



## First carpometacarpal joint osteoarthritis : trapeziectomy with ligament reconstruction and tendon interposition versus ball-and-socket arthroplasty

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The objective of this study was to compare trapeziectomy with ligament reconstruction and tendon interposition versus ball-and-socket arthroplasty for first carpometacarpal joint osteoarthritis treatment.

In this retrospective study, a total of 98 patients were included between January 2011 and December 2015 : 27 patients were submitted to ligament reconstruction and tendon interposition technique (group A) (mean age of 62.01 years-old) and 71 patients to prosthesis replacement (group B) (mean age of 62,14 years-old). Clinical assessment was undertaken at the last appointment before discharge.

Groups didn't significantly differ regarding VAS (group A : 1.04 ; group B : 1.03 ;  $p=0.486$ ) and Quick DASH (group A : 13.72 ; group B : 11.76 ;  $p=0.290$ ).

First carpometacarpal joint osteoarthritis arthroplasty was associated with greater strength when performing key-pinch (group A : 4.44KgF ; group B : 5.20KgF ;  $p=0.031$ ) and grip (group A : 19.25KgF ; group B : 22.35 ;  $p<0.001$ ).

There were no significant differences between groups concerning complications ( $p=0.502$ , Fisher's exact test).

There were no differences in terms of clinical outcome and complication rate between the two groups for patients with first carpometacarpal joint osteoarthritis stage Eaton II and III. However, patients with prosthesis have greater key-pinch and grip-strength.

**Keywords :** first carpometacarpal joint osteoarthritis ; ligament reconstruction and tendon interposition ; joint replacement ; prosthesis replacement.

## INTRODUCTION

First carpometacarpal (CMC1) joint osteoarthritis is a frequent and very incapacitating cause of pain and its incidence is growing with an increasingly active aged population (18).

Since the first description of trapeziectomy for treatment of CMC1 osteoarthritis in 1949 by Gervis (10) numerous surgical techniques have been developed over the years. Albeit trapeziectomy with ligament reconstruction and tendon interposition (LRTI) is considered gold standard for CMC1 treatment. However, an increased number of patients is starting to reveal good long-term outcomes following "ball-and-socket" arthroplasty (12). LRTI is widely applied with good long-term outcomes : pain relive in 80-90% of patients (7,11) but it is usually associated with decreased thumb height

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Table I. — Characteristics of the two groups

	LRTI n=27		Prosthesis n=71		p, value
Age (years, 95% CI)	62.01	(57.83;66.19)	62.14	(60.45;63.85)	.953
Gender (n, %)					
Female	22	(81.5)	66	(92.9)	.094
Male	5	(18.5)	5	7.1	
Eaton classification (n, %)					
I	0	(0)	0	(0)	.892
II	11	(40.7)	30	(42.3)	
III	16	(59.3)	41	(57.7)	
IV	0	(0)	0	(0)	
Mean follow-up (months)					

Abbreviations : LRTI : trapeziectomy with ligament reconstruction and tendon interposition ; CI : confidence interval.

(up to 40% of cases), longer recovery period, reduced pinch strength (23), and aggravation of the metacarpophalangeal (19) hyperextension. The CMC1 prostheses have been used since 1973 with variable results, although these have improved in recent years (26). The main complication is dislocation and in the long-term wear and loosening (1,13-15). However, the prostheses may have several advantages : restore normal length of the thumb column, faster recovery, increase pinch strength and they still allow for later trapeziectomy as a salvage procedure.

Although it is possible to find numerous studies evaluating the outcomes of different techniques in the treatment of CMC1 osteoarthritis, there are only few comparative studies between these 2 procedures trying to assess the clinical outcome and the patient satisfaction (4,7,8,21,23,25).

The first objective of this study was to determine the procedure with better outcomes, and the second objective to access which one had fewer complications.

