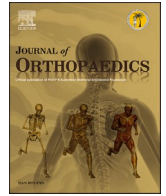




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Tenoplasty in suspension with or without tendon interposition: A prospective randomized study in the treatment of advanced thumb carpometacarpal arthritis

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ABSTRACT

Introduction: The aim of this prospective and randomized study is to analyze and compare the outcomes of two surgical techniques for trapeziometacarpal joint osteoarthritis (Eaton-Littler grade III and IV).

Materials and methods: 52 consecutive patients underwent surgical intervention by two different surgical techniques and checked for subjective outcomes (DASH, NPRS), objective outcomes (ROM, opposition test, grinding test, pulp pinch, hand grip) and radiographic outcomes. Surgical time was calculated.

Results: 26 patients underwent suspension arthroplasty using abductor pollicis longus tendon interposition (Ceruso procedure) and 26 patients underwent arthroplasty using suspension tenoplasty of the flexor radialis carpi (Altissimi procedure). Both techniques were performed by a single surgeon and showed good and satisfactory results, with best outcome reported in Altissimi procedure regarding DASH and ROM ($p = 0.011$ and $p = 0.012$, respectively), with reduced surgical time (about 6 min less, $p = 0.03$). The proximal shift between scaphoid and the base of first metacarpal did not influence the final results of the cases treated.

Conclusion: This study provides evidence that trapeziectomy in combination with both tendon suspension arthroplasty and tendon interposition are two surgical procedures useful to solve advanced basal joint arthritis. Patients who underwent suspension tenoplasty without tendon interposition seemed to be generally more satisfied with significantly better symptomatic and functional outcomes.

1. Introduction

Trapeziometacarpal joint (TMJ) osteoarthritis (OA), also known as basal joint arthritis (BJA), is a common condition that impairs hand function, dexterity, and strength by causing gradual discomfort, weakness, and stiffness.¹

For patients who fail conservative treatment, surgery must be considered.² Isolated trapeziectomy was introduced by Gervis in 1949³

and has continued to be performed ever since. However, to improve long-term results, over the time a number of modifications and combinations of techniques have been developed, such as arthrodesis, trapeziectomy with suspension arthroplasty, or with ligament reconstruction and tendon interposition, joint resurfacing. However, it remains controversial which surgical technique to consider as the gold standard,⁴ and the recent literature is unclear as to whether interposition is necessary or not.⁵

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The aim of the present comparative study is to analyze the outcomes of two surgical techniques for BJA: suspension arthroplasty with tendon interposition (SATI), described by Weilby,⁶ modified by Ceruso et al.⁷ versus arthroplasty with suspension tenoplasty (AST), described by Altissimi,⁸ who continued and modified Pellegrini' and Burton's original idea⁹

2. Materials and methods

The present study has been approved by the Internal Review Board and all patients signed a consent to participate. The research was approved by the Young European Hand Surgeons (YEHS). Inclusion criteria: patients surgically treated between 2017 and 2020 for advanced BJA (Eaton-Littler stage III-IV), who had previously failed conservative treatment (consisting of either cortisone or hyaluronate injections, analgesics, patient education, strengthening exercises, aids and orthoses).

Patients with systemic diseases, rheumatoid arthritis or post-traumatic arthritis were excluded.

All patients meeting our inclusion criteria were randomly divided into two groups.

2.1. Clinical and radiographic evaluation

Every patient had a functional and symptomatic assessment using measurement recording both before the operation and after surgery (at 15, 30 days, 6 months and then yearly) by the same independent observer blinded for the surgical technique.

