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Trapeziometacarpal narrow pseudarthrosis: a new surgical technique to treat thumb carpometacarpal joint arthritis

M. Rubino, A. Civani, D. Pagani and V. Sansone
Orthopaedic Department, Università degli Studi di Milano, Instituto Ortopedico Galeazzi IRCCS, Milano, Italy

Abstract
We describe a technique that arose from the observation of the clinical outcome of failed arthrodeses of the thumb carpometacarpal joint. In these cases a pseudoarthrosis developed which, surprisingly, rarely lead to a poor clinical outcome. Thus we developed a simple technique which deliberately caused the formation of a narrow pseudoarthrosis in the carpometacarpal joint. We present a retrospective review of 248 consecutive patients treated for Eaton stages II and III osteoarthritis. We observed a statistically significant improvement in mean appositional and oppositional pinch strength, mean DASH score (63.8 pre-operatively to 10.5 at final follow-up), and the mean pain score (8.3 to 0.2). We conclude that trapeziometacarpal limited excision arthroplasty is a simple and reliable alternative to existing surgical techniques for treating Stage II or III thumb carpometacarpal joint arthritis.

Keywords
Thumb carpometacarpal joint osteoarthritis, trapeziometacarpal joint arthritis, pseudoarthrodesis, pseudoarthrosis

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Introduction

The thumb carpometacarpal (CMC) joint is the second most common site of arthritis in the hand (Armstrong et al., 1994). Although most classifications are based primarily on radiographic evidence of morphological changes owing to arthritis (Brown et al., 2003; Dell et al., 1978; Eaton and Glickel, 1987), we believe that pain, CMC joint instability and functional impairment are more appropriate indications for surgical treatment than radiological staging. Surgical treatments include, among others, trapeziectomy with or without interpositional tendon arthroplasty or implant arthroplasty, prosthetic joint replacement, arthrodesis of the CMC joint and metacarpal extension osteotomy, although trapeziectomy has remained the commonest operation (Burton 1998, Dell et al., 1978; Kuschner and Lane, 1996; Maru et al., 2012, Nordback et al., 2012; Salem and Davis, 2012). Various techniques of resec- tion arthroplasty have been developed but the results have not proved to be better than those for trapeziectomy (Vermeulen et al., 2011; Wajon et al., 2009).

The use of prosthetic solutions is diminishing owing to concerns about implant stability over time, and the risks of failure (Hernandez Cortes et al., 2012; Johnston et al., 2012; Klahn et al., 2012; Maru et al., 2012; Nilsson et al., 2010; Nordback et al., 2012; Salem and Davis, 2012; Ulrich-Vinther et al., 2008). CMC joint arthrodesis is an alternative, but prevents movement in this important joint (Bamberger et al., 1992) and results in a non-union in a significant number of cases (up to 12.5%) (Chamay and Piaget-Morerod, 1994; Lisanti et al., 1997). In our experience, patients with non-union of their attempted arthrodesis only complain of pain until the metalwork has been removed, and thereafter regard the treatment as successful. In essence, a pseudoarthrosis forms,

Corresponding author:
V. Sansone MD, Orthopaedic Department, Università degli Studi di Milano, Instituto Ortopedico Galeazzi IRCCS, Via Galeazzi 4, Milano 20161, Italy.
Email: valerio.sansone@unimi.it

as for a trapeziectomy, but with less skeletal shortening. This observation has led us to develop a new surgical technique aimed at creating a narrow thumb CMC joint pseudoarthrosis.

We have performed a retrospective study in order to assess the outcome of creating this pseudoarthrosis.

Methods and patients

Patients

From January 2004 to January 2009 we treated 270 consecutive cases (248 patients) of primary thumb CMC joint arthritis (Eaton stages II or III) with this new technique. Of these, 226 patients (226 hands) had surgery on one side and 22 patients (44 hands) had surgery to both thumbs. Prior to surgery all patients had had appropriate non-operative treatment for at least six months including one or more of the following: activity modification, splinting, nonsteroidal anti-inflammatory drugs, or steroid injections.

Figure 1. Intra-operative radiograph showing the correct positioning of the K-wires.