## MATERIAL AND METHODS

This is a single-center retrospective cohort study, including all patients that underwent trapeziectomy with LTRI or ball-and-socket arthroplasty for CMC1 osteoarthritis, between January 2011 and December 2015. We excluded patients with a previous surgery in the same thumb or presence of another upper limb lesion. A minimum follow-up of 1 year was

mandatory. As such, 6 patients were excluded : 4 patients were lost to the follow-up and 2 patients had previous surgeries in the operated hand. The criteria for the choice of surgical procedure was no other than patient preference after careful and detailed explanation of both procedures, including their benefits and disadvantages. A total of 98 patients were included in this study : 27 patients were submitted to trapeziectomy and abductor pollicis longus (APL) suspensoplasty as described by Sigfusson and Lundborg (group A) (22) and 71 patients to a CMC1 ball-and-socket arthroplasty (group B).

No statistically significant differences between groups were found regarding their age, sex, osteoarthritis severity as described by Eaton-Littler, and mean follow-up, as shown in table I. Mean age was 62.01 (95% confidence interval (CI) [57.83 ;66.19]) years-old for group A and 62,14 (95% CI [60.45 ;63.84]) years-old for group B (p=0,953). Gender distribution was also comparable, with 22 (81,5%) females in group A and 66 (92,9%) in group B (p=0,094). Only patients with stage Eaton II (group A : 11 patients ; group B : 30 patients) and stage Eaton III (group A : 16 patients ; group B : 41 patients) osteoarthritis were found (p=0,892). The mean follow-up was 60.38 months (95% CI [54.42 ;64.32]), with nearly equivalent follow-up for both groups (group A : 61.71, 95% CI [51.28 ;72.15] ; group B : 59.87, 95% CI [55.91 ;63.82] ; p=0,737).



**Figure 1.** — Pre-operative radiographs of a patient submitted to Ivory prosthesis.



**Figure 2.** — Post-operative radiographs of a patient submitted to Ivory prosthesis.

First carpometacarpal arthroplasty (figure 1, 2) : we used the prosthesis Ivory<sup>®</sup> (Memometal, Stryker Corporate, Kalamazoo, Michigan, USA) in all cases of arthroplasty replacement. This is a fully modular ball and socket prosthesis composed of an anatomical hydroxyapatite-covered metal stem, a double-coned hydroxyapatite-covered cup, and an ultra-high molecular weight (UHMW) polyethylene liner. As a modular implant, it is possible to choose between 3 neck heights (short, medium and long) and the neck can be fixed on the stem in different rotations ( $-30^{\circ}$ ,  $0^{\circ}$ ,  $+30^{\circ}$ ).

The procedure begins using an anterolateral approach do expose the CMC1. The sensory radial nerve branch is identified and protected. The



**Figure 3.** — Pre-operative radiographs of a patient submitted to trapeziectomy and abductor pollicis longus tendon arthroplasty.



**Figure 4.** — Post-operative radiographs of a patient submitted to trapeziectomy and abductor pollicis longus tendon arthroplasty.

abductor pollicis longus tendon is partially detached from its insertion on the 1<sup>st</sup> metacarpal. The capsule is opened longitudinally, and the base of the 1<sup>st</sup> metacarpal is released anterolaterally from all of its ligamentous and capsular attachments. All osteophytes are then carefully resected, especially at the anterior side of the 1<sup>st</sup> metacarpal and trapezium. A metacarpal and trapezium surface osteotomy is then performed before manual reaming the metacarpal canal and trapezium subchondral bone. The correct orientation and implantation of the trapezium cup is checked intraoperatively under fluoroscopy. The smallest diameter of 9 mm is preferred in primary cases. After choosing the size of the implants, it is necessary to test tension, stability and mobility to decide between neck height and rotation. The definitive prosthesis is placed under press-fit fixation.

Abductor pollicis longus (APL) tendon interposition arthroplasty (figure 3, 4) : this technique

was first described by Sigfusson and Ludborg (22) in 1991. A longitudinal curved dorsoradial incision over the trapezium is made. The branches of the radial nerve are protected. A distally base fascia-capsule flap is raised to expose the first carpometacarpal joint. The trapezium is removed in pieces or *en bloc* and care is taken not to damage the flexor carpi radialis (FCR) tendon. A distally based strip of the most radial part of the APL tendon with 6-7 cm long is prepared. The strip is inserted through the radial part of capsule and then through a cut in the FCR tendon. The strip is then pulled up and around one of the remaining parts of the APL tendon. The rest of the tendon strip is sutured into a roll and placed in the trapezial defect as a soft tissue spacer.

