitkomsten na een prothese. Op basis hiervan lijkt het veilig om patiënten, met goede voorlichting, hun herstel zelfstandig te laten doormaken. Echter, onderzoeken met grotere groepen worden aanbevolen om de effectiviteit en veiligheid van deze interventie te bevestigen.

Dankwoord

DANKWOORD

Na mijn deeltijd masterstudie klinische epidemiologie heb ik gezworen nooit meer iets dergelijks te gaan doen wat zoveel tijd en energie vergt naast gezin en baan. Op de vraag die me vaak gesteld werd of ik nog zou willen promoveren antwoordde ik dan ook steevast met: “Nee, daar heb ik geen zin in, dat ga ik nóóit doen.” Er was alleen niemand die dat geloofde, behalve ikzelf. Toen duidelijk werd dat er een lijn zat in de onderzoeken waar ik mee bezig was, waren er mensen die me stimuleerden om deze onderzoeken te bundelen. In een proefschrift. Dus ik maakte een promotie ‘plannetje’, wat evolueerde tot een echt plan. En zo gebeurde het dat ik toch overstag ging en mijn proefschrift nu het daglicht ziet. Never say never....

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Allereerst **de patiënten** die met zoveel vertrouwen en vaak ook enthousiasme voor de wetenschap hebben deelgenomen aan alle studies. Zonder jullie bijdrage waren de studies er niet gekomen.

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Al **mijn vrienden**, jullie aanwezigheid en gezelligheid heeft zeker voor de nodige ontspanning en balans gezorgd tijdens mijn promotietraject. Op, maar vooral naast, de tennisbaan, in restaurants en kroegen, in het bos, in de stad of waar dan ook. Met jullie is het leven leuker!

Mijn familie; mama ik ben blij dat je in een goede gezondheid, hoewel met duimbasisartrose, mijn promotie mee kan maken en ik weet zeker dat papa trots op mij zou zijn geweest. Marije, zussie, heel vaak zijn wij twee zielen met één gedachte en daarom vind ik het heel fijn dat jij mijn paranimf wilt zijn.

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About the author
Portfolio

ABOUT THE AUTHOR



Elske was born on 11 September 1978 in Beilen and after graduating from the Dr Nassau College in Assen in 1995, she began studying physiotherapy at the Hanze Hogeschool, University of Applied Sciences in Groningen. After graduating in 1999, she continued her education in occupational therapy at the Amsterdam University of Applied Sciences. Following her work across various fields in both roles, she developed a strong interest in hand disorders and injuries. In 2009, she specialized as a hand therapist by completing the one-year Hand Therapy course at the Erasmus Medical Centre in Rotterdam. That same year, she joined the hand therapy department at Isala, where her interest in research further developed. After participating in various research projects she started in 2017 the master study Evidence Based Practice in Health Care at the University of Amsterdam graduating in 2019 as a clinical epidemiologist. Her master's thesis, "Trapeziometacarpal Total Joint Arthroplasty, With or Without Supervised Hand Rehabilitation: A Quasi-Experimental Trial," sparked a deeper interest in trapeziometacarpal osteoarthritis, ultimately leading to her PhD research.

Currently, she holds a dual position as a Paramedisch Onderzoeker, integrating clinical work as a hand therapist with ongoing research at the Isala Hand-Wrist Centre in Zwolle.

