Orthopaedics & Traumatology: Surgery & Research 104 (2018) 1095–1100

Available online at
ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com/en

Original article

Do trapeziometacarpal prosthesis provide better metacarpophalangeal stability than trapeziectomy and ligamentoplasty?

Benjamin Degeorge[a,*], Louis Dagneaux[b], Julien Andrin[a], Cyril Lazerges[a], Bertrand Coulet[a], Michel Chammas[a]

[a] *Unité de chirurgie du membre supérieur, de la main et des nerfs périphériques, département de chirurgie orthopédique, CHU de Lapeyronie, 191, avenue du Doyen Gaston-Giraud, 34295 Montpellier, France*
[b] *Unité de chirurgie du membre inférieur, département de chirurgie orthopédique, CHU de Lapeyronie, 191, avenue du Doyen Gaston-Giraud, 34295 Montpellier, France*

ARTICLE INFO

Article history:
Received 15 November 2017
Accepted 19 July 2018

Keywords:
Rhizarthrosis
Metacarpophalangeal
Hyperextension
Trapeziometacarpal prothesis
Trapeziectomy

ABSTRACT

Background: No surgical management is better than another regarding functional recovery for trapeziometacarpal joint osteoarthritis. Metacarpophalangeal (MCP) hyperextension, directly due to the shortening of thumb height, appears to be a factor of poor prognosis.
Hypothesis: MCP hyperextension can be corrected by implantation of a trapeziometacarpal prosthesis (TMP), as opposed to trapeziectomy and ligamentoplasty (TL), and pinch strength is greater with TMP in this indication.
Material and methods: Sixty-nine patients (41 TMP and 28 TL) were retrospectively evaluated. The following were evaluated: pain, mobility of the metacarpophalangeal joints, palmar grip and pinch strength. Thumb height was measured on radiographs as a post/preoperative ratio.
Results: The mean follow-up was 20 months (6–38). The TMP group showed greater reduction of the metacarpophalangeal hyperextension in all hyperextension groups, especially hypertension >30°, compared with TL. The TMP group provided significant greater pinch strength in all the subgroups with preoperative MCP hyperextension. Patient with postoperative MCP hyperextension had a significant lower grip and pinch strength compared with patient without MCP hyperextension. Radiographic analysis showed that thumb height changes were related to the degree of preoperative hyperextension. Postoperatively, patients with postoperative MCP hyperextension had a significant lower thumb height than patient without MCP hyperextension.
Discussion: Metacarpophalangeal hyperextension appears to be a factor of poor prognosis for surgical treatment of trapeziometacarpal osteoarthritis when it is not managed. TMP provides better metacarpophalangeal stabilization by restoring thumb length and would avoid surgery on the metacarpophalangeal joint. TMP may be recommended in patients having symptomatic trapeziometacarpal joint osteoarthritis and MCP joint hyperextension.
Level of evidence: III, retrospective observational case control study.

1. Introduction

Osteoarthritis of the trapeziometacarpal joint (TMJ) is a common cause of hand pain and disability in the aging population [1]. Arthroplasty and trapeziectomy, which may be associated with ligamentoplasty with autologous and synthetic fillers, preserve postoperative metacarpophalangeal (MCP) mobility [2]. In a 2010 review of the literature, Vermeulen et al. concluded that no technique was better than another with regard to pain relief and functional recovery [3]. MCP hyperextension deformity, which is directly due to the shortening of thumb height and TMJ subluxation [4,5] is found in more than two thirds of advanced cases of TMJ osteoarthritis [6]. This deformity causes hyperextension instability in key pinch, and its correction seems to have an impact on

* Corresponding author.
E-mail address: b-degeorge@chu-montpellier.fr (B. Degeorge).

