Hand Surgery and Rehabilitation 41 (2022) 59–64

Available online at ScienceDirect www.sciencedirect.com

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

Original article

Trapeziectomy with suture-button suspensionplasty versus ligament reconstruction and tendon interposition: a randomized controlled trial

Trapézectomie avec suspension à l'aide d'un bouton de suture vs reconstruction ligamentaire et interposition tendineuse: une étude contrôlée randomisée

Bruno Morais *, Tiago Botelho, Nuno Marques, João Nóbrega, Ana Ferrão, João Jorge, Frederico Teixeira

Department of Orthopedics Central Lisbon University Center, 8 Beneficiência Street, 1069-166 Lisbon, Portugal

ARTICLE INFO

Article history:
Received 28 June 2021
Received in revised form 21 September 2021
Accepted 2 October 2021
Available online 30 October 2021

Keywords:
Hand surgery
Basal thumb joint arthritis
Trapeziectomy

ABSTRACT

The purpose of the present study was to compare the results of patients operated with trapeziectomy and ligament reconstruction and tendon interposition (LRTI) using flexor carpi radialis tendon versus trapeziectomy followed by suspension of the first metacarpal to the second metacarpal using a Mini TightRope® suture button (suture button suspension: SBS). A single-center prospective randomized controlled trial was performed, comparing 37 patients with SBS and 39 with LRTI. All surgeries were performed by the same fellowship-trained hand surgeon. Patients were assessed by an independent observer at 40 months' follow-up. Pre- and postoperative strength, trapezial space ratio (TSR), range of motion, QuickDASH and visual analogue pain score were recorded. Both procedures improved functional parameters of pain, key strength, tip strength and grip strength while maintaining range of motion, without significant differences. In the SBS group, TSR decreased by 17%, compared to 28% in the LRTI group. The mean operative time was shorter in SBS (63 vs 91 minutes; $p < 0.0001$), as was immobilization time (2 vs 6 weeks; $p < 0.0001$), and patients resumed normal activity sooner (10 vs 12 week; $p = 0.0138$) and required less physical therapy (19.3 vs 13.1 weeks; $p < 0.0001$). We believe that our results are related to the hypothesis suggested by biomechanical studies that revealed better initial load bearing profile and maintenance of trapezial space following serial loading in cadaver models.

Mots-clés:
Chirurgie de la main
Rhizarthrose du pouce
Trapézectomie

RÉSUMÉ

Le but de cette étude était de comparer les résultats obtenus chez des patients opérés d'une trapézectomie avec une ligamentoplastie et interposition tendineuse par le tendon fléchisseur radial du carpe (LRTI) et d'une trapézectomie suivie d'une suspension du premier métacarpien au deuxième métacarpien à l'aide d'un bouton de suture Mini TightRope® (SBS). Un essai contrôlé randomisé prospectif monocentrique a été réalisé. Dans un groupe de 37 patients, une SBS a été réalisée et dans l'autre de 39 patients une LRTI. Toutes les opérations ont été réalisées avec la participation du même chirurgien de la main boursier. L'évaluation des patients a été faite par un observateur indépendant avec un suivi moyen de 40 mois. La force préopératoire et postopératoire, le rapport d'espace trapézien (TSR), l'amplitude des mouvements, le score QuickDASH et la douleur cotée sur une échelle visuelle analogique ont été enregistrés. Les deux techniques ont apporté une amélioration des paramètres fonctionnels, notamment la douleur, la force de pince termino-latérale et pulpo-pulpaire et la force de poigne tout en maintenant l'amplitude des mouvements, sans différence entre eux. Le groupe SBS avait une diminution de la TSR de 17 % contre 28 % dans le groupe LRTI. Le temps opératoire moyen était plus court dans le groupe SBS : 63 vs 91 minutes ($p < 0,0001$) ainsi que le temps d'immobilisation : 2 vs 6 semaines ($p < 0,0001$). Les patients avaient également repris une activité normale plus tôt : 10 vs 12 semaines

* Corresponding author.
E-mail address: brunosaraivademorais@gmail.com (B. Morais).

https://doi.org/10.1016/j.hansur.2021.10.315
2468-1229/

(p = 0,0138) et avaient nécessité moins de kinésithérapie : 19,3 vs 13,1 semaines (p < 0,0001). Nous pensons que nos résultats sont liés à l'hypothèse suggérée par des études biomécaniques qui ont révélé un profil de charge initiale supérieur et un maintien de l'espace trapézien après chargement en série sur des modèles cadavériques.

1. Introduction

The trapeziometacarpal (TMC) joint is one of the most common locations for primary degenerative osteoarthritis in the hand. It is frequently symptomatic in middle-aged women and in patients older than 75 years [1]. Armstrong et al. found a prevalence of 25% in a group of 25 post-menopausal women [2]. Although non-surgical interventions such as lifestyle modification, hand therapy and medication are the initial treatment [3–6] and must be tried, surgery is necessary in many cases.