PORTFOLIO

Research Period: Part-time (2 days/week) January 2023 - July 2025

PhD Training and activities	Year	ECTS
Courses		
Data visualisation in R, e-learning course, Statistics Globe, San Francisco, USA	2025	
Start to supervise, University of Groningen	2025	0.4
Participation-action research, workshop, Isala and Windesheim University of Applied Sciences, Zwolle	2025	0.15
Implementation science, Radboud Medical Center and University of Nijmegen	2024	1.5
BROK, e-learning course, EMWO/NFU BROK	2024	1.5
Presentation skills, workshop, Isala Academy, Zwolle	2024	0.1
Ethics in research and scientific integrity for researchers, University of Groningen	2024	2.5
Research data management awareness, workshop, University of Groningen	2023	0.1
Writing in the sciences, e-learning course, Stanford University, Stanford, USA	2023	
Negotiation skills, workshop, University of Groningen	2023	0.2
Science communication, webinar, Science Network Physical Therapy, Royal Dutch Society for Physical Therapy (KNGF)	2022	0.1
Basic concepts of qualitative research in health care, Post-Master education Master Evidence Based Practice in Health Care, University of Amsterdam/ Amsterdam University Medical Center	2021	
Longitudinal data analysis, EPIDM/ Amsterdam University Medical Center	2020	
Presentations		
Oral presentation: Trapeziometacarpal prostheses. Congress of Dutch Society for Hand Therapy (NVHT), Zeist, The Netherlands	2025	
Oral presentation: Total joint arthroplasty versus trapeziectomy in the treatment of trapeziometacarpal joint arthritis: 5-year follow-up of a randomized controlled trial. Congress of Federation of European Societies for the Surgery of the Hand (FESSH), Helsinki, Finland	2025	0.4
Poster presentation: Patients' perspectives of hand function after bilateral trapeziometacarpal surgery: trapeziectomy versus total joint arthroplasty. A qualitative thematic analysis. Congress of Federation of European Societies for the Surgery of the Hand (FESSH), Helsinki, Finland	2025	0.4

PhD Training and activities	Year	ECTS
Oral presentation: Total joint arthroplasty versus trapeziectomy in the treatment of trapeziometacarpal joint arthritis: 5-year follow-up of a randomized controlled trial. Isala Science Symposium, Zwolle, The Netherlands	2024	0.4
Oral presentation: Long term outcomes of function, activity and participation after distal radioulnar joint total joint arthroplasty. Congress of Dutch Society for Hand Therapy (NVHT), Zeist, The Netherlands	2024	0.4
Workshop: Hand therapy in the treatment of DRUJ instability. Congress of Dutch Society for Hand Therapy (NVHT) , Zeist, The Netherlands	2024	0.4
Oral presentation: Immobilization, rehabilitation and complication classification after thumb trapeziometacarpal total joint arthroplasty. A scoping review. Congress of Federation of European Societies for the Surgery of the Hand (FESSH), Rotterdam, The Netherlands	2024	0.5
Oral presentation: Isala Hand-Wrist Center Multidisciplinary Science meeting, Long term outcomes of function, activity and participation after distal radioulnar joint total joint arthroplasty, Zwolle, The Netherlands	2023	
Oral presentation: Postoperative supervised hand rehabilitation or education alone after thumb carpometacarpal total joint arthroplasty: a quasi-experimental trial. Congress of International Federation of Societies for Surgery of the Hand (IFSSH) and International Federation of Societies for Hand Therapy (IFSHT), London, United Kingdom	2022	
Attended (inter)national conferences		
Congress The Thumb, Dutch Society for Hand Therapy (NVHT), Zeist, The Netherlands	2025	
Congress Federation of European Societies for the Surgery of the Hand (FESSH), Helsinki, Finland	2025	1
Congress The Wrist, Dutch Society for Hand Therapy (NVHT), Zeist, The Netherlands	2024	0.6
Congress of Federation of European Societies for the Surgery of the Hand (FESSH), Rotterdam, The Netherlands	2024	1
Symposium “Handsurgery and Handtherapy: Extensors in motion”, Dutch Society for Hand Therapy (NVHT) and Dutch Society for Hand Surgery (NVvH), Amsterdam, The Netherlands	2023	0.25

PhD Training and activities	Year	ECTS
Symposium Dutch Society for Hand Therapy (NVHT), Bussum, The Netherlands	2023	0.25
Teaching		
Trapeziometacarpal osteoarthritis, Esser Masterclass Hand Therapy, Erasmus Medical Center/ Esser, Rotterdam, The Netherlands	From 2020	
Supervisor master thesis medical students	From 2024	1.1
Supervising hand therapy trainees over the years		
Other activities		
Reviewer European Journal of Hand Surgery	From 2025	
Supervised reviewing of manuscripts and grant application	2025	1.5
Session chair at Congress for European Federation of Societies of Hand Therapy (EFSHT), Rotterdam, The Netherlands	2024	0.25
Session chair at Congress for International Federation of Societies for Hand Therapy (IFSHT), London, United Kingdom	2022	
Scientific Congress Committee International Federation of Societies of Hand Therapy (IFSHT)	2021-2022	
Member Editorial board Dutch Journal of Hand Therapy	2015-2022	