The thumb and wrist are immobilized in a cast splint for 3 weeks, with the thumb in abduction and opposition. Patients are referred to the rehabilitation department after those 3 weeks.

Preoperative x-rays were used to stage the osteoarthritis according to Eaton-Littler classification. All patients were assessed postoperatively at 2, 6 and 12 weeks, 6 months and then annually. The clinical and radiological outcomes used in this study were assessed in the last clinical appointment, with minimal follow-up of 24 months for both groups. The Visual Analog Scale (VAS) was used to assess the pain level (0, absence of pain ; 10, severe pain), the Quick Disabilities of the Arm, Shoulder and Hand score (QuickDASH) was used to evaluate the functional results and it was asked to the patients if they would repeat the same surgery. Strength was measured using a calibrated hydraulic pinch gauge and calibrated hydraulic hand dynamometer. All clinical or radiological complications were

described, like, dislocation, subluxation, osteolysis or loosening.

Population idiosyncratic variables were tested at first, in order to understand group comparison viability, as may be seen previously in the cohort description. For the study variables, group comparison was performed using the Pearson chi-squared test for the categorical ones (unless cell counts were under 5, in which Fisher's exact test was read) and parametric tests for continuous ones (unless Shapiro-Wilk's test discommended it, in which case nonparametric tests were run). Statistical significance was considered for  $p < 0.05$ . Data processing was performed using *IBM SPSS Statistics version 21*.

## RESULTS

Groups didn't significantly differ in regards of VAS (group A : 1.04, 95% CI [0.55 ;1.52] ; group B : 1.03, 95% CI [0.79 ;1.28] ;  $p=0.486$ ) and QuickDASH score (group A : 13.72, 95% CI [7.11 ;20.33] ; group B : 11.76, 95% CI [8.56 ;14.95] ;  $p=0.290$ ).

The same was verified regarding the question about hypothetical surgery repetition, albeit the small amount of negative answers : 2 (7,4%) group A and 11 (15,5%) group B patients, no statistical differences were found ( $p=0.505$  ; 95% CI [0.09 ;2.11]) (table II). Only 2 patients without complications answered negatively to the question.

CMC1 arthroplasty was associated with greater strength when performing key-pinch (group A : 4.44 KgF, 95% CI [3.80 ;5.09] ; group B : 5.20 KgF, 95% CI [4.83 ;5.57] ;  $p=0.031$ ) and grip (group A : 19.25 KgF, 95% CI [18.55 ;19.97] ; group B : 22.35 KgF, 95% CI [21.81 ;22.89] ;  $p < 0.001$ ).

Table II. — Functional outcomes

	LRTI n=27		Prosthesis n=71		p, value
Mean VAS (95% CI)	1.04	(0.55;1.52)	1.03	(0.79;1.28)	.486
Mean QuikDASH (95% CI)	13.72	(7.11;20.33)	11.76	(8.56;14.95)	.290
Negative answer (n, %)	2	(7.4)	11	(15.5)	.505
Key-pinch (kg, 95% CI)	4.44	(3.80;5.09)	5.2	(4.83;5.57)	<.001*
Grip-strength (kg, 95% CI)	19.25	(18.55;19.97)	22.35	(21.81;22.89)	<.001*

Abbreviations : LRTI : trapeziectomy with ligament reconstruction and tendon interposition ; VAS : Visual Analog Scale ; CI : Con-fidence Interval ; QuickDASH : Quick Disabilities of the Arm, Shoulder and Hand ; \*significant.