https://doi.org/10.1016/j.otsr.2018.07.008
1877-0568/

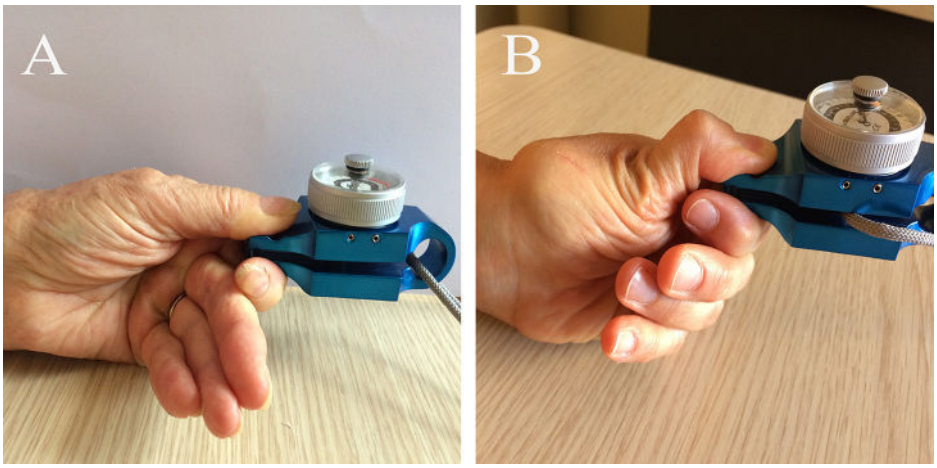

Fig. 1. Evaluation of dynamic MCP instability in hyperextension while the patient used the pinch Gauge®: patient without MCP instability (A) and with MCP instability (B).

postoperative pain and function [6,7]. Although thumb height seems to adversely affect the final result [8], the literature indicates no consensus on the best treatment to manage this instability [9].

We hypothesized that MCP hyperextension instability would be corrected, at least partially, by implantation of a trapeziometacarpal prosthesis (TMP), as opposed to trapeziectomy and ligamentoplasty (TL). We believed that pinch and grip strength would be greater with TMP in this indication and that MCP hyperextension would be detrimental on the final result.

The primary objective of this study was to assess the correction of MCP hyperextension instability using TMP as opposed to TL in the case of thumb base osteoarthritis with MCP hyperextension deformity. The secondary objective was to highlight that strength would be greater with TMP than with TL. We also quantified the loss of thumb height and evaluated the functional impact on MCP instability.

2. Material and methods

2.1. Patients

We retrospectively reviewed a monocentric multi-operator series of patients with TMJ osteoarthritis. All patient remained symptomatic after first class medical management (splint and infiltration). One hundred and thirty-two patients were operated on between November 2013 and December 2015. We were able to include 74 patients in this study, 43 TMPs and 31 TLs. The procedure was chosen by the surgeon with the patient's agreement after the patient had been informed of the advantages and disadvantages of both procedures. A symptomatic scapho-trapezio-trapezoid (STT) osteoarthritis, insufficient size of the trapezium (<5 mm) were contraindications for placing the prosthesis. We considered that patient's age less than 55 years as an indication for TL. The procedure was performed bilaterally in 10 patients. Each subject signed an approved consent form for publication.

2.2. Surgical technique

The procedure was performed under regional anesthesia. Patients were placed in supine position with an upper arm pneumatic tourniquet. In the prosthesis group, we implanted a Maia® modular trapeziometacarpal uncemented prosthesis (Lépine Biomedical, Genay, France) in all cases. An anterolateral Gedda-Möberg approach was used. The prosthesis was placed with a dedicated ancillary. A straight neck was used in all cases to allow maximal abduction of the TMJ and its length was chosen to allow stability and mobility of the joint.

For the TLs, the anterolateral Gedda-Moberg approach was also used. The trapeziectomy was achieved with fragmentation. The ligamentoplasty used the anterior two thirds of the abductor pollicis longus, which remained attached to the base of the first metacarpal. It was sutured under tension to a Mitek Mini® anchor (Depuy Synthes Companies, Johnson & Johnson Group, New Brunswick, NJ, USA) placed at the base of the second metacarpal and then tied at the distal end of the flexor carpi radialis and sutured to itself. The rest of the tendon was used for interposition.

For both groups, the patient's hand was then immobilized in a resin cast for 3 weeks with the thumb in a neutral position. A thermoformed splint was then worn for an additional 3 weeks for the TL group only.

