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ORIGINAL STUDY

Trapeziumectomy and Mini Tightrope stabilization of the first metacarpal for thumb carpometacarpal osteoarthritis : a prospective case series

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Our purpose was to investigate the short-term results of trapeziumectomy and stabilization of the first metacarpal by using the TightRope© device, at a maximum follow-up of 1 year post-op. This is a novel method in treating first carpometacarpal joint osteoarthritis and an alternative to the variety of other methods that have been previously reported. We recruited 21 patients and assessed them at regular intervals, comparing pre-operative and post-operative variables. We recorded all complications during the study period. There was a statistically significant improvement in pain, hand grip and tip pinch power and functional outcome scores. Patients were very satisfied at 12 months after surgery. No significant change in thumb opposition was noted. There was subsidence of the first metacarpal at 1 year after surgery. Despite the existence of a significant number of alternative procedures, we feel that the procedure described in this paper has promising short-term results and is safe.

Keywords : First carpometacarpal joint ; Mini Tightrope ; Trapezium ; Osteoarthritis ; Trapeziumectomy.

INTRODUCTION

First carpometacarpal joint osteoarthritis is one of the commonest causes of radial sided pain in the wrist and hand, with an increased incidence in females compared to males (*1*). Since 1949, when Gervis (*11*) described the excision of the trapezium in order to treat this disorder, several modifications have been introduced (*3*), each conveying different advantages and disadvantages according to relevant studies.

These modifications include the use of synthetic implants in the residual void, the use of an interposed autologous tendon graft or the use of a ligament in order to stabilise the first metacarpal to the second metacarpal. Despite the large variety of methods described in the literature, first metacarpal subsidence has been recorded consistently after surgery and this problem remains unresolved, although Yang et al (*26*) report that it does not seem to affect functional outcome. A newer modification includes the use of a synthetic implant, the TightRope (Arthrex, Naples, FL), which is made from size 2 fibre wire and two stainless steel buttons on either end. The implant is used in order to suspend the first metacarpal off the second metacarpal, by reconstructing the anterior oblique ligament. This implant was approved in the United States by the FDA with the 510(k) process for use in the hand.

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Our study sets out to assess the short-term results of this new modification to the simple trapeziumectomy, by comparing several pre-operative to post-operative variables in our patients. This was a prospective study and the procedures were performed by the same surgeon, who has received adequate training in this technique. The maximum post-operative follow-up was 1 year and we used a series of validated subjective and objective outcome measures in order to assess the operative outcome, while recording all complications.

MATERIALS AND METHODS

This was a prospective study. Patients were recruited pre-operatively in the outpatient clinic after a thorough discussion of the rationale of the study and what that would entail. We excluded revision cases of patients that previously underwent trapeziumectomy and cases that presented with concurrent thumb metacarpophalangeal joint hyperextension, post-traumatic degenerative changes and inflammatory arthropathy.

Patients were assessed once pre-operatively by the surgeons and the hand therapist and at that point they had postero-anterior and lateral radiographs of the thumb (Fig. 1), which included the scapho-trapezial and first carpometacarpal joints. We utilized a combination of subjective and objective measurements that have been validated in previous studies. These included pain on a visual analog scale (VAS), the Eaton-Littler classification of radiographic osteoarthritis (*7*), opposition of the affected thumb as per Kapandji cotation (*13*), the hand grip/ key pinch/ tip pinch strengths through the use of the Jamar dynamometer (Sammons Preston, Rolyon, Bolingbrook, IL) and the B&L pinch gauge (B&L Engineering, Tustin, CA) and the length of the proximal phalanx over distance from distal scaphoid to base of metacarpal on a PA radiograph. We measured this length ratio both in pre-op and post-op radiographs in order to eliminate potential magnification errors between the two radiographs. The distance between the distal scaphoid and the base of the first metacarpal was measured using the method described by Goffin and Saffar (*12*). In terms of patient-reported functional scores, we utilized the Quick DASH score and the Patient Evaluation Measure (PEM) form, both of which are validated scoring systems for disorders of the hand (*5*).

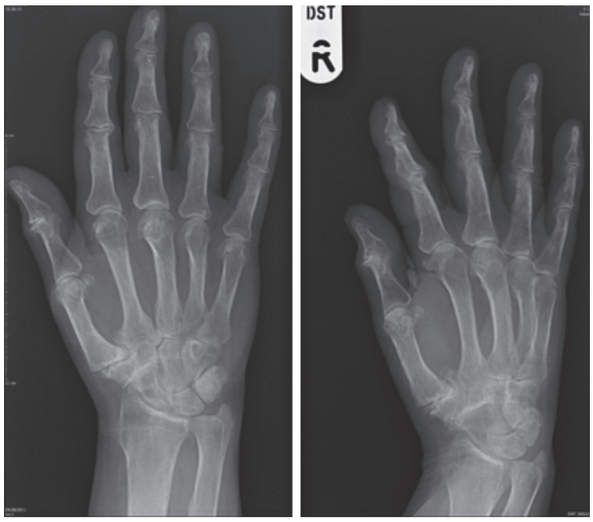

Fig. 1. — Pre-operative radiograph of one of the patients recruited in our study, demonstrating first CMC joint OA, grade 4 as per the Eaton-Littler classification.