Several surgical procedures have been described: metacarpal extension osteotomy [7], carpometacarpal joint denervation [8], arthroscopy [9], arthrodesis [10], prosthetic joint replacement [11], trapeziectomy alone [12], hematoma distraction arthroplasty [13], trapeziectomy and ligament reconstruction with or without tendon interposition [14,15], abductor pollicis longus suspensionplasty [16], suture-button suspensionplasty [17], and others, with no consensual gold standard [18–20].

Trapeziectomy is the root treatment in current thumb basilar arthritis surgery. It provides adequate pain relief with few complications, making it a suitable option for older patients. In younger patients, however, good range of motion associated with strength and precision is required for fine and gross motor function, which this technique does not currently achieve [11,12,21]. Jager, nevertheless, claimed that total trapeziectomy is currently the only surgical technique for thumb basal joint arthritis that provides a potential life-long solution [22].

In 1986, ligament reconstruction and tendon interposition (LRTI) arthroplasty was described by Burton and Pellegrini, using the flexor carpi radialis (FCR) tendon. LRTI using the FCR and abductor pollicis longus (APL) tendons rapidly became the most widely performed techniques for thumb basilar arthritis. Despite the many methods available, none have demonstrated superiority [20,23]. Prospective randomized clinical trials have been conducted and failed to prove the superiority of LRTI vs trapeziectomy alone, yet only a minority of hand surgeons prefer trapeziectomy alone [19].

Suture-button suspensionplasty (SBS) with trapeziectomy has been employed to prevent subsidence and potentially to improve functional outcome, with a minimally invasive approach with earlier rehabilitation and return to function [17,24–26]. Yao and Cheah, in a review of 16 thumbs that were followed for a mean 5 years after arthroscopic hemi- or full trapeziectomy and suture suspensionplasty, reported clinical and radiological improvement. The authors noted that patients could continue to show improved strength over this 5-year time frame [27]. Dréant showed that the advantage of this new device, which suspends the first metacarpal to the second metacarpal, is the very short immobilization period, in contrast to other suspensionplasty procedures [28]. An additional concern is inadvertent overtightening of the thumb metacarpal to the index finger or trapezoid, causing impingement pain. To mitigate impingement, Endress and Kakar described the technique of double-suture suspensionplasty in a case series of 12 thumbs. At a mean 17 months, the authors reported pain relief, improvement in grip and pinch strength, and conserved range of motion of the thumb metacarpophalangeal and interphalangeal joints. Trapezial space height was maintained and there was no evidence of metacarpal impingement or fracture surrounding the implants [36].

Some studies compared trapeziectomy alone to trapeziectomy associated to suspensionplasty using the APL. Barthel et al. reviewed 35 patients at a minimum 6 years' follow-up and found no statistically significant difference in Quick DASH score and no significant differences in terms of improvement in pain, thumb opposition and key pinch [29]. Rhee et al. reviewed 57 hands and compared LRTI and modified Weilby suspensionplasty with the APL; they showed that, in patients under 57 years of age, this procedure can result in considerable improvement in pain and grip strength, with a 10-year revision-free survivorship [30].

No prospective, randomized clinical trials proving superiority of SBS over trapeziectomy alone were found. Moahn et al. compared functional outcomes retrospectively between suture-button suspensionplasty and trapeziectomy alone. Substantial improvements were found with both techniques; however, there was no significant difference in postoperative scores between the two [31]. Although SBS has gained popularity, there is a lack of evidence and of comparative studies advocating either LRTI or SBS. Only comparative biomechanical studies in cadaver models were found [5,6,32,33].

The purpose of the present study was to compare results between trapeziectomy and LRTI using FCR tendon versus trapeziectomy followed by suspension of the first metacarpal to the second metacarpal using a single strand of non-absorbable suture with the Mini TightRope® suture button.

2. Patients and methods

2.1. Study design

This study was conducted with Institutional Review Board and Ethics Committee approval (2015-A123). A single-center prospective randomized controlled trial was performed. Following informed consent, the patients with TMC arthritis were randomized into two groups and underwent surgery between 2015 and 2019. One of two procedures was randomly assigned computationally. All surgeries were performed by the same fellowship-trained hand surgeon as main surgeon (FT). Patients underwent either trapeziectomy with suture-button suspensionplasty (SBS) or LRTI using FCR tendon. Inclusion criteria comprise having undergone primary procedures, follow-up >2 years, and patient's consent. Exclusion criteria comprised having undergone associated procedures or follow-up impossible.