- Personal/subjective evaluations

The patient's pain was evaluated using the Numeric Pain Rating Scale (NPRS),¹⁰ a segmented numerical version of the Visual Analog Scale (VAS).¹¹

Patient satisfaction was evaluated with a Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.¹²

- Objective evaluations

The clinical assessment involved standard evaluations of range of motion (ROM) by using a universal 360° goniometer which fulcrum has been dorsally placed on the 1st metacarpophalangeal joint.¹²

Measurement of the thumb opposition was performed using the Kapandji method.¹³

The first metacarpal bone of the patient was gripped, moved in a circular motion, and loaded with mild axial forces to perform the thumb grind test.^{14,15}

A Jamar® dynamometer was used to evaluate the hand grip and the pulp pinch strength, according to the guidelines of the American Society for Surgery of the Hand.¹² The same instrument was used on all patients and calibrated on regular intervals. All the measurements were repeated three times and the average was calculated.

- Radiographic evaluation

In both groups, proximal migration of the thumb has been assessed pre- and post-operatively by measuring the "gap" between the base of the metacarpal and the distal end of the scaphoid on the antero posterior radiographs. This distance was measured according to Goffin and Saffar technique¹⁶ (Fig. 1 A, B).

- Surgical time

Tourniquet was applied in all surgeries before incision and removed before wound closure. The duration of tourniquet application was recorded to define surgical time.

2.2. Surgical techniques

All operations were performed by the same surgeon. Both surgical techniques were performed under brachial plexus anesthesia. In these procedures only one surgical approach is required: a 4 cm longitudinal incision is made, along the dorsal radial margin of the trapeziometacarpal joint. The radial artery was released and pulled back in the ulnar direction. The cutaneous branch of the radial nerve was isolated. Our team performed a Y-shaped capsulotomy, thus exposing the articular surfaces and to obtain a wide distal triangular flap inserted into the base of the 1st metacarpal bone. Trapezium was isolated and excised,

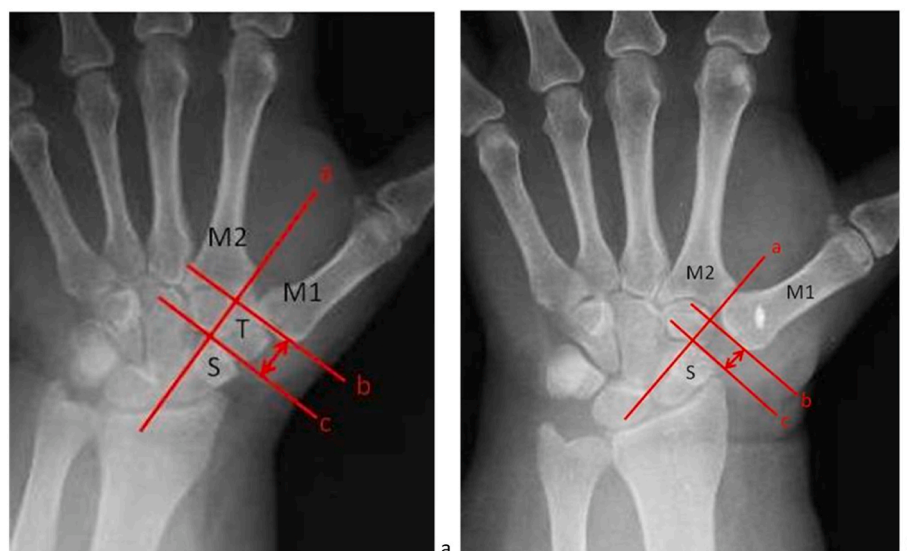


Fig. 1. A, B: Preoperative (A) and postoperative (B) radiographic reference points for measurement of the trapeziometacarpal joint (TMJ) gap in patient 63 years old who underwent tendon suspension arthroplasty (Altissimi procedure) post trapeziectomy
Line (a) is the line projected through the radial articular surface of the index metacarpal an the trapezium. Line (b) is the line tangent to the thumb metacarpal base and perpendicular to line (a). Line (c) is the line tangent to the distal extreme of the scaphoid and perpendicular to line (a). The distance between line (b) and line (c) is the height of the TMJ space. M1 = 1st metacarpal; M2 = 2nd metacarpal; T = trapezium; S = scaphoid.

as well as any other osteophytes occurring between the first and second metacarpal bones. Flexor carpi radialis (FCR) tendon, which is located in the trapezial groove, has been protected during this procedure (Fig. 2A and B,C).