Surgical technique

The operation is performed under regional anaesthesia, using a pneumatic tourniquet on the arm. Via a 4 cm curved (ulnar concave) incision the dorsal CMC joint capsule is exposed and incised transversally. By pressing down on the trapezium and levering up the base of the thumb metacarpal, the entire base of the metacarpal can be exposed. The distal trapezium and base of the thumb metacarpal are resected by 1–2 mm using a saw to obtain a cut roughly perpendicular to the long axis of the thumb metacarpal. Osteophytes are removed and the sharp edges of the saw cuts are smoothed. The aim is to achieve a quadrilateral space with parallel, flat joint surfaces. The first metacarpal base is stabilized with two crossed 1.6 mm K-wires, which are passed through the opposing surfaces of the thumb metacarpal and the trapezium, avoiding penetrating the STT joint that would dam- age the STT articular surfaces. The positioning is confirmed radiologically (Figure 1). The wounds are closed in a standard manner and the hand is supported in a bulky dressing for 15 days. Postoperatively, the patient is encouraged to move the thumb immediately within the pain-free arc of movement, and if possible, to touch the thumb to the fingers (Figure 2). The patients are seen for follow-up at 15 days, when the dressing and stitches are removed. The K-wires are removed in the outpatient clinic at approximately 25 days, and the patient is encouraged to move their thumb freely and gradually re-introduce their normal activities.

Assessment

Post-operative follow-ups were conducted by a single independent examiner at three and six months, and a

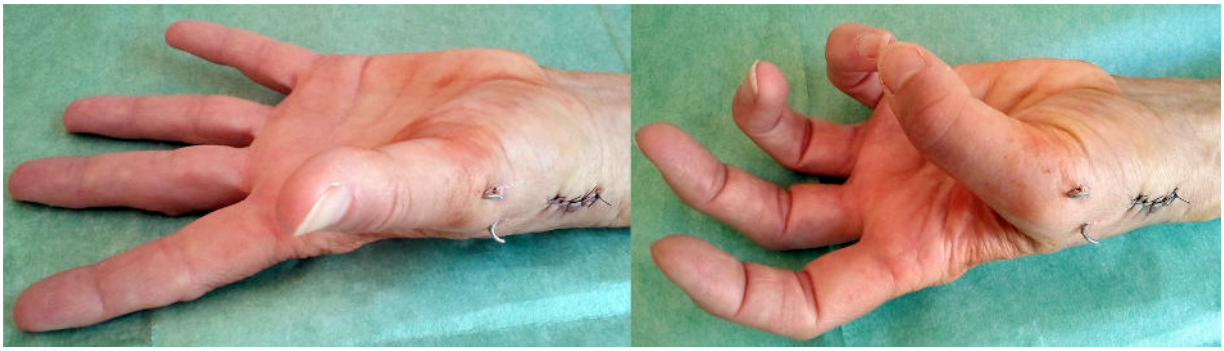

Figure 2. The percutaneous K-wires permit pain-free, active mobilization of the thumb.

Figure 3. Pre-operative dorso-palmar radiograph showing advanced degenerative changes of the CMC.

final follow-up was performed for this study. The final follow-up was at a mean of 3.7 years (range 2.1–6.0). A total of 204 patients (82%) underwent final follow-up, 19 patients (7.7%) were unavailable and 25 patients (10%) were untraceable.

A clinical evaluation was performed pre-operatively and at each post-operative follow-up to measure pain using a visual analogue scale (VAS), thumb range of motion according to the Kapandji evaluation scale (Kapandji, 1992) and pinch strength. Key (appositional) and tip (oppositional) pinch strength were measured in Newtons (N) using a Jamar hydraulic pinch gauge (Lafayette Instrument Co., Lafayette, IN). The pinch strengths were compared with the contralateral hand where only one thumb was operated on.

All the patients were asked to complete the disabilities of the arm shoulder and hand (DASH) questionnaire (McConnell et al., 1999) pre-operatively, at six months and at final follow-up. The 19 patients who were unable to come in for final follow-up were sent the DASH questionnaire by post and asked to fill it out at home. A further telephone check was made to ensure that they had understood the questions and completed the form correctly. PA and oblique radiographs were performed pre-operatively, after a month and where possible at final follow-up (82% of cases). The purpose of the first post-operative radiograph was to check that a pseudoarthrosis had been achieved, i.e. that there was a clearly visible, complete, radiolucent space separating the trapezium and the base of the thumb metacarpal (Figures 1, 3, 4 and 5). At final follow-up, we checked the radiographs for signs of degeneration of the surrounding joints (in particular the STT joint).

Figure 4. Post-operative dorso-palmar radiograph prior to removal of K-wires.

The data were distributed normally, so a statistical analysis was performed using a paired Student's *t*-test with significance set at $p < 0.05$.