2.2. Data collection

Patient's clinical evaluation, medical charts and radiographs were assessed by an independent observer (JJ). Data concerning demographic and operative characteristics as well as functional and radiographic outcomes were recorded. Pre- and post-operative grip, key pinch, and tip pinch strength were obtained using a hydraulic hand dynamometer (Jamar®, JLW Instruments, Cambridge, MA, USA). Metacarpophalangeal and interphalangeal pre- and post-operative range of motion was recorded. Patients were asked to complete the Quick Disabilities of the Arm, Shoulder and

Hand (QuickDASH) questionnaire at first and last follow-up. Patients also classified and quantified their pain relief upon admission and discharge on a Visual Analogue Pain Scale (VAS).

Metacarpal subsidence was obtained indirectly by calculating the Trapezial Space Ratio (TSR) as described by Kadiyala et al. [34]; 0% postsurgical TSR indicates 0% subsidence. As in other studies, trapezial space height (TSH) was measured on a lateral radiograph of the thumb, drawing three lines: one connecting the corners of the base of the first metacarpal, a second joining the two corners of the scaphoid, and a third along the metacarpal central axis, bisecting the other two; TSH was measured as the length along the third line that lies between the lines at the metacarpal base and distal scaphoid. The Picture Archiving and Communication System software was used for the measurement (SECTRA™, Linköping, Sweden). The severity of the patient's disease was classified according to the Eaton classification [35].

2.3. Data processing

A power analysis was performed to determine whether the samples were sufficient to detect a clinically meaningful correlation. The data were analyzed using the Statistical Package for the Social Sciences 22.0 for MAC® (SPSS Inc, Chicago, IL, USA). Shapiro-Wilk test was used as a normality test.

A descriptive statistical analysis of the results was performed including frequency, percentage, mean and standard deviation. The chi-square test was used for analysis of non-parametric data; independent samples t test and Mann-Whitney U test were used for the analysis of parametric data. A 95% confidence interval (CI) was used; a p-value of <0.05 was considered statistically significant.

2.4. Trapeziectomy with suture-button suspensionplasty

The operation was performed under peripheral or general anesthesia, using an above-elbow tourniquet. For the trapeziectomy, a 3-4 cm dorsoradial skin incision was used over the TMC joint. Capsulotomy was performed just volar to the APL insertion on the first metacarpal, with care to avoid damaging the superficial branch of the radial nerve. Next, the trapeziectomy was performed with the aid of an osteotome and rongeur forceps. A second (2 cm) incision was made dorsally between the second and third metacarpal bases to prepare the exit point of the guidewire in the index metacarpal. To do so, the dorsal interosseous muscle was elevated subperiosteally from the ulnar aspect of the second metacarpal to expose its base. With the hand in neutral position, a 1.1 mm tapered suture-passing wire was drilled from the base of the first metacarpal, just beneath a portion of the radial aspect of the APL tendon, to the second metacarpal metadiaphyseal junction, at a 40 ° angle trajectory. Then, the n° 2 non-absorbable FiberWire suture of the Mini TightRope was passed through the loop in the guidewire from radial to ulnar, leaving the button in the first metacarpal base. A second button was passed down to the index metacarpal cortex. The thumb was then reduced to its anatomical position by axial traction, extension and palmar abduction, and the suture was tied in the second webspace. To have the correct tensioning, we interposed a 1-mm-thick clamp between the button and the base of the first metacarpal before tightening the knot. This allowed approximately 10% to 20% subsidence and avoided potential complications of decreased ROM and pain from impingement of the thumb and second metacarpal bases if the SBS was tied too tightly.

The wounds were closed with an absorbable suture and a Robert Jones bandage was kept in place for 2 weeks. During the first follow-up visit, at 2 weeks postoperatively, the immobilization was removed, and the patients were referred to physical therapy. Strength activities were restricted to 50% of grip power until week 6.

2.5. Ligament reconstruction and tendon interposition

The operation was performed under peripheral or general anesthesia, using an above-elbow tourniquet. This technique was a modification the Burton-Pellegrini technique [35]. For the trapeziectomy, we used a 3-4-cm dorsoradial skin incision over the TMC joint. Capsulotomy was performed just volar to the APL insertion on the first metacarpal, with care to avoid damaging the superficial branch of the radial nerve. Next, trapeziectomy was performed with the aid of an osteotome and rongeur forceps. A bone tunnel was drilled through the base of the first metacarpal. The FCR tendon was transected proximally, delivered into the trapeziectomy defect, and split. Half of the FCR tendon was then passed through the drill hole in the first metacarpal. The 2 halves of the FCR tendon were then tied to each other to suspend the first metacarpal base and sutured together. The rest of the tendon halves were tied together to create an anchovy which was placed in the trapeziectomy void. The wounds were closed with an absorbable suture and a cast was kept in place for 6 weeks; physical therapy could begin immediately.