GROUP A: SUSPENSION ARTHROPLASTY WITH TENDON INTERPOSITION (SATI) by Ceruso (Fig. 3).

In normal circumstances, the abductor pollicis longus (APL) is made up of several tendons. The dorsal branch of the APL was dissected free and released for approximately 4 cm proximal to the trapezium and then it was passed through the FCR tendon, creating a hole nearby its insertion into the proximal epiphysis of the second metacarpal bone and placed in the cavity with an anchovy of tendon. After that, the free end of the APL was put into the triangle-shaped capsular gap that had been previously created during the capsulotomy. The rolled up APL acts either as a spacer and a suspensor. If there was just one tendon, we recommended harvesting as much as 50 % of the APL after ensuring that it was inserted into the first metacarpal bone.

GROUP B: ARTHROPLASTY WITH SUSPENSION TENOPLASTY (AST) by Altissimi (Fig. 4).

A strip of FCR was dissected and released for 3–4 cm proximal to its insertion into the 2nd MC. Distal insertion was left intact. The free end of FCR passed through the triangular capsular space drawn during capsulotomy, surrounding the base of the 1st metacarpal bone, was fixed with suture anchor (Arthrex, Inc., Naples, FL) on radial edge of it, thus achieving a suspension stability. What remains of the FCR strip, distal to the anchor, is eliminated.

Finally, the edges of the capsule were sutured and the skin was closed.

The same post-operative care was provided to both groups: a three-week cast immobilization of the thumb and wrist, followed by passive and active motor rehabilitation exercises to improve the thumb's opposition up to the head of the fifth MC (Kapandji 10) and restore the function of the tip-to-tip pinch. Strengthening exercises for the thenar eminence muscles were also carried out. Weight bearing exercises were allowed one month after surgery. Inquiries were made of the patients, and medical records were examined to look for proof of any problems following surgery or other surgical procedures.

2.3. Statistical analysis

The statistical analysis was based on an estimated sample size of at least 24 subjects, with a ratio 1:1 for the 2 treatment groups, which was calculated to be adequate to achieve 90 % power to detect a large effect size (Cohen's f : 0.40) with 1df and p-value of 0.05 on the ROM test. Data were collected in a database and analysed using the SAS System version 9.4. T-student, Chi-squared test and Fisher's exact test as appropriated were conducted to assess the starting disparities between the randomized groups. In order to understand if a surgical procedure may give better results, time per techniques interaction was performed using 2-



Fig. 3. SATI: suspension arthroplasty with tendon interposition by Ceruso (Group A).

factor ANOVA for repeated statement with the general linear model procedure and a p-value less than 0.05 was considered statistically significant. Analysis was performed on variables logarithmically transformed to enhance symmetry of measures. If not otherwise specified, data are presented as means \pm standard deviation (SD).

3. Results

Four patients did not meet our inclusion criteria (3 with rheumatoid arthritis and one with post-traumatic osteoarthritis). A total of 52 patients were enrolled in the study. General characteristics of the study cohort are shown in Table 1. 26 patients underwent suspension arthroplasty using abductor pollicis longus tendon interposition (Ceruso procedure, Group A) and 26 patients underwent arthroplasty using suspension tenoplasty of the flexor radialis carpi (Altissimi procedure,