Results

The mean age of the patients was 64 years (range 38–83). There were 206 women (83%) and 42 men (17%). The dominant hand was treated in 87% of the cases that underwent surgery for one thumb (197 cases). The patients had suffered pain for an average of 4 years (range 1–8) before seeing an orthopaedic specialist. The mean procedure time was 25 minutes (range 19–31). The tourniquet was inflated an average of 17 minutes (range 16–25).

The mean pain score improved from 8.3 pre-operatively to 0.2 at final follow-up ($p < 0.001$ - see Table 1). All patients were pain-free at the first post-operative follow-up when the hand was at rest (VAS score = 0), while the mean VAS score rose to 7.2 when

they were asked to grip. In all cases, pain during gripping resolved (VAS score = 0) at the three-month follow-up. In the 223 cases that underwent dynamometric tests at final follow-up, we observed statistically significant improvements ($p < 0.01$) in mean appositional pinch and oppositional pinch strength between the pre-operative and final follow-up values (Table 2). In the 185 cases that were operated on one side, key pinch strength increased from 28 N pre-operatively to 59 N (94% of opposite hand) post-operatively, and tip pinch strength from 26 to 52 N (93% of opposite hand) (Table 3). At the three-month follow-up, all patients had regained full movement of their thumb compared with the opposite hand with complete flexion and extension, radial abduction and thumb opposition (Kapandji stage 10). This mobility was maintained at final follow-up. The mean DASH score improved from 63.8 pre-operatively to 10.5 at final follow-up ($p < 0.001$ – Table 1).

Figure 5. Dorso-palmar radiograph at three years post-operative. Note the maintenance of the TM joint line.

Complications

No patient required revision surgery. In seven cases a superficial painful reaction to the K-wires was observed at the 15-day follow-up. The removal of the wires followed by the application of an elastic bandage was sufficient to solve the problem and it did not affect the outcome. There were also two cases of persistent hypoaesthesia over the dorso-radial surface of the thumb, presumably owing to intra-operative damage to the sensory branches of the radial nerve.

Discussion

Over the years many surgical treatments have been developed for the treatment of thumb CMC joint arthritis. The resection–suspension arthroplasty (Eaton and Littler, 1973) and its variants have commonly been

Table 1. Mean DASH and VAS scores

	Pre-operatively $n = 248$	Six month follow-up $n = 248$	Final follow-up $n = 223$*
Mean DASH† score	63.8 SD 8.5 (range 44.2–82)	9.9 SD 4.5 (range 0–33)	10.5 SD 4.5 (range 0–35)
Mean VAS‡ score	8.3 SD 1.1 (range 6.4–10)	0.1 SD 0.3 (range 0–0.5)	0.2 SD 0.3 (range 0–0.8)

Data show mean SD, $p < 0.001$.
*25 cases out of 248 lost at final follow-up. In 19 cases the VAS and DASH were performed by the patient at home. Median final follow-up was 3.3 years.
†100 point score where 0 is no disability and 100 is complete disability.
‡10 point scale where 0 = absence of pain and 10 = severe pain.
DASH, disabilities of the arm shoulder and hand; VAS, visual analogue scale.

Table 2. Appositional and oppositional pinch strength for all cases

Key pinch (appositional)		Tip pinch (oppositional)	
Pre-operatively $n = 270$	Final follow-up $n = 223$*	Pre-operatively $n = 270$	Final follow-up $n = 223$*
27 SD 10 N (range 2–48 N)	57 SD 17 N (range 29–81 N)	26 SD 11 N (range 1–47 N)	51 SD 15 N (range 27–83 N)

Data show mean SD.
*At final follow-up 19 cases (20 hands) could not come in to be examined, and 25 (27 hands) were untraceable. Median final follow-up was 3.3 years.

Table 3. Appositional and oppositional pinch strength for cases operated on one side only

	Key pinch (appositional)		Tip pinch (oppositional)	
	Pre-operatively $n = 226$	Final follow-up $n = 185$*	Pre-operatively $n = 226$	Final follow-up $n = 185$*
Reconstructed hand	28 SD 9 N (range 2–48 N)	59 SD 17 N (range 29–81 N)	26 SD 12 N (range 1–47 N)	52 SD 15 N (range 27–83 N)
Contralateral hand	64 SD 20 N (range 29–108 N)	63 SD 20 N (range 29–107 N)	57 SD 14 N (range 40–88 N)	56 SD 14 N (range 37–88 N)