2.3. Clinical and radiological evaluation

Active MCP joint mobility (in flexion/extension) was assessed pre and postoperatively with a goniometer. We also measured grip and pinch strength (in Kg/F) using the Jamar® hydraulic hand dynamometer and the Jamar® hydraulic pinch gauge (Kit Baseline1, Arex, Palaiseau, France). The functional QuickDASH score was assessed. At the last follow-up, we assessed dynamic MCP instability in hyperextension while the patient used the pinch Gauge® (Fig. 1).

Preoperative X-rays were used to stage the TMJ osteoarthritis preoperatively according to Dell et al. [10] and assess any STT damage. Thumb height was measured pre and postoperatively on a strict frontal radiograph of the hand according to the scale presented in Fig. 2. The ratio of the postoperative/preoperative measurements (without unit) indicated the percentage of lengthening (>1) or shortening (<1), and also limited the radiographic measurement bias due to magnification.

2.4. Statistical analysis

We divided the series into two groups: TMP and TL. The only variability between the two groups concerned the two factors that influenced the therapeutic decision: age and STT arthritis. We further discerned four subgroups: patients without MCP hyperextension (hyperextension <10°, subgroup A), those with hyperextension between 10 and 30° (subgroup B) and those with hyperextension greater than or equal to 30° (subgroup C). The fourth group, the total hyperextension (THE) group, was composed

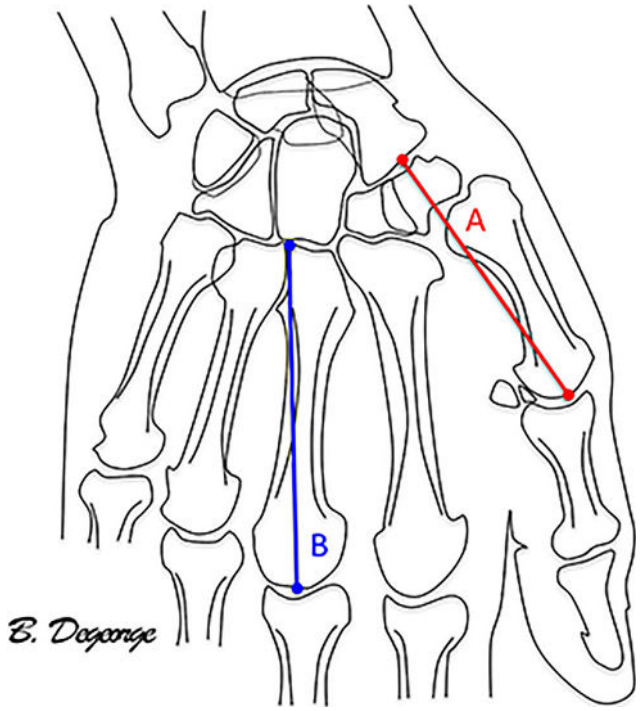

Fig. 2. Measurement of thumb height: metacarposcaphoid height (A) measured between the center of the distal joint surface of the scaphoid and the center of the joint surface of the head of the first metacarpal. The length of the third metacarpal (B) is measured between the ulnar tubercle of its base and the center of the metacarpophalangeal joint surface. The third metacarpal is used for reference calibration to compare the measurements on the pre- and post- operative radiographs, which are therefore expressed without a unit (ratio).

of all patients with at least 10° MCP hyperextension–that is, subgroups B and C.

All statistical tests were performed using SPSS 22.0 software® (IBM Corporation, Armonk, NY, USA). Continuous variables were compared using a parametric Student's *t*-tests for paired and unpaired samples. The results are expressed as mean and standard deviation (SD), and the significance threshold was set at $p < 0.05$. Qualitative variables are expressed as mean and percentage and were compared using Chi^2 test.

3. Results

The mean follow-up was 20 months (6–38). Sixty-nine patients were seen in consultation, with 5 lost to follow-up. We thus followed 41 TMPs and 28 TLs. Indications for TLs were STT osteoarthritis ($n = 17$), insufficient size of the trapezium ($n = 3$) and patients under 55 years old ($n = 8$). All other patients underwent TMP. There was no statistical difference between the TMP and TL group according to MCP hyperextension, grip or pinch strength (Table 1, $p > 0.05$). The mean patient age was 63.2 years (42–79).