3. Results

3.1. Demographic characteristics

A total of 95 patients and 95 hands were operated during the study period. Nineteen patients who did not meet the inclusion criteria were excluded: 5 were lost during follow up, associated procedures were performed in 7, 4 underwent revision surgeries and 3 refused to participate in the study. Mean follow-up in the LRTI and SBS groups was 40.5 (SD = 14.8) vs 37.3 (SD = 12.6) months respectively ($p = 0.3128$).

The LRTI technique was used on 39 patients and the SBS technique on 37. In both groups, patients were predominantly of female gender and in their 60 s. The right hand was most often the dominant and involved hand. More than 40% of patients in both groups had comorbidities and the majority had stage III Eaton and Littler disease (Table 1).

3.2. Operative characteristics

Mean operative time was shorter in SBS group: 63 (SD = 13.2) vs 91 (SD = 15.6) minutes ($p < 0.0001$), as was immobilization time: 2 (SD = 0.2) vs 6 (SD = 0.6) weeks ($p < 0.0001$). Patients operated with the SBS technique also resumed their normal activity sooner than with LRTI: 10 (SD = 3.2) vs 12 (SD = 3.7) weeks ($p = 0.0138$) and required less physical therapy: 19.3 (SD = 4.5) vs 13.1 (SD = 2.5) weeks ($p < 0.0001$) (Table 2).

3.3. Functional results

No differences between techniques were found regarding preoperative pain, strength, range of motion or DASH score. Both techniques were effective for pain relief. In the LRTI group, 92.3% of patients reported pain relief, with a mean 1.3 (SD = 1.2) points on VAS at discharge. The results were similar in the SBS group, with 94.6% of patients reporting pain relief ($p = 0.6877$), with a mean 1.5 (SD = 1.4) points on VAS ($p = 0.9658$).

In terms of strength, the results of Grip, Tip and Key tests were similar in the LRTI and SBS groups, with values of 19.5 (SD = 3.1) vs 20 (SD = 3.4); 3.4 (SD = 0.9) vs 3.6 (SD = 0.3) and 4.4 (SD = 0.8) vs

Table 1
Demographic characteristics.

	LRTI	SBS	p
Patients	39	37	
Mean age (years)	61.1 (7.4) *	61.8 (7.8) *	0.6896
% Male	5.2% (2)	10.8% (4)	0.3585
% Right hand dominant	92.3% (36)	91.9% (34)	0.9464
% Right hand involved	53.8% (21)	56.8% (21)	0.7987
BMI	31.4 (4.2)	32.1 (5.6)	0.5414
Comorbidities	46% (18)	42% (15)	0.6957
Diabetes	12.8% (5)	8.2% (3)	0.5034
Coronary artery disease	7.7% (3)	5.4% (2)	0.6877
Obesity	15.4 (6)	13.5% (5)	0.8167
Chronic renal failure	5.1% (2)	5.4% (2)	0.9569
Rheumatoid arthritis	10.3% (4)	16.2% (6)	0.4423
COPD	2.6% (1)	2.7% (1)	9.970
Smoking	7.7% (3)	5.4% (2)	0.6877
Eaton and Littler			
Stage I	0%	0%	NA
Stage II	7.7% (3)	10.8% (4)	0.6384
Stage III	69.2% (27)	59.5% (22)	0.3737
Stage IV	23.1% (9)	29.7% (11)	0.5103

LRTI: trapeziectomy with ligament reconstruction and tendon interposition; *SBS*: trapeziectomy with suture-button suspensionplasty; *BMI*: body mass index; *COPD*: chronic obstructive pulmonary disease.
* Standard deviation.

Table 2
Operative characteristics.

	LRTI	SBS	p
Patients	39	37	
Operative time (minutes)	91 (15.6) *	63 (13.2) *	<0.0001
Immobilization time (weeks)	6 (0.6) *	2 (0.2) *	<0.0001
Time to return to usual activities (weeks)	12 (3.7) *	10 (3.2) *	0.0138
Physical therapy	19.3 (4.5) *	13.1 (2.5) *	<0.0001
Follow-up	40.5 (14.8) *	37.3 (12.6) *	0.3128
Complications rate	8% (3)	11% (4)	0.3585
Surgical site infection	3% (1)	0	
Complex regional pain syndrome	3% (1)	5% (2)	
Symptomatic subsidence	3% (1)	0	
Metacarpal fracture	0	3% (1)	
Device intolerance	0	3% (1)	
Reoperation rate	5.1% (2)	2.7% (1)	0.5873

LRTI: trapeziectomy with ligament reconstruction and tendon interposition; *SBS*: trapeziectomy with suture-button suspensionplasty.
* Standard deviation.

4.3 (SD = 0.6) kg, with no significant difference: p = 0,.5058, 0.196 and 0.5382 respectively.