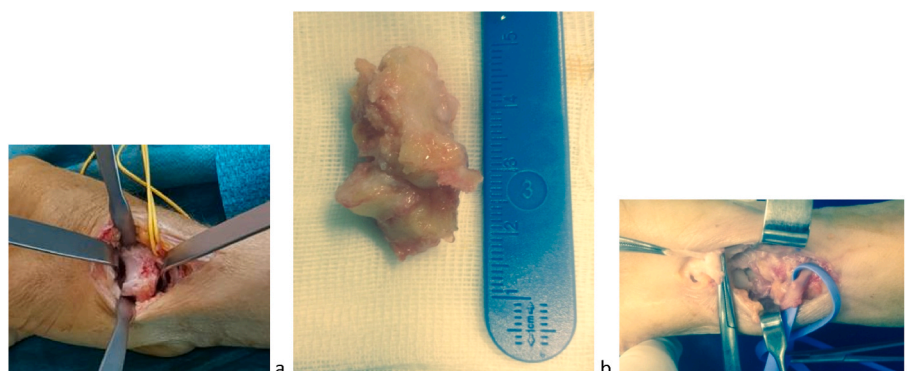


Fig. 2. A, B, C: Trapezium isolated (A); trapezium excised (B); the cavity left empty post-trapeziectomy (C).



Fig. 4. AST: arthroplasty with suspension tenoplasty by Altissimi (Group B).

Table 1
The composition of the sample.

	Group A SATI procedure by Ceruso	Group B AST procedure by Altissimi	
Gender	24 women, 2 men	22 women, 4 men	Fisher's exact test: $p = 0.287$
Age (mean in years)	62 ± 8.9	60 ± 9.7	T-student test: $p = 0.425$
Eaton-Littler stage III	4	8	Chi-squared test: $p = 0.312$
Eaton-Littler stage IV	22	18	

SATI: suspension arthroplasty with tendon interposition; AST: arthroplasty with suspension tenoplasty.

Group B). The non-significant p-values shown in Table 1 testify that there were not preoperative differences on age, gender and BJA stage between the two randomized groups.

The time from the day of surgery to the last evaluation ranged from 32 to 72 months (mean 4,5 years). All patients have completed follow-up. To date, no long-term postoperative complications have been reported in any patient. Only one patient reported delayed wound healing, which resolved spontaneously approximately 45 days after surgery.

All the measurements are summarized in Table 2. The results of patient's pain intensity were good, we noticed substantial stabilization of pain starting from the third month after surgery: at last follow-up NPRS score decreased from 8.64 ± 1.55 preoperatively to 2.5 ± 1.16 in group A and from 8.40 ± 0.84 to 2 ± 1.25 in group B ($p = 0.270$).

Table 2
General results of personal and objective evaluations.

variables	Group A (SATI procedure)		Group B (AST procedure)		Time x techniques interaction ^a
	preoperative	post-surgery	preoperative	post-surgery	
NPRS	8.64	2.50	8.40	2.00	$p = 0.270$
DASH	69.93	20.21	71.20	9.40	$p = 0.011$
ROM	49.1°	57.8°	58.3°	70.5°	$p = 0.012$
KAPANDJI	4	7	4	8	$p = 0.834$
GRINDING	100 %	30 %	100 %	0 %	$p = 0.650$
PULP	positive	positive	positive	positive	$p = 0.237$
PINCH	2.2 Kg	3.2 Kg	2.9 Kg	4.9 Kg	
HAND GRIP	21.3 Kg	23.3 Kg	26.3 Kg	31.6 Kg	$p = 0.202$

^a 2-factor ANOVA using repeated statement.