3.1. Metacarpophalangeal instability

Preoperatively, MCP hyperextension was diagnosed in 42 patients (61%): respectively 27 and 15 patients from TMP and TL groups. Postoperatively, hyperextension instability was observed in 11 cases (14%) with improvement in 47%. MCP hyperextension was residual in 3 cases (7%) in TMP and 8 cases in TL (29%), and the difference was significant (Table 2, $p = 0.013$).

The postoperative hyperextension was measured lower in the TMP group than in the TL group (0.9 versus 4,8, $p = 0.026$). For both the TMP and TL groups, the improvement in MCP hyperextension was significant in the B, C and THE subgroups (Fig. 3, $p < 0.001$). The C and THE subgroups of TMP showed a significantly greater reduction of hyperextension than the subgroups of the TL group ($p = 0.002$ and $p = 0.012$, respectively).

Postoperative dynamic MCP instability was diagnosed in 28 patients (41%): respectively 7 (17%) and 21 (75%) patients from TMP and TL groups ($p < 0.001$). Dynamic MCP instability was measured lower in the TMP group than in the TL group (4,0° versus 17,9°, $p < 0.001$). All subgroups from the TMP group showed significant lower MCP instability than the subgroups of the TL group (Fig. 4).

Grip and pinch strength was significantly improved in the 2 groups ($p < 0.05$). The TMP group showed significant greater pinch strength than the TL group (3,9 Kg/F versus 3,1, $p = 0.003$). The TMP group provided significant greater pinch strength in all the subgroups with preoperative MCP hyperextension (Fig. 5).

3.2. Thumb height

In the TMP group, all patients showed a postoperative increase in thumb height, with a mean ratio of 1.09 (SD 0.04, $p < 0.001$). Conversely, all patients in the TL group showed a postoperative loss of height, with a mean ratio of 0.92 (SD 0.03, $p < 0.001$). In both groups, thumb height changes were related to the degree of preoperative hyperextension (Table 3, $p < 0.001$).

3.3. Influence of postoperative MCP hyperextension

Patients with postoperative MCP hyperextension had a significant lower grip and pinch strength ($p = 0.019$ and $p < 0.001$ respectively) and greater dynamic MCP instability ($p < 0.001$) (Table 4). In both TMP and TL groups, patients with postoperative MCP hyperextension had a significant lower thumb height than patients without MCP hyperextension.

4. Discussion

TMJ osteoarthritis is seen in more than 50% of women over 70 years [1]. In advanced cases, MCP hyperextension is often

Table 1
Characteristics of the two groups (mean and SD or percentage). Significant values are noted in bold.

	TMP group ($n = 41$)	TL group ($n = 28$)	Comparability (p)
Age, (years and SD)	66.3 (SD 6.5)	58.6 (SD 7)	**<0.001**
Female patients, (n, %)	38 (93%)	24 (86%)	0.346
Dell stage, (n, %)			
2	9 (22%)	7 (25%)	0.474
3	28 (68%)	20 (71%)	
4	4 (10%)	1 (4%)	
STT arthritis, (n, %)			
Non-symptomatic	4 (10%)	7 (25%)	**<0.001**
Symptomatic		12 (43%)	
Dominant side affected, (n, %)	17 (42%)	16 (57%)	0.201

Table 2
Pre- and post- operative distribution of patients (number and percentage) in the subgroups.

MCP hyperextension	TMP group ($n = 41$)			TL group ($n = 28$)		
	Preoperative	Postoperative	Significance (p)	Preoperative	Postoperative	Significance (p)
<10°	14 (34%)	38 (93%)	<0.001	13 (46%)	20 (71%)	0.0572
>10° et <30°	10 (24%)	3 (7%)	0.0343	8 (29%)	8 (29%)	1
>30°	17 (42%)	0	<0.001	7 (25%)	0	0.00468
THE group >10°	27 (66%)	3 (7%)	<0.001	15 (54%)	8 (29%)	0.0572