Patients went on to have their surgery, which was performed by the senior author who has been formally trained in this procedure and the use of the relevant implant. Procedures were performed under tourniquet and radiographic control and under general anaesthesia in the majority of cases, with infiltration of local anaesthetic at the end of the procedure. The first incision was centered over the affected first carpometacarpal joint and after identification and protection of the superficial radial nerve and radial artery a capsulotomy was performed, respecting the capsular flaps which were later used during repair and closure. The trapezium was removed with piecemeal excision while protecting the scaphoid and the tendon of flexor carpi radialis (FCR). A second longitudinal incision was placed dorsally, over the base of the second metacarpal. Blunt dissection was performed down to the bone and under fluoroscopic control a 1.1 mm guide wire was inserted from the metaphyseal-diaphyseal junction of the second metacarpal to the base of the first metacarpal with the thumb in a position such that the shaft of the first metacarpal was in line with the axis of the scaphoid and level to the base of the second metacarpal. After ensuring that the guide wire

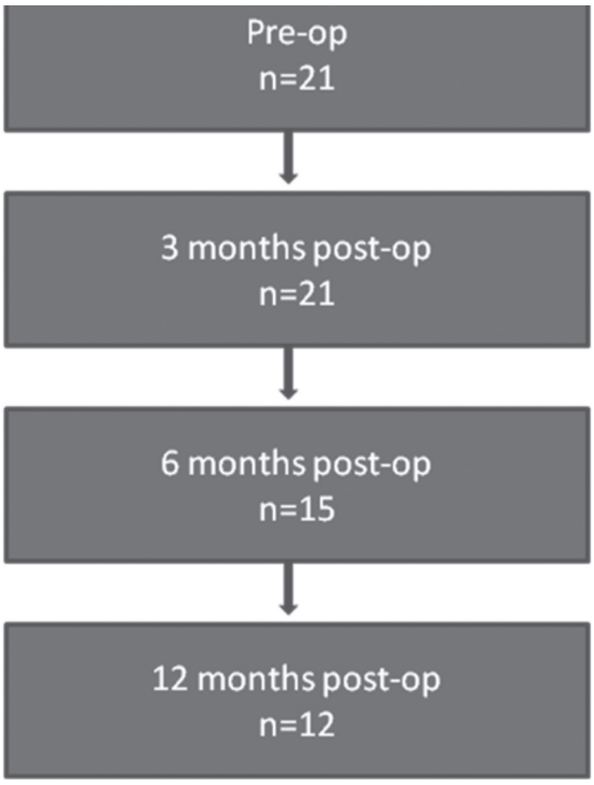

Fig. 2. — Follow-up at 3, 6 and 12 months in our study.

is in a satisfactory position, the two bones were drilled with a 2.7 mm cannulated drill bit and the Tight Rope was deployed from the second toward the first metacarpal with the aid of a cannulated suture passer. The implant was tensioned under fluoroscopy after checking that the thumb retained a full range of movement, carefully avoiding over-tensioning which could be problematic, by introducing the tip of a MacDonald tissue dissector in the joint between the index and thumb metacarpals. A fluoroscopy-assisted ballottement test ensured that tensioning was appropriate. Repair included suturing of the capsule with 4-0 absorbable suture and subcuticular suturing of the skin after local anaesthetic infiltration. Patients were then placed in a thumb spica cast and were given slings in order to maintain elevation for the first 48 hours. They were all seen by our hand therapist 48 hours after surgery in order to ensure that they are mobilizing all other digits. Sutures were removed at ten days at which point the patients had the thumb spica removed and a removable thermoplastic splint applied. They were advised to refrain from lifting heavy loads for at least 10 weeks.

At two weeks after surgery, patients were questioned regarding satisfaction from surgery and their pain score was noted. Following this, patients were seen at 6 weeks, 3 months, 6 months and 12 months after surgery and at each of these points, the data collected were the same as data collected pre-operatively with an addition of satisfaction from the operation and any complications that were diagnosed post-operatively. We reviewed 21 patients at 3 months post-op, 15 patients at 6 months and 12 patients at the one year follow-up review. (Fig. 2). Patients also underwent repeat PA and lateral thumb radiographs at 12 months. (Fig. 3). The ratio of the length of the proximal phalanx of the thumb over the distance between the scaphoid and first metacarpal was measured at 12 months.