DASH score decreased from 69.93 ± 9.48 to $20,21 \pm 12.01$ in group A and from 71.20 ± 4.42 to 9.40 ± 6.26 in group B ($p = 0.011$). In group A, flexion-extension of the thumb metacarpophalangeal joint was $49,1 \pm 15.2^\circ$ preoperatively and it increased to $57,8 \pm 17.4^\circ$; in group B it increased from $58.30 \pm 8.56^\circ$ to $70.50 \pm 8.42^\circ$ ($p = 0.012$). Before surgical interventions, in all the patients of both groups a Kapandji grade 4 ± 1.2 thumb opposition was assessed. Up to the present time, in group A only one patient showed a complete recovery of the abduction (grade 9) whereas 50 % of patients could touch the pulp of the little finger (grade 7) (SD 0.65). In group B, a grade 8 ± 0.82 thumb opposition was assessed, although 3 patients reached grade 9 ($p = 0.834$). Before surgery, grinding test was positive for 100 % of patients. At the final follow-up, the totality of patients in group B had a negative grinding test, while in 4 patients (30 %) of group A the grinding test remained positive ($p = 0.650$). Preoperatively, pulp pinch in group A was 2.19 ± 0.59 Kg and increased up to 3.20 ± 1.21 Kg during follow up, while in group B it increased from 2.98 ± 1.57 to 4.95 ± 2.63 ($p = 0.237$). Preoperatively, average score for hand grip test was 21.3 ± 6.1 Kg in group A and 26.3 ± 11.4 Kg in group B. Postoperatively, it rose to 23.3 ± 6.7 Kg in group A and to 31.6 ± 14.5 Kg in group B ($p = 0.202$). Immediate post-operative radiograph revealed that the distance between the base of 1st MC and scaphoid in group A was 7.2 ± 1.2 mm. At last X-Ray follow-up, the proximal shift was 1.9 mm, with an average distance of 5.3 ± 1.3 mm. Group B: immediate post-operative X-Ray gap was 7.6 ± 1.2 mm. Up to now, this space is reduced to 5.0 ± 1.4 mm, with an average step off of 2,6 mm. No significant differences in the outcome respect to the measured distance was revealed between the two surgical procedures ($p = 0.230$). Surgical time (Tourniquet) was 46 ± 8.83 min in group A and 39.8 ± 6.86 min in group B ($p = 0.03$).

4. Discussion

The findings of this analysis provide evidence that trapeziectomy and tendon suspension arthroplasty with or without tendon interposition for stage III and IV rhizarthrosis are useful to get satisfactory symptomatic and functional outcomes, when conservative therapy does not resolve the painful symptoms.^{17,18} Treatment of TMJ OA remains a controversial issue with many surgical techniques described in literature, including fusion, total trapeziectomy with or without ligament reconstruction, tendon interposition, arthroplasty, replacement.^{4,6,8,19–22} However, it is still uncertain what the gold standard of care might be.^{4,19} Wajon et al. reached the same finding in a 2005 Cochrane review, reporting that no procedure showed clear superiority over others.²³ In the last decades, use of TMC implants has increased in most hand surgeons practice to treat basal joint arthritis. Numerous types of implants for total joint replacement²⁴ or interposition arthroplasty²⁵ have been described and used. Advantages of TMC prostheses are the capacity to relieve rapidly patient's pain restoring full mobility and strength.

Moreover, those implants have proven to be reliable having a survival rate at ten years of 90 %.²⁶ On the other side, this survival rate seems to decrease at 15 years of follow-up²⁷ and some contraindications, such as presence of scapho-trapezio-trapezoid arthritis²⁸ or trapezium bone stock²⁹ among others, to use total joint prostheses for TMC treatment are still discussed. Finally, recent reviews^{30,31} have shown no superiority of total joint replacement over other techniques. For those reasons, authors of this manuscript still believe it is important to study and to have an extended knowledge of different trapeziectomy and associated procedures techniques. This is even more important, as those techniques have been proven efficient as salvage procedures in failed trapeziometacarpal joint replacement.³²

Based on the premise of the possibility of proximal migration of the first metacarpal and instability, we studied two different methods for ligament suspension with or without tendon interposition.

According to Ceruso procedure (Group A), the use of APL allows the surgical intervention to be carried out using a single radial approach, through which the trapeziectomy, as well as the tendon band and the suspension arthroplasty are performed. It also allows the autologous tissue to be interposed between the skeletal elements (double passage of the APL on the FCR), constituting a biological interosseus spacer between 1st metacarpus and scaphoid.