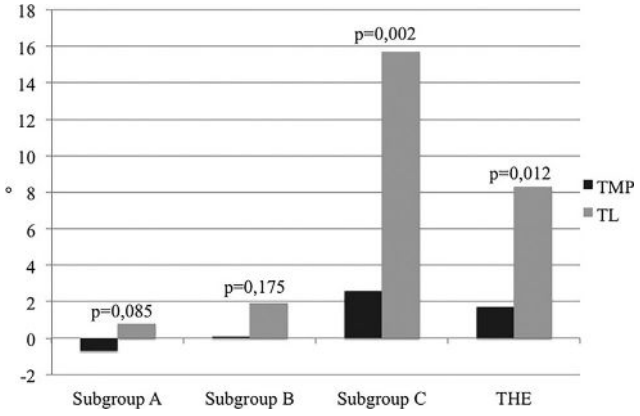

Fig. 3. Comparison of postoperative MCP hyperextension (in degrees) in the TMP and TL subgroups with significance thresholds (p).

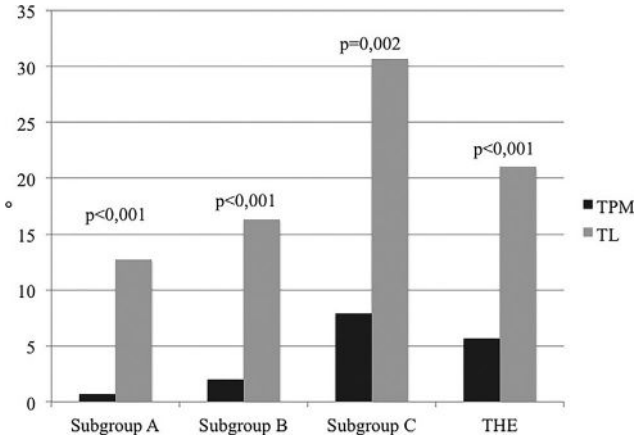

Fig. 4. Comparison of postoperative dynamic MCP instability (in degrees) in the TMP and TL subgroups with significance thresholds (p).

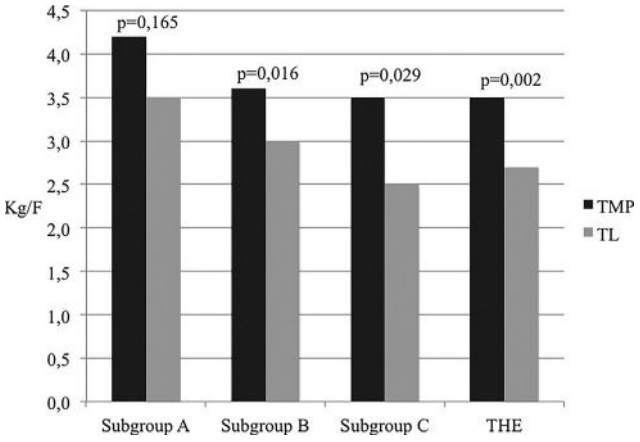

Fig. 5. Comparison of postoperative pinch strength (Kg/F) in the TMP and TL subgroups with significance thresholds (p).

Table 3
Preoperative/postoperative ratio of thumb height in the subgroups (without unit and SD). Values >1 and <1 respectively reflect lengthening and loss of thumb height.

	TMP group	TL group	Significance (p)
Subgroup A	1.07 (SD 0.03)	0.92 (SD 0.03)	<0.001
Subgroup B	1.09 (SD 0.04)	0.92 (SD 0.03)	<0.001
Subgroup C	1.10 (SD 0.05)	0.90 (SD 0.03)	<0.001
THE group	1.10 (SD 0.05)	0.92 (SD 0.05)	<0.001
Total	1.09 (SD 0.04)	0.92 (SD 0.03)	<0.001

associated, flexible at first and then becoming progressively irreducible [6]. This causes dynamic MCP hyperextension instability that can be measured by the pinch test, and particularly causes weakness in the tip pinch. The literature reveals that the functional results of instability are variable, though MCP instability is a prognostic factor for poor functional outcome. For example, Armbruster and Tan [6] and Moineau et al. [7] described the negative effects on pain and function when this instability was not corrected. Poulter and Davis [11], however, found contradictory results regarding strength and pain