Data were analysed with the Wilcoxon signed rank test and the paired t-test, depending on whether the variables were parametric or non-parametric. A significance level of $p < 0.05$ was accepted as defining statistical significance.

RESULTS

There were 6 male and 15 female patients. Eight operations involved the right hand and 13 operations involved the left hand. The mean age at surgery was 65.7 years and the average Eaton-Littler grade of osteoarthritis was 3.

Median satisfaction from as early as two weeks after surgery was 2 out of 3 (‘better than before’) and 3 out of 3 (‘would do it again with no hesitation’) at 12 months after surgery.

Median VAS pain score pre-operatively was 7 and at twelve months it came down to 0. Pain was significantly reduced at three, six and twelve months after surgery when compared to the pre-operative status ($p<0.001$ at all stages).

There was no statistically significant improvement in the Kapandji score for thumb opposition between pre-operative and post-operative thumbs at twelve months after surgery ($p = 0.41$).

In terms of power measurements, there was a statistically significant improvement in hand grip power at 12 months ($p = 0.04$) and tip pinch

Fig. 3. — Pre-op and one year post-op radiographs of patient who underwent the procedure.

power at 12 months (p = 0.007). Key pinch power increased but not to a statistically significant degree at 12 months post-op.

When comparing patient-reported outcome measures, there was statistically significant improvement in the PEM score at 3, 6 and 12 months after surgery (p=0.002 at all times) and in the Quick DASH score at 3, 6 and 12 months (p = 0.002).

There was a loss of the position of the first metacarpal by subsidence towards the distal pole of the scaphoid at 12 months after surgery (p = 0.012). However, there was no incidence of any thumb metacarpal impinging on the distal scaphoid at final follow-up. All results are summarized in Table I.

In terms of complications, there were two superficial wound infections that were treated successfully with oral antibiotics and one patient presented with features consisted with complex regional pain syndrome, which has since resolved with intensive physiotherapy and input from our local pain clinic.

DISCUSSION

The TightRope (Arthrex) implant has been used in other anatomical areas, such as the ankle, the forefoot, the midfoot, the knee and the shoulder girdle. The implant was introduced for use in the hand in the past few years and it comprises two stainless steel buttons with 4 strands of FiberWire passing between them (*2*). FiberWire comprises a polyethylene monofilament core and a polyester jacket (*14*) and is a particularly inelastic material. Yao et al demonstrated that in a cadaveric model, TightRope stabilization of the first metacarpal is comparable to the traditional use of a Kirschner wire, with the added benefit of allowing the patient to commence earlier mobilization and also avoidance of possible pin-site infections from the use of k-wires (*30*).

Our study has demonstrated that at a short-term follow-up of 1 year, the results of trapeziumectomy and stabilization of the first metacarpal with the Mini Tight Rope implant demonstrate significant improvement in most variables assessed. At the same time, our complications were minimal and certainly not increased when compared to the published literature regarding other alternative methods of suspension. Our results are supported by a retrospective study that Yao et al published, at a minimum of two years after surgery. They demonstrated

Table I. — Summary of results at three, six and twelve months after surgery.
Results are reported as means or medians and statistical significance defined as p<0.05.

Time from surgery	VAS scale	Kapandji cotation	Quick DASH	PEM	Hand grip (kg)	Tip pinch (kg)	Key pinch (kg)	Proximal phalanx to scaphoid-first metacarpal length ratio
Pre-op average n = 21	7	8	40	63	15.2	1.36	2.38	2.56
3 months average n = 21	2 (p<0.001)	9 (p = 0.15)	27 (p<0.001)	43 (p<0.001)	15.9 (p = 0.57)	1.57 (p = 0.48)	2.05 (p = 0.41)	-
6 months average n = 15	2 (p<0.001)	9 (p = 0.10)	23 (p<0.001)	31 (p<0.001)	20.7 (p = 0.13)	2.35 (p = 0.095)	3.13 (p = 0.17)	-
12 months average n = 12	0 (p<0.001)	9 (p = 0.41)	17 (p = 0.002)	24 (p = 0.002)	26.2 (p = 0.04)	2.75 (p = 0.007)	3.28 (p = 0.46)	5.06 (p = 0.012)

a minimal complication rate, quick rehabilitation of patients and favorable functional outcomes (*28*). Parry (*22*) reported on a retrospective case series of patients after the use of a dual mini TightRope, which is a modification of the device that we used. They suggested that pain, grip and tip pinch powers were improved and range of movement remained unchanged in these patients, findings that are similar to ours.