Range of motion was measured in the LRTI and SBS groups: at discharge, metacarpophalangeal extension was 6.2 (SD = 3.8) vs 7.4 (SD = 2.3) (p = 0.0988) and flexion, 51.4 (SD = 8.3) vs 52.5 (SD = 7.6) (p = 0.5484); interphalangeal extension was 7.3 (SD = 4.3) vs 7.5 (SD = 3.8) (p = 0.8302), and flexion, 62.6 (SD = 5.8) vs 64.1 (SD = 6.0) (p = 0.2718) degrees.

QuickDASH at discharge showed a mean 30.1 (SD = 17.8) points in the LRTI group and 31.6 (SD = 20;3) points in the SBS group, with no significant difference (p = 0.7336) (Table 3).

3.4. Radiographic results

The LRTI group showed preoperative mean TSR of 0.364 (SD = 0.012) and the SBS group a mean 0.368 (SD = 0.011), with no significant difference (p = 0.1506). The postoperative values were 0.262 (SD = 0.08) in the LRTI group and significantly better in the SBS group: 0.304 (SD = 0.06) (p = 0.012). Decrease was 28% in the LRTI group and 17% in the SBS group Table 4).

Table 3
Functional results.

	LRTI	SBS	p
Patients	39	37	
Pain			
Pain relief	92.3% (36)	94.6% (35)	0.6877
VAS preop	4.8 (2.3) *	4.3 (3.1) *	0.4294
VAS postop	1.4 (1.2) *	1.5 (1.4) *	0.9658
Strength			
Grip test preop	18.1 (2.6) *	16.8 (4.3) *	0.1184
Grip test postop	19.5 (3.1) *	20 (3.4) *	0.5058
Tip test preop	2.8 (1.2) *	2.3 (1.6) *	0.1296
Tip test postop	3.4 (0.9) *	3.6 (0.3) *	0.196
Key test preop	3.8 (1.4) *	3.1 (1.7) *	0.0548
Key test postop	4.4 (0.8) *	4.3 (0.6) *	0.5382
Range of motion			
MCP extension preop	6.8 (3.1) *	7.5 (3.3) *	0.3442
MCP extension postop	6.2 (3.8) *	7.4 (2.3) *	0.0988
MCP flexion preop	53.5 (6.4) *	53.8 (7.3) *	0.8498
MCP flexion postop	51.4 (8.3) *	52.5 (7.6) *	0.5484
IP extension preop	7.2 (3.8) *	7.4 (3.5) *	0.7212
IP extension postop	7.3 (4.3) *	7.5 (3.8) *	0.8302
IP flexion preop	59.8 (4.1) *	61.5 (6.1) *	1.1612
IP flexion postop	62.6 (5.8) *	64.1 (6.0) *	0.2718
DASH preop	59.8 (21.3) *	62.1 (26.4) *	0.6782
DASH postop	30.1 (17.8) *	31.6 (20.3) *	0.7336

LRTI: trapeziectomy with ligament reconstruction and tendon interposition; *SBS*: trapeziectomy with suture-button suspensionplasty; *VAS*: visual analogue scale: *MCP*: metacarpophalangeal; *IP*: interphalangeal; *preop*: preoperative; *postop*; postoperative; *DASH*: Disabilities of the Arm, Shoulder and Hand score.
* Standard deviation.

3.5. Complications

A total of 9% patients (n = 7) had postoperative complications, 4% (3) of which required new surgery: 3 (8%) in the LRTI group and 4 (11%) in the SBS group (p = 0.3585). Two patients (5.1%) in the LRTI group and 1 (2.7%) in the SBS group (p = 0.5873) required new surgery (Table 2).

In the LRTI group, a 42-year-old woman developed a complex regional pain syndrome from which she partially recovered with medication and 6 months of intense physiotherapy; a 63-year-old woman, diabetic, developed a surgical site infection that required debridement and prolonged wound healing; finally, a 59-year-old female manual laborer developed symptomatic subsidence and was reoperated on with an SBS technique.

In the SBS group two 51- and 58-year-old women had a complex regional pain syndrome that required 3- and 4-months' physiotherapy respectively, resulting in partial resolution. A 57-year-old woman sustained a second metacarpal fracture that was treated conservatively, with good clinical and radiological results. A 45-year-old woman developed device intolerance for the first

Table 4
Radiographic results.

	LRTI	SBS	p
Patients	39	37	
TSR preop	0.364 (0.012) *	0.368 (0.011) *	0.1506
TSR postop	0.262 (0.08) *	0.304 (0.06) *	0.012
TSR decrease	28%	17%	

LRTI: trapeziectomy with ligament reconstruction and tendon interposition; *SBS*: trapeziectomy with suture-button suspensionplasty; *TSR*: trapezial space ratio.
* Standard deviation.

metacarpal button, which required surgical removal 6 months postoperatively, with complete resolution of complaints.

4. Discussion

The aim of the present study was to compare functional and radiographic outcomes and complications following LRTI and SBS. Although LRTI is one of the most common procedures for basilar thumb arthritis and SBS is gaining popularity, there is no reliable literature supporting one over the other [36].