in cases of MCP hyperextension following trapeziectomy. Our results contradict those of Poulter and Davis [11] because postoperative MCP hyperextension adversely affected pinch strength in our study. Nethertheless, it had not influence on pain, functional score or MCP flexion. Therefore, effective management is crucial since pinch grip is fundamental to many activities of daily living and yet is weaker in the case of MCP instability. No recent study has compared this instability in relation to the type of TMJ surgery. We showed in this study that the TMP provided better stabilization of the postoperative hyperextension than TL. Moreover, TMP provided greater pinch strength in patients with preoperative MCP hyperextension than TL. We considered that dynamic MCP hyperextension as instability because of its dynamic nature, in contrast with MCP active hyperextension. We highlighted that it was related to the degree of preoperative hyperextension and that patients with postoperative MCP hyperextension had greater dynamic MCP instability. Moreover, TMP provided lower dynamic MCP instability than TL.

The pathophysiology of MCP hyperextension is directly related to the loss of thumb height [8]. The tension exerted on the extensor pollicis brevis leads to hyperextension and interphalangeal flexion by traction on the flexor pollicis longus [4,12], which causes the Z-shaped deformity [5]. TMJ prostheses help restore height, tighten the flexor system, recenter the TMJ, and thus help resolve reduce hyperextension [8]. The association of ligamentoplasties with trapeziectomies was intended to slow down the ineluctable loss of height [13].

De le Caffinière [14] found that the TMP corrected the subluxation of the first metacarpal and restored thumb height. In their study, Jager et al. [15] showed postoperative height gain (+3.4 mm) for the prosthesis group, as opposed to height loss (−6.3 mm) for the trapeziectomy-interposition group. In addition, the prosthesis group showed a substantial reduction in subluxation, unlike

Table 4
Postoperative results and preoperative/postoperative ratio of thumb height according to postoperative MCP hyperextension. Values >1 and <1 respectively reflect lengthening and loss of thumb height. Significant values are noted in bold.

	Postoperative MCP hyperextension ($n = 11$)	Postoperative MCP without hyperextension ($n = 58$)	Significance (p)
Pain			
Rest	0.3 (SD 0.5)	0.4 (SD 0.7)	0.620
Activity	1.8 (SD 1.5)	1.3 (SD 1.8)	0.429
MCP flexion	60 (SD 5.5)	62 (SD 10.7)	0.371
Dynamic MCP hyperextension	30 (5.5)	5.8 (SD 5.6)	**<0.001**
QuickDASH	22.5 (SD 10.1)	15.4 (SD 13.6)	0.127
Strength			
Pinch	2.3 (SD 0.5)	3.9 (SD 1.4)	**<0.001**
Grip	16.1 (SD 2.9)	20 (SD 4.6)	**0.019**
Thumb height			
TMP	1.05 (SD 0.02)	1.09 (SD 0.04)	**0.002**
TL	0.90 (SD 0.02)	0.92 (SD 0.03)	**0.010**

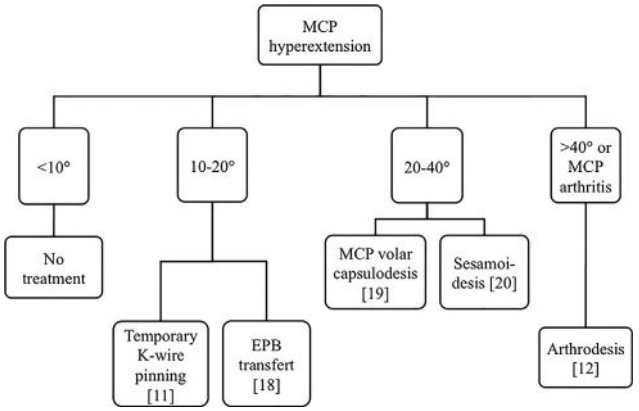

Fig. 6. Algorithm for managing MCP hyperextension in the context of thumb base osteoarthritis [6,12,21]. EPB: extensor pollicis brevis.

the trapeziectomy-interposition group (−5.6 mm versus −1.7 mm). Nevertheless, several authors have not found that the prosthesis corrected MCP instability [16,17]. We highlighted in our study that thumb height had an impact on MCP hyperextension: patients with postoperative MCP hyperextension had a significantly lower thumb height than patients without hyperextension.