The complication rate in group A was 7.14%, with 2 patients with postoperative metacarpophalangeal hyperextension deformity. These 2 cases were managed conservatively. In group B the complication rate was 14.5% : 1 infection, 1 trapezium fracture, 4 dislocations, 3 aseptic loosening. The infection corresponded to an acute case 2 weeks after surgery that resolved after irrigation, debridement, change of liner and antibiotherapy. The trapezium fracture occurred almost one year after the surgery as a consequence of a fall. It was necessary to convert the prosthesis into a trapezectomy and LRTI. according to Sigfusson and Lundborg. The 4 dislocations occurred long after the removal of the cast and all patients described some type of thumb trauma. It was possible to carry out a closed reduction under sedation in all cases followed by the use of a cast for about 4 weeks. No further dislocation occurred in these patients. We considered that there was prosthesis aseptic loosening when a patient had pain, acute phase reactants were normal and osteolysis was observed in a plain X-ray. The 3 patients underwent surgical revision of the prosthesis into a trapezectomy and ligamentoplasty as described by Sigfusson and Lundborg. There were no cases of dysesthesia of the superficial branch of the radial nerve or complex regional pain syndrome in both groups. While there were more complications in group B, this result wasn't statistically significant (Odds Ratio 2.05, 95% CI [0.42 ;10.03] ; p=0.502, Fisher's exact test).

## DISCUSSION

Although the decision of treatment technique was based on surgeon and patient preferences, there were no statistical differences between these 2 groups regarding their age, sex, osteoarthritis severity as described by Eaton-Littler, and mean follow-up time.

Our results demonstrate that both techniques are effective for the treatment of CMC1 osteoarthritis with Eaton stage II and III with low complication rates. With about 5 years of mean follow-up, we found no significantly difference between the 2 techniques concerning post-operative pain relief,

as measured by VAS, and functional outcome evaluated by QuickDASH score.

Our department's choice regarding trapeziectomy with LRTI falls on the procedure described by Sigfusson and Lundborg because we believe it is a technically easy procedure and therefore more reproducible. Like other LRTI procedures, it is very effective on pain relief and it has good functional results. However, some authors defend that patients treated by LRTI technique lost some pinch strength and have a longer recover time, most of them needing rehabilitation after surgery (9).

More than two thirds of advanced cases of CMC1 osteoarthritis have MCP hyperextension deformity (3) which is caused due to shortening of thumb and CMC1 subluxation (16). This is a progressive instability that can be aggravated by trapeziectomy procedures and become irreducible and, therefore, it is associated with pain and lower pinch strength (3,20). In this study, we had 2 cases of hyperextension deformity of the MCP joint among patients submitted to LRTI and no cases in patients with prosthesis. Robles-Molina et al. (21) found the same results and defended that prostheses seem to prevent secondary deformity of the MCP joint as these can restore the thumb height. Degeorge et al. (8) found that MCP hyperextension following trapeziectomy adversely affected pinch strength and that prostheses provide better stabilization of the postoperative hyperextension.

In this study, although there were no clinical differences between groups, patients that underwent prostheses replacement had more key-pinch and grip-strength that patients submitted to trapeziectomy with LRTI. Ulrich-Vinther et al. (23), in a prospective study of 98 patients, demonstrated that prostheses resulted in faster, better pain relief and better functional outcome when compared with LRTI, without further increase in the complication rate. A retrospective study of 65 patients by Robles-Molina et al. (21) compared Arpe® prostheses with LRTI using the Burton-Pellegrini technique and reported similar postoperative pain relief and improved strength and earlier functional recovery with prostheses. In other 2 studies (7,25) that were based in same initial series of patients, the long-term outcomes after a mean follow-up of 5.4 and 9

years respectively, differences could not be found in pain relief or functional improvement between the techniques. In a recent study, Cebrian-Gomez et al. (4) reported that the prosthetic procedure provided better pain relief and QuickDASH score, higher patient satisfaction and faster recovery to daily activities and work.

In a 5 years follow-up study, Goubau et al. (13) evaluated 22 patients that underwent Ivory prostheses and reported a high satisfaction rate with restoration of a substantial functional range of motion and grip strength, reduction in pain, and restoration of daily functioning. The 5-year overall survival of the Ivory prosthesis was 95%.

There is still some concern regarding prostheses complications and high failure rates: dislocation, instability, wear of components and implant loosening can occur (1,1315).