Publications

Broekstra DC, Bonhof-Jansen EEDJ, Marks M. Avoiding pitfalls in conducting hand surgery research – potential consequences of common errors in statistical analyses. J Hand Surg Eur 2025; Apr 12. Epub ahead of print.

Bonhof-Jansen EDJ, van Ham A, Kroon GJ, Winter RW, Brink SM. Validity and reliability of a portable handheld dynamometer compared to a fixed isokinetic dynamometer to assess forearm torque strength. Hand Surg Rehabil. 2023 Apr;42(2):147-153.

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Van Rijt WG, Delnoy RE, Bonhof-Jansen EEDJ, de Jong TR. The role of routine radial styloidectomy in proximal row carpectomy: a retrospective review of 120 patients. J Hand Surg Eur. 2022 Jul;47(7):705-710.

Kroon GJ, Bonhof-Jansen EDJ. Handtherapy; prevention and management of complications in bone and joint fractures. Management of Complications in Common Hand and Wrist Procedures. FESSH Instructional Course Book 2021, Chapter 24, p223-226. Thieme. Editors: Brigitte van der Heijden, Henk Coert, Jan-Ragnar Haugstvedt.

Van Kooij Y, Fink A, Bonhof – Jansen EDJ. Wissenschaftsdschungel: Wie finde ich den richtigen Weg? Praxis Handreha (DAHT), 2021:2;149-200.

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Kroon GJ, Bonhof-Jansen EDJ, de Jong TR. Klinische uitkomsten van een prothese voor het distale radio-ulnaire gewricht. Nederlands Tijdschrift voor Hand Therapie, november 2019.

Bonhof-Jansen E, Kroon G, Brink S, van Uchelen JH. Rehabilitation with a stabilizing exercise program in triangular fibrocartilage complex lesions with distal radioulnar joint instability: A pilot intervention study. Hand Therapy. 2019;24(4):116-122.

Bonhof-Jansen EDJ, Kroon GJ. Letter to the editor regarding "Outcomes of surgically treated distal radial fractures with associated triangular fibrocartilage complex injury". J Hand Ther. 2018 Jul-Sep;31(3):e3.

Oud TAM, Bonhof-Jansen EDJ. PICO-CAT: Is koude-intolerantie bij volwassenen met een handletsel te behandelen? Nederlands Tijdschrift voor Hand Therapie, november 2017.

Bonhof-Jansen EDJ. Spiegeltje, spiegeltje…. Reflectie op een wonderlijke casus. Nederlands Tijdschrift voor Hand Therapie, april 2015.

Bonhof-Jansen EDJ, Kroon GJ. Provocatietesten van het TFCC. Nederlands Tijdschrift voor Hand Therapie, november 2011.

Kroon GJ, Bonhof-Jansen EDJ. Laten we er niet omheen draaien; Instabiliteit van het DRU gewricht nader bekeken. Nederlands Tijdschrift voor Hand Therapie, april 2011/ In dit Verband, juli 2011

Bonhof-Jansen EDJ, Malessy MJA, de Boer K. Gilliatt Sumner Hand. Nederlands Tijdschrift voor Hand Therapie, november 2009.

Submitted manuscripts

Peppelman M, Brink SM, Bonhof-Jansen EDJ. Thumb range of motion and strength are not associated with Michigan Hand Outcomes Questionnaire (MHOQ) after trapeziometacarpal total joint arthroplasty.

Nieuwenhuijs L, Bonhof-Jansen EDJ, van Rijt WG, de Jong TR. Early active mobilization versus cast immobilization after trapeziometacarpal total joint arthroplasty. A non-inferiority study.