Many surgical procedures for the management of MCP hyperextension have been described [11,12,18–20] but none is considered the gold standard [9]. Evidence for these procedures is largely limited to technique descriptions, case reports, and retrospective case series. Several authors [6,12,21] have proposed an algorithm to guide the management of MCP hyperextension in the context of thumb base osteoarthritis (Fig. 6). In our study, we found a significantly greater correction of MCP hyperextension in the TMP group than the TL group. Our findings suggest that TMP could be used for treating MCP hyperextension without further surgical procedure on MCP joint.

The major disadvantage of TMP is the risk of repeat surgery for mechanical failure of the implant or osteolysis, especially when the patient is young and does heavy manual work. In addition, too much lengthening of thumb height to correct MCP hyperextension can be detrimental because it places excessive stress on the trapezial cup [14] thereby causing premature wear on the cup, as well as on the STT joint, and therefore pain. Nevertheless, several authors have studied salvage surgery for failed TMP by trapeziectomy [22–24] and have obtained similar clinical results for postoperative pain and mobility than after primary trapeziectomy. These observations suggest that the indications for TMP can be extended, thus offering better MCP stabilization.

Trapeziectomies provide pain relief and satisfactory functional results at the cost of a loss in strength and a longer time to functional recovery [25,26]. According to some authors, TMP provides greater functional gain and the maintenance of grip strength [27,28]. In a literature review of 35 studies, Vermeulen et al. concluded that no one technique was better than the others to treatment TM joint osteoarthritis [3]. It should nevertheless be noted that stabilization of MCP hyperextension was not considered in their analysis.

The main limitations of our study are its retrospective design and the low number of subjects with preoperative MCP hyperextension. Splitting the population into subgroups decreased the power of the study but allowed us to analyze our results according to preoperative MCP hyperextension. The two groups had different postoperative protocols, which may influence the final result. Moreover, indications between the two surgical procedures are not comparable; preoperative STT arthritis may influence final function or strength, even after TL. A prospective study in a larger sample should be carried out to confirm these findings. The aim would be to fill in the algorithm for MCP stabilization using TMP.

5. Conclusion

Postoperative MCP hyperextension adversely affects functional outcome. By restoring thumb height, the TMP provides better stabilization of MCP hyperextension than trapeziectomy-ligamentoplasty. Given the improvement of MCP hyperextension and pinch strength, TMP may be recommended in patients having symptomatic first carpo-metacarpal joint osteoarthritis and MCP joint hyperextension instability.

Disclosure of interest

The authors declare that they have no competing interest.

Funding

No financing was received for the presented study.

Contribution

All authors have contributed to the study.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at: https://doi.org/10.1016/j.otsr.2018.07.008.

References

[1] Sodha S, Ring D, Zurakowski D, Jupiter JB. Prevalence of osteoarthrosis of the trapeziometacarpal joint. J Bone Joint Surg (Am) 2005;87:2614–8.