We performed the first study comparing the two techniques, performed by the same surgeon with a similar 40-month follow-up and no confounding factors such as associated procedures or lack of good clinical data. We studied two groups similar in terms of demographic characteristics, comorbidities and disease stages.

The management of trapeziometacarpal arthritis has progressed from trapeziectomy alone described by Gervis in 1949 in an attempt to relieve pain, optimize thumb stability and improve physical functioning [12]. LRTI arthroplasty, described by Burton and Pellegrini, emerged as a favored technique to achieve these goals [14]. As described in the literature [37] we share concerns related to the complications reported with traditional tendon transfer-based ligament reconstruction techniques: tenosynovitis, paresthesia, scar-related issues, infection and reoperation.

Yao et al. advocated that the joint between the thumb metacarpal and the trapezium must be removed, either by arthrodesis or by removing some or all of the trapezium [27]. Beyond that, ligament reconstruction and interposition are not necessary for an excellent outcome when treating thumb CMC joint OA [27]. Based on these good medium-term results with SBS, the procedure has been gaining popularity [27]. We believe, however, that their series was short and heterogeneous, including both full and partial trapeziectomy, and had other limitations concerning clinical measurements and associated procedures.

Although there is no evidence supporting the superiority of either LRTI or SBS over trapeziectomy alone, we believe that it is important to reestablish the normal biomechanics of the thumb and, in agreement with most hand surgeons, trapeziectomy alone must be reserved for low-demand patients [18].

In the present study, patients with TMC arthritis were randomized into two groups. In one group of 37 patients trapeziectomy with SBS was performed and in the other, of 39 patients, LRTI using FCR tendon, with medium-term follow-up of 37.3 (SD = 12.6) and 40.5 (SD = 14.8) months, respectively. Both procedures demonstrated improvement in functional parameters including pain, key strength, tip strength and grip strength while maintaining range of motion. Mean postoperative TSR values were better in the SBS group, with a decrease rate of 17% vs 28% in the LRTI group. This may be related to first dorsal interosseous muscle atrophy due to prolonged immobilization and FCR harvesting. No significant difference was found between groups on the functional parameters analyzed.

A great concern in the community is the increase in cost by choosing SBS over LRTI. We believe that this matter is outweighed by the reduction in operative time (91 vs 63 minutes, $p < 0.0001$). Other results that are critical in terms of costs comprise shorter immobilization (6 vs 2 weeks, $p < 0.0001$), with faster return to normal activity (12 vs 10 weeks, $p = 0.0138$) and reduced physical therapy requirements 19.3 (SD = 4.5) vs 13.1 (SD = 2.5) weeks, especially in a context of later retirement. Taking in to consideration that implant prices range between 250 and 495 US dollars [24,31] and that physical/occupational therapy after thumb CMC procedures costs around 85 to 95 US dollars per patient per session [38], we believe that the early rehabilitation provided by the SBS device accelerates recovery compared with the techniques that involve immobilization, requiring fewer sessions to achieve full recovery, and is therefore more cost-effective.

Regarding complications, incidence was similar to that reported in the literature [1,25,37], with no difference reported between techniques overall. Complex regional pain syndrome is a well-documented complication and was one of the most prevalent complications, present in both groups [1,20].

The SBS group included 2 patients with specific complications already described in the literature [24,27,39]: metacarpal fracture and device intolerance. The case of index metacarpal fracture was attributed to the surgeon's learning curve. It may have resulted from an increased angle of fixation or overtensioning of the wire, which may restrict the natural motion of the thumb metacarpal, exerting increased force on the second metacarpal [40]. The case of implant intolerance was also attributed to being one of the first cases, where the suture button was not placed beneath a portion of the radial aspect of the abductor pollicis brevis belly.

We found no cases in our series of impingement between the first metacarpal and the scaphoid. We propose SBS as a revision surgery for failed trapeziectomy in case of impingement. According to Yao [27], if the metacarpal does not subside to the level of the scaphoid and there is no concomitant z-deformity of the thumb, a good outcome can be expected regarding maintenance of pinch and grip strength and thumb ROM. Also, by maintaining space, bone-on-bone pain eliminated.

5. Conclusion

This study demonstrated that, in groups with comparable demographic and disease characteristics, the LRTI and SBS techniques provided similar functional results at end of follow-up. The SBS technique was faster to perform and required less immobilization and physical therapy time. Patients in the SBS group were able to return sooner to their usual activities and showed less decrease in Trapezial Space Ratio at end of follow-up. We believe that these results are explained by the hypothesis suggested by biomechanical studies that revealed a greater initial load-bearing profile and maintenance of trapezial space following serial loading in cadaver models, and by first dorsal interosseous muscle atrophy due to prolonged immobilization and FCR harvesting [33,40].