In the current study, in spite of a higher observed complication rate among the prostheses group (Odds Ratio 2.05, 95% CI [0.42 ;10.03]), it didn't reach statistical significance. These were mostly dislocations. However, with the same prosthesis Goubau et al. (13) reported no dislocations. Robles-Molina et al. (21) reported higher complication rate with prostheses group and had 3 dislocations while Ulrich-Vinther et al. (23) found no differences with respect to complications and found no dislocations. The literature indicates no consensus about the dislocation rate among the different prosthesis, but these mainly occur in the first postoperative year, in about 2-5% (6). While it is a severe complication, some authors found no differences for pain and range of motion in patients submitted to a salvage procedure for failed CMC1 prostheses due to dislocation when compared to primary trapeziectomy (2,17).

In this study we found 3 (4.2%) patients with implant loosening, which is in agreement with the literature (2,13). As the use of prostheses is still a concern due to implant loosening, in active handwork individuals, younger than 60 years and with higher demand we prefer trapeziometacarpal arthrodesis (5,24).

The main limitations of this study are the retrospective design and the inevitable non-randomized population. Although there were no statistical dif-

ferences of the idiosyncratic variables between the 2 groups, this study is not a randomized clinical trial, so it may exist some unknown biases which may affect the results.

In conclusion, there were no significant differences in terms of clinical outcome and complication rate between the trapeziectomy with LRTI technique as described by Sigfusson and Lundborg and CMC1 arthroplasty addressing patients with CMC1 osteoarthritis stages Eaton II and III. However, patients that underwent CMC1 arthroplasty presented greater key-pinch and grip strengths when compared to the trapeziectomy with LRTI group.

## REFERENCES

1. **Adams BD, Pomerance J, Nguyen A, and Kuhl TL.** Early outcome of spherical ceramic trapezium-metacarpal arthroplasty. *J. Hand Surg. Am.* 2009 ; 34 : 213-218.
2. **Apard T, and 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.
3. **Armbruster EJ, and Tan V.** Carpometacarpal joint disease : addressing the metacarpophalangeal joint deformity. *Hand Clin.* 2008 ; 24 : 295-299, vii.
4. **Cebrian-Gomez R, Lizaur-Utrilla A, Sebastia-Forcada E, and Lopez-Prats FA.** Outcomes of cementless joint prosthesis versus tendon interposition for trapeziometacarpal osteoarthritis : a prospective study. *J. Hand Surg. Eur.* 2019 ; 44 : 151-158.
5. **Chakrabarti AJ, Robinson AH, and Gallagher P.** De la Caffiniere thumb carpometacarpal replacements. 93 cases at 6 to 16 years follow-up. *J. Hand Surg. Br.* 1997 ; 22 : 695-698.
6. **Comtet JJ, and Rumelhart C.** [Total trapezometacarpal prostheses : concepts and classification study]. *Chir. Main* 2001 ; 20 : 48-54.
7. **De Smet L, Vandenberghe L, and Degreef I.** Long-term outcome of trapeziectomy with ligament reconstruction and tendon interposition (LRTI) versus prosthesis arthroplasty for basal joint osteoarthritis of the thumb. *Acta Orthop. Belg.* 2013 ; 79 : 146-149.
8. **Degeorge B, Dagneaux L, Andrin J, Lazerges C, Coulet B, and Chammas M.** Do trapeziometacarpal prosthesis provide better metacarpophalangeal stability than trapeziectomy and ligamentoplasty? *Orthop. Traumatol. Surg. Res.* 2018 ; 104 : 1095-1100.
9. **Ferriere S, Mansat P, Rongieres M, Mansat M, and Bonneville P.** [Total trapeziectomy with suspension and interposition tendinoplasty for trapeziometacarpal osteoarthritis : results at 6.5 years average follow-up]. *Chir. Main* 2010 ; 29 : 16-22.