[2] Badia A. Total joint arthroplasty for the arthritic thumb carpometacarpal joint. Am J Orthop (Belle Mead NJ) 2005;37:4–7.
[3] Vermeulen GM, Slijper H, Feitz R, Hovius SER, Moojen TM, Selles RW. Surgical management of primary thumb carpometacarpal osteoarthritis: a systematic review. J Hand Surg (Am) 2011;36:157–69.
[4] Harris H, Joseph J. Variation in extension of the metacarpo-phalangeal and interphalangeal joint of the thumb. J Bone Joint Surg (Br) 1949;31: 547–59.
[5] Landsmeer JMF. The coordination of finger-joint motions. J Bone Jt Surg (Am) 1963;45:1654–62.
[6] Armbruster EJ, Tan V. Carpometacarpal joint disease: addressing the metacarpophalangeal joint deformity. Hand Clin 2008;24:295–9.
[7] Moineau G, Richou J, Liot M, Le Nen D. Prognostic factors for the recovery of hand function following trapeziectomy with ligamentoplasty stabilisation. Orthop Traumatol Surg Res 2009;95:352–8.
[8] Teissier J, Gaudin T, Marc T. Problems with the metacarpophalangeal joint in the surgical treatment of osteoarthritis by inserting an ARPE type joint prosthesis. Chir Main 2001;20:68–70.
[9] Klinefelter R. Metacarpophalangeal hyperextension deformity associated with trapezial-metacarpal arthritis. J Hand Surg (Am) 2001;36:2041–2.
[10] Dell PC, Brushart TM, Smith RJ. Treatment of trapeziometacarpal arthritis: results of resection arthroplasty. J Hand Surg (Am) 1978;3:243–9.
[11] Poulter RJ, Davis TRC. Management of hyperextension of the metacarpophalangeal joint in association with trapeziometacarpal joint osteoarthritis. J Hand Surg (Eur) 2011;36:280–4.
[12] Lourie GM. The role and implementation of metacarpophalangeal joint fusion and capsulodesis: indications and treatment alternatives. Hand Clin 2001;17:255–60.
[13] Putnam MD, Rattay R, Wentorf F. Biomechanical test of three methods to treat thumb CMC arthritis. J Wrist Surg 2014;3:107–13.
[14] De La Caffinière JY. Longevity factors in total trapezometacarpal prostheses. Chir Main 2001;20:63–7.
[15] Jager T, Barbary S, Dap F, Dautel G. Evaluation of postoperative pain and early functional results in the treatment of carpometacarpal joint arthritis. Comparative prospective study of trapeziectomy vs. MAIA® prosthesis in 74 female patients. Chir Main 2013;32:55–62.
[16] Moutet F, Lignon J, Oberlin C, Alnot JY, Sartorius C. Total trapeziometacarpal prostheses. Results of a multicenter study (106 cases). Ann Hand Up Limb Surg 1990;9:189–94.
[17] Semere A, Vuillerme N, Corcella D, Forli A, Moutet F. Results with the Roseland® HAC trapeziometacarpal prosthesis after more than 10 years. Chir Main 2015;34:59–66.
[18] Kessler I. A simplified technique to correct hyperextension deformity of the metacarpophalangeal joint of the thumb. J Bone Joint Surg (Am) 1979;61:903–5.
[19] Eaton RG, Floyd WE. Thumb metacarpophalangeal capsulodesis: an adjunct procedure to basal joint arthroplasty for collapse deformity of the first ray. J Hand Surg (Am) 1988;13:449–53.
[20] Tonkin MA, Beard AJ, Kemp SJ, Eakins DF. Sesamoid arthrodesis for hyperextension of the thumb metacarpophalangeal joint. J Hand Surg (Am) 1995;20:334–8.
[21] Brogan DM, Kakar S. Metacarpophalangeal joint hyperextension and the treatment of thumb basilar joint arthritis. J Hand Surg (Am) 2012;37:837–8.
[22] Apard T, Saint-Cast Y. Revision of the ARPE prosthesis by the Jones procedure: a study of 6 cases and review of literature. Chir Main 2007;26:95–102.
[23] Cooney III WP, Leddy TP, Larson DR. Revision of thumb trapeziometacarpal arthroplasty. J Hand Surg (Am) 2006;31 [219.e1–219e9.
[24] Lenoir H, Erbland A, Lumens D, Coulet B, Chammas M. Trapeziectomy and ligament reconstruction tendon interposition after failed trapeziometacarpal joint replacement. Hand Surg Rehabil 2016;35:21–6.
[25] Ferrière S, Mansat P, Rongières M, Mansat M, Bonnevialle P. Total trapeziectomy with suspension and interposition tendinoplasty for trapeziometacarpal osteoarthrisis: results at 6.5 years average follow-up. Chir Main 2010;29:16–22.
[26] Parvex PO, Egloff DV. Surgery for root arthrosis: retrospective study and search for an algorithm. Chir Main 2001;20:351–61.
[27] Kubát P, Trtík L. Maïa trapeziometacarpal implant for treatment of advanced osteoarthritis of the basal joint of the thumb. Acta Chir Orthop Traumatol Cech 2012;79:520–3.
[28] Ulrich-Vinther M, Puggaard H, Lange B. Prospective 1-year follow-up study comparing joint prosthesis with tendon interposition arthroplasty in treatment of trapeziometacarpal osteoarthritis. J Hand Surg (Am) 2008;33:1369–77.