Although the number of complications was similar between groups, we believe that, without the cases due to inexperience in the SBS group, there would have been more complications due to the aggressiveness of FCR harvesting and longer immobilization in the LRTI group.

Patient progression over the coming years is of great interest, with the question as to whether the differences found here will persist as differences in functional outcome. Further prospective randomized controlled studies with longer follow-up are recommended to confirm the present findings and to reveal other differences between these two techniques.

Human and animal rights

The authors declare that the work described has been carried out in accordance with the Declaration of Helsinki of the World Medical Association revised in 2013 for experiments involving humans as well as in accordance with the EU Directive 2010/63/EU for animal experiments.

Informed consent and patient details

The authors declare that this report does not contain any personal information that could lead to the identification of the patient(s) and/or volunteers.

Disclosure of interest

The authors declare that they have no known competing financial or personal relationships that could be viewed as influencing the work reported in this paper.

Funding

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

Author contributions

All authors attest that they meet the current International Committee of Medical Journal Editors (ICMJE) criteria for Authorship.

References

[1] Murray PM. Treatment of the osteoarthritic hand and thumb., In: Wolfe S, Pederson W, Kozin S, Cohen M, editors. 2nd volume, Green's operative hand surgery, 11, 2nd volume Philadelphia: Elsevier; 2016. p. 359–60.
[2] Armstrong AL, Hunter JB, Davis TRC. The prevalence of degenerative arthritis of the base of the thumb in post-menopausal women. J Hand Surg Br 1994;19:340–1.
[3] Lue S, Koppikar S, Shaikh K, Mahendira D, Towheed TE. Systematic review of non-surgical therapies for osteoarthritis of the hand: an update. Osteoarthritis Cartilage 2017;25:1379–89.
[4] Villafañe JH, Cleland JA, Fernández-De-Las-Peñas C. The effectiveness of a manual therapy and exercise protocol in patients with thumb carpometacarpal osteoarthritis: A randomized controlled trial. J Orthop Sports Phys Ther 2013;43(4):204–13.
[5] Hamann N, Heidemann J, Heinrich K, Wu H, Bleuel J, Gonska C, et al. Stabilization effectiveness and functionality of different thumb orthoses in female patients with first carpometacarpal joint osteoarthritis. Clin Biomech (Bristol Avon) 2014;29:1170–6.
[6] Heyworth BE, Lee JH, Kim PD, Lipton CB, Strauch RJ, Rosenwasser MP. Hylan versus corticosteroid versus placebo for treatment of basal joint arthritis: A prospective, randomized, double-blinded clinical trial. J Hand Surg Am 2008;33:40–8.
[7] Tomaino MM. Treatment of Eaton stage I trapeziometacarpal disease with thumb metacarpal extension osteotomy. J Hand Surg Am 2000;25:1100–6.
[8] Arenas-Prat JM. Wagner approach for first carpometacarpal joint denervation. Tech Hand Up Extrem Surg 2012;16:107–9.
[9] Furia JP. Arthroscopic Debridement and synovectomy for treating basal joint arthritis. Arthroscopy 2010;26:34–40.
[10] Rizzo M, Moran SL, Shin AY. Long-term outcomes of trapeziometacarpal arthrodesis in the management of trapeziometacarpal arthritis. J Hand Surg Am 2009;34:20–6.
[11] Swanson AB. Disabling arthritis at the base of the thumb: treatment by resection of the trapezium and flexible (silicone) implant arthroplasty. J Bone Joint Surg Am 1972;54:456–71.
[12] Gervis WH, Wells T. A review of excision of the trapezium for osteoarthritis of the trapezio-metacarpal joint after twenty-five years. J Bone Joint Surg Br 1973;55:56–7.
[13] Gray KV, Meals RA. Hematoma and distraction arthroplasty for thumb basal joint osteoarthritis: Minimum 6.5-year follow-up evaluation. J Hand Surg Am 2007;32:23–9.
[14] Burton RI, Pellegrini Jr VD. Surgical management of basal Joint arthritis of the thumb. Part II. Ligament reconstruction with tendon interposition arthroplast. J Hand Surg Am 1986;11:324–32.
[15] Avisar E, Elvey M, Wasrbrout Z, Aghasi M. Long-term follow-up of trapeziectomy with abductor pollicislongus tendon interposition arthroplasty for osteoarthritis of the thumb carpometacarpal joint. J Orthop 2013;10:59–64.