10. **Gervis WH.** Excision of the trapezium for osteoarthritis of the trapezio-metacarpal joint. *J. Bone Joint Surg. Br.* 1949 ; 31B : 537-539, illust.
11. **Ghavami A, and Oishi SN.** Thumb trapeziometacarpal arthritis : treatment with ligament reconstruction tendon interposition arthroplasty. *Plast. Reconstr. Surg.* 2006 ; 117 : 116e-128e.
12. **Gottschalk MB, Patel NN, Boden AL, and Kakar S.** Treatment of Basilar Thumb Arthritis : A Critical Analysis Review. *JBJS Rev.* 2018 ; 6 : e4.
13. **Goubau JF, Goorens CK, Van Hoonacker P, Berghs B, Kerckhove D, and Scheerlinck T.** Clinical and radiological outcomes of the Ivory arthroplasty for trapeziometacarpal joint osteoarthritis with a minimum of 5 years of follow-up : a prospective single-centre cohort study. *J. Hand Surg. Eur.* 2013 ; 38 : 866-874.
14. **Hansen TB, and Vainorius D.** High loosening rate of the Moje Acamo prosthesis for treating osteoarthritis of the trapeziometacarpal joint. *J. Hand Surg. Eur.* 2008 ; 33 : 571-574.
15. **Klahn A, Nygaard M, Gvozdenovic R, and Boeckstyns ME.** Elektra prosthesis for trapeziometacarpal osteoarthritis : a follow-up of 39 consecutive cases. *J. Hand Surg. Eur.* 2012 ; 37 : 605-609.
16. **Landsmeer JM.** The Coordination of Finger-Joint Motions. *J. Bone Joint Surg. Am.* 1963 ; 45 : 1654-1662.
17. **Lenoir H, Erbland A, Lumens D, Coulet B, and Chammas M.** Trapeziectomy and ligament reconstruction tendon interposition after failed trapeziometacarpal joint replacement. *Hand Surg. Rehabil.* 2016 ; 35 : 21-26.
18. **Martinez de Aragon JS, Moran SL, Rizzo M, Reggin KB, and Beckenbaugh RD.** Early outcomes of pyrolytic carbon hemiarthroplasty for the treatment of trapezial-metacarpal arthritis. *J. Hand Surg. Am.* 2009 ; 34 : 205-212.
19. **McPherson EJ, Woodson C, Holtom P, Roidis N, Shuffelt C, and Patzakis M.** Periprosthetic total hip infection : outcomes using a staging system. *Clin. Orthop. Relat. Res.* 2002 ; 8-15.
20. **Moineau G, Richou J, Liot M, and Le Nen D.** Prognostic factors for the recovery of hand function following trapeziectomy with ligamentoplasty stabilisation. *Orthop. Traumatol. Surg. Res.* 2009 ; 95 : 352-358.
21. **Robles-Molina MJ, Lopez-Caba F, Gomez-Sanchez RC, Cardenas-Grande E, Pajares-Lopez M, and Hernandez-Cortes P.** Trapeziectomy With Ligament Reconstruction and Tendon Interposition Versus a Trapeziometacarpal Prosthesis for the Treatment of Thumb Basal Joint Osteoarthritis. *Orthopedics* 2017 ; 40 : e681-e686.
22. **Sigfusson R, and Lundborg G.** Abductor pollicis longus tendon arthroplasty for treatment of arthrosis in the first carpometacarpal joint. *Scand. J. Plast. Reconstr. Surg. Hand Surg.* 1991 ; 25 : 73-77.
23. **Ulrich-Vinther M, Puggaard H, and 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 : 1369-1377.
24. **van Cappelle HG, Elzenga P, and van Horn JR.** Long-term results and loosening analysis of de la Caffiniere replacements of the trapeziometacarpal joint. *J. Hand Surg. Am.* 1999 ; 24 : 476-482.
25. **Vandenbergh L, Degreef I, Didden K, Fievs S, and De Smet L.** Long term outcome of trapeziectomy with ligament reconstruction/tendon interposition versus thumb basal joint prosthesis. *J. Hand. Surg. Eur.* 2013 ; 38 : 839-843.
26. **Weiss AC, and Goodman AD.** Thumb Basal Joint Arthritis. *J. Am. Acad. Orthop. Surg.* 2018 ; 26 : 562-571.