According to our experience, the Altissimi procedure, derived directly from the Burton-Pellegrini studies, facilitates the operation, making it faster and less invasive. The abolition of the tendon interposition in the space left empty by the trapezius allows the use of just a 3–4 cm FCR strip which is prepared within the same surgical approach without additional incisions and without moving the APL tendon. This tendon sparing is particularly interesting to underline, according to the Brunelli's theory, who in an anatomical study on 100 hands demonstrated that in 28 % of the general population the APL tendon has no insertion on the trapezius.³³ The absence of this musculotendinous unit means that the APL tendons act only on the basis of the first MC, creating a point of extremely harmful tangential forces in the TMJ.³⁴ Brunelli found signs of RA in all cases with failed APL insertion on the trapezius, and only in 3 % of all other cases. Finally, the use of a mini-anchor to fix this tendon strip on the base of the 1st metacarpal bone without the need to drill a hole in the metacarpal bone makes the procedure quicker, keeping unchanged the stabilization and suspension effect of the 1st MC.

Nonetheless, patients with tendon interposition (group A) had greater preservation of the height of the trapezial space; elsewhere no correlation was found between trapezial space ratio and outcomes. At the last follow-up, any radiograph showed evidence of adjacent joint disease. Despite those good and satisfactory results, patients of group B seemed to be generally more satisfied with significantly better subjective (DASH) and objective (ROM) outcomes, with a reduced surgery time (7 min less on average).

In a similar study, comparing different techniques, Morais et al.³⁵ also found that suspension arthroplasty seemed superior to tendon interposition in terms of trapezial space ratio, surgical time, immobilization time, return to normal activity and physical therapy required.

A limitation of the study is that only reports mid-term outcome, and longer term investigations are necessary. Even the modest number of patients population could appear limiting, however this seems to be in line with or even larger than the other cohorts cited in the literature.

To our knowledge this is the first prospective randomized controlled trial comparing the outcomes of interposition tendon arthroplasty versus suspension tenoplasty.

5. Conclusion

Trapeziectomy and tenoplasty in suspension appear to be a valid option in the treatment of advanced thumb carpometacarpal arthritis. Avoiding the tendon interposition is a safe operation that uses only the flexor carpi radialis, without involving or injuring the abductor pollicis longus. Altissimi procedure seems to offer better functional and

symptomatic results with reduced surgical times.

Conflict of interest

The authors declare that they have no competing interests.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Use of AI tool

No AI tool has been used.

Ethical statement

The study was approved by the Internal Review Board of University of L'Aquila, Italy (authorization number 9/2018).

FUNDING statement

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

The research was approved by the scientific committee of Young European Hand Surgeons (YEHS) without any financial support.

Guardian/patient's consent

Patients were treated according to the ethical standards of the Helsinki Declaration, and were invited to read, understand, and sign the informed consent form for the publication of data for scientific purposes.

CRedit authorship contribution statement

Andrea Fidanza: conception, data collection, first draft of manuscript, surgeries, editing, and revision. **Giuseppe Rovere:** conception, data collection, blinded investigation. **Olivo Colafarina:** surgeries, editing, and revision, supervision, All authors have read and agreed to the published version of the manuscript. This manuscript is the result of a collaborative effort. **Fabrizio Chiarolanza:** conception, data collection, blinded investigation. **Camillo Fulchignoni:** conception, data collection, blinded investigation. **Francesco Liuzza:** revision, supervision, All authors have read and agreed to the published version of the manuscript. This manuscript is the result of a collaborative effort. **Paquale Farsetti:** revision, supervision, All authors have read and agreed to the published version of the manuscript. This manuscript is the result of a collaborative effort. **Giandomenico Logroscino:** revision, supervision, All authors have read and agreed to the published version of the manuscript. This manuscript is the result of a collaborative effort.

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