[16] Soejima O, Hanamura T, Kikuta T, Iida H, Naito M. Suspensionplasty with the abductor pollicis longus tendon for osteoarthritis in the carpometacarpal joint of the thumb. J Hand Surg Am 2006;31:425–8.
[17] Cox CA, Zlotolow DA, Yao J. Suture button suspensionplasty after arthroscopic hemitrapeziectomy for treatment of thumb carpometacarpal arthritis. Arthroscopy 2010.
[18] Wajon A, Vinycomb T, Carr E, Edmunds I, Ada L. Surgery for thumb (trapeziometacarpal joint) osteoarthritis. Cochrane Database Syst Rev 2015;2015(2):CD004631.
[19] Gottschalk MB, Patel NN, Boden AL, Kakar S. Treatment of basilar thumb arthritis: A critical analysis review. JBJS Rev 2018;6:e4.
[20] Baker RHJ, Al-Shukri J, Davis TRC. Evidence-based medicine: Thumb basal joint arthritis. Plast Reconstr Surg 2017;139:256e–66e.
[21] Gangopadhyay S, McKenna H, Burke FD, Davis TRC. Five- to 18-year follow-up for treatment of trapeziometacarpal osteoarthritis: A prospective comparison of excision, tendon interposition, and ligament reconstruction and tendon interposition. J Hand Surg Am 2012;37:411–7.
[22] Jager T. Total trapeziectomy. Hand Surg Rehabil 2021;40S:S71–6.
[23] Avant KR, Nydick JA, White BD, Vaccaro L, Hess AV, Stone JD. Basal joint osteoarthritis of the thumb: comparison of suture button versus abductor pollicis longus suspensionplasty. Hand (N Y) 2015;10:80–4.
[24] Yao J, Song Y. Suture-button suspensionplasty for thumb carpometacarpal arthritis: A minimum 2-year follow-up. J Hand Surg Am 2013;38:1161–5.
[25] Yao J, Lashgari D. Thumb basal joint: Utilizing new technology for the treatment of a common problem. J Hand Ther 2014;27:127–33.
[26] Yao J. Suture-button suspensionplasty for the treatment of thumb carpometacarpal joint arthritis. Hand Clin 2012;28:579–85.
[27] Yao J, Cheah AEJ. Mean 5-year follow-up for suture button suspensionplasty in the treatment of thumb carpometacarpal joint osteoarthritis. J Hand Surg Am 2017;42(7):569.e1–569.e11.
[28] Dréant N. Mini TightRope® suture button indications for thumb basal joint arthritis. Hand Surg Rehabil 2021;40S:S77–82.
[29] Barthel L, Hidalgo Diaz JJ, Vernet P, Gouzou S, Facca S, Igeta Y, et al. Results of the treatment of first carpometacarpal joint osteoarthritis: trapeziectomy alone versus trapeziectomy associated with suspensionplasty. Eur J Orthop Surg Traumatol 2018;28:1555–61.
[30] Rhee PC, Paul A, Carlsen B, Shin AY. Outcomes of Surgical Management for Thumb Basilar Arthritis in Patients 55 Years of Age and Younger. Hand (N Y) 2019;14:641–5.
[31] Mohan A, Shenouda M, Ismail H, Desai A, Jacob J, Sarkhel T. Patient functional outcomes with trapeziectomy alone versus trapeziectomy with TightRope®. J Orthop 2015;12:S161–5.
[32] Hooke AW, Parry JA, Kakar S. Mini Tightrope fixation versus ligament reconstruction - Tendon interposition for maintenance of post-trapeziectomy space height: A biomechanical study. J Hand Surg Am 2016;41(3):399–403.
[33] Desai MJ, Brogan DM, Richard MJ, Mithani SK, Leversedge FJ, Ruch DS. Biomechanical comparison of suture-button suspensionplasty and LRTI for basilar thumb arthritis. Hand (N Y) 2016;11:438–43.
[34] Kadiyala RK, Gelberman RH, Kwon B. Radiographic assessment o f the trapezial space before and after ligament reconstruction and tendon. J Hand Surg Br 1996;21:177–81.
[35] Eaton RG, Littler JW. Ligament reconstruction for the painful thumb carpometacarpal joint. J Bone Joint Surg Am 1973;55:1655–6.
[36] Endress RD, Kakar S. Double tightrope for basilar thumb arthritis. J Hand Surg Am 2014;39:2512–6.
[37] DeGeorge Jr BR, Chawla SS, Elhassan BT, Kakar S. Basilar thumb arthritis: The utility of suture-button suspensionplasty. Hand (N Y) 2019;14:66–72.
[38] Shah RF, Zhang S, Li K, Baker L, Sox-Harris A, Kamal RN. Physical and occupational therapy use and cost after common hand procedures. J Hand Surg Am 2020;45:289–297.e1.
[39] Khalid M, Jones ML. Index metacarpal fracture after tightrope suspension following trapeziectomy: Case report. J Hand Surg Am 2012;37:418–22.
[40] Hozack BA, Fram B, Ilyas AM, Rivlin M, Liss FE, Jones CM. Optimal Position of the suture button suspensionplasty (TightRope) for thumb basal joint arthritis. Hand (N Y) 2020. 1558944720906551.