There has been a healthy debate in the literature as to whether trapeziumectomy fares better or worse when compared to trapeziumectomy plus other procedures, such as tendon interposition, ligament reconstruction and tendon interposition (LRTI), with or without temporary Kirschner wire stabilisation (*16*). From recently published studies it seems that these added soft tissue procedures do not result in improved outcomes when compared to simple excision of the trapezium (*3, 25,10,23, 8, 9, 4*). A level II systematic literature review was published in 2011 by Li et al which concluded that between trapeziumectomy with or without LRTI, there is no great benefit in terms of the commonly investigated outcome measures and that choice of procedure is still made on the basis of personal experience rather than best evidence (*17*). A recent Cochrane review compared the available surgical options at that time and concluded that simple trapeziumectomy has similar results and fewer complications than other methods ; the authors did recognize that further research with well constructed studies would be necessary in the future (*25*). Mathoulin et al (*20*) reported on the 4-year follow up of a new technique that utilizes distally based slips of abductor pollicis longus tendon as a 'hammock' that would support the first metacarpal. They reported that 78% of their patients experienced significant pain relief. Another method in dealing with this pathology is trapeziumectomy and implant arthroplasty, with the use of metal, pyrocarbon (*19*), synthetic or human donor allograft (*15,24*) and silicone implants (*6,21*). Short-term follow-up periods, small patient numbers in existing studies and complications such as osteolysis, synovitis, malrotation of the thumb (*18*), implant loosening and dislocation have contributed in the lack of widespread use of these implants.

There is scarcity of studies utilizing this new technique, and although we have not set out to present a long-term outcome nor to compare the Tight Rope technique to other established procedures, our results demonstrate that this technique is promising and has a place in the treatment of this common pathology. Yao has already published on his method of performing open and arthroscopic trapeziumectomy and TightRope suspension of the first metacarpal and reports satisfactory results at 2 to 3 year post-operatively (*27*). A previous publication by Cox et al also described the technique in the context of suspending the thumb metacarpal following arthroscopic hemi-trapeziumectomy (*2*) and explains in detail a method of checking appropriate positioning of the implant and correct tensioning of the FibreWire through the use of fluoroscopy and the

ballottement test. Despite utilizing these methods in our cohort, we found out that the first metacarpal had subsided at one year after surgery. This finding is consistent with recent studies published by Parry et al (*22*) and Yao et al (*28*). We hypothesize that this is much preferred to over-tensioning the device and in support of this statement, our cohort's post-op thumb opposition, pain and functional outcomes were very favorable. A significant advantage of this technique when compared to LRTI is avoiding the need to harvest tendon autografts from the patient, therefore reducing donor site morbidity.

We have demonstrated that this procedure is safe in the hands of a trained surgeon and more specifically there were no fractures noted, a complication that was reported in a previous case report by Khalid et al (*14*). We are aware that the technique has now evolved by eliminating the need for over-drilling after the insertion of the guide wire, thereby minimizing the theoretical risk of fracturing the second metacarpal (*28*). The hypothesis that the device may be causing osteolysis has not been radiographically or clinically verified in our patient series. An easily recognizable benefit from this new technique is the avoidance of harvesting tendons or slips of tendons, thereby avoiding relevant morbidity and also reducing operative time.

This study is not without several limitations. This was a case series, with all methodological flaws that come with such study designs and very importantly, we did not have a control group of patients. Out of the initial cohort of 21 patients, only 12 patients completed the 1-year follow-up. On telephone consultations with the remaining 9 patients, they reported that they were not interested in attending the clinic for the one year follow-up and all 9 of these patients confirmed that their function was satisfactory. Despite the relatively low numbers and the fact that this study is most likely under-powered, we have demonstrated significant improvement on a number of clinically important parameters. A cost analysis was not performed, in other words we do not know whether the additional cost of the implant along with the additional operative time and use of fluoroscopy, could be offset by the earlier mobilisation that these patient have, compared to other traditional surgical methods. Lastly, our follow-up of 1 year after surgery is clearly short-term and findings may change significantly in the future. Given, however, the scarcity of studies in the use of this promising technique, we feel that our study has a place in relevant literature, in an attempt to identify the best method of operative management of the common pathology that is osteoarthritis of the first carpometacarpal joint. Finally, we did not compare this procedure to what is considered the 'gold-standard' treatment which is simple trapeziumectomy. There clearly is a place for a well constructed randomized controlled trial in order to answer that question.

Despite the above limitations, our study demonstrates that the short-term results of this method are more than satisfactory and complications limited. This technique also results in quick mobilization of the thumb, with removal of the plaster at 10 days after surgery and very importantly, it avoids the need for autologous tendon grafting and the resulting donor site morbidity, as with the commonly used LRTI. We agree with Yao et al (*28*), who stated that as with all new surgical technologies, the surgeon should be adequately trained and that careful patient selection is the key to a successful outcome. We look forward to seeing further and more long-term studies assessing this technique in the literature in the future and comparing it to the simple trapeziumectomy.

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