Data show mean SD, $p < 0.01$.
*At final follow-up 18 cases could not come in to be examined, and 23 were untraceable. Median final follow-up was 3.3 years.

used with good results (Burton, 1998; Kuschner and Lane, 1996; Nordback et al., 2012; Salem and Davis, 2012). As well as standard operative complications, specific complications occur including: proximal migration of the thumb metacarpal; instability at the site of the resection (Kuschner and Lane, 1996); CRPS; radial or median sensory nerve dam- age; and continued instability of the metacarpophalan- geal joint (Burton, 1998). Moreover, in our experience, a significant number of patients develop flexor carpi radialis tendonitis which is often resistant to conservative treatment. A recent variation of trapeziectomy without interposition is the 'hematoma distraction arthroplasty' where the trapezium is excised, the thumb distracted and pinned with a K-wire, and then immobilized for five weeks (Kuhns et al., 2003). In this study only 73% of patients were pain-free at six months and there was a 51% reduction in scaphoid–thumb metacarpal distance was observed. A total of 42% of patients required post-operative rehabilitation.

Salem and Davis (2012) have compared outcomes of trapeziectomy with and without ligament reconstruction and K-wire stabilization at six years. They concluded that there was no significant difference between the results of the two procedures. Pinch strength was less than the pre-operative values at final follow-up in almost all the patient groups studied. Only 51% of the trapeziectomy group, and 64% of the trapeziectomy with ligament construction and stabilization, were completely without pain or restriction at final follow-up.

An arthroscopic hemitrapeziectomy with capsular shrinkage (Edwards and Ramsey 2010; Hofmeister et al., 2009; Menon, 1996) has been described recently but the data are limited. It is a technically demanding, time-consuming and costly procedure, which is not suitable for all patients (Hofmeister et al., 2009), and subsidence of the first metacarpal of 2–4 mm has been reported (Culp and Rekant, 2001).

Thumb CMC joint arthrodesis has been used for younger, active patients who require strong grip and pinch. Although it provides good strength and pain relief, it is a demanding surgical technique, because the surgeon is faced with the difficult decision of choosing the optimal thumb position intra-operatively. Excessive adduction makes it difficult to grip awkward objects. Conversely, excessive metacarpal abduction does not allow thumb–finger opposition. The loss of mobility results in a transfer of loads that may cause laxity, pain and degenerative changes in the surrounding joints (Klimo al., 2001).

This new technique addresses the major issues of instability, lack of mobility and transfer of loads. Instability caused by ligament laxity results in a continuous dorsal subluxation of the base of the first metacarpal over the trapezium, which damages the articular cartilage (Pellegrini, 1991). We believe that primary joint stability is provided by the resected wide, flat surfaces in the narrow pseudoarthrosis. As joint movement is restored after the removal of the K-wires, a sort of shock-absorbing cushion made of fibro-cartilaginous tissue is formed, rather than bone (Buckwalter, 2002). We hypothesize that this new tissue, aided by the resected joint surfaces, provides stability while allowing a certain degree of articular mobility. This stability could be particularly attractive for younger female patients in whom ligamentous laxity is common.

Our technique transforms the CMC joint from a synovial diarthrodial joint into a fibrous joint, which consequently reduces movement. Our results show that this does not appear to affect the functionality of the thumb as a whole. In our study, all patients regained full thumb mobility (Kapandji grade 10) and all patients declared 'no difficulty' with any of the functional tasks covered by the DASH questionnaire – even at final follow-up. We hypothesize that these good results are primarily owing to having addressed the joint instability, which, we believe, is a fundamental factor in the development of this pathology.

The low number of complications was particularly pleasing given the size of the study group. We believe that the low complication rate is owing to the minimally invasive nature of the procedure (a minimal

incision and resection are required), and to the post-operative protocol that encourages immediate movement of the thumb. Correctly positioned K-wires provide initial stability without hampering overall thumb movement, avoiding any potential complications associated with skin traction or immobilization of the thumb.

In their 2009 Systematic Review of the current accepted surgical treatments for thumb CMC joint arthritis, Wajon et al. were unable to identify any additional benefit in terms of pain, physical function, patient global assessment, range of motion or strength of any of the analysed procedures over another (Wajon et al., 2009). Our results concur with this finding, as our results for pinch strength, pain and functionality were similar to those reported for trapeziectomy both with and without interposition and for arthrodesis (Edwards and Ramsey, 2010; Kuschner and Lane, 1996; Rizzo et al., 2009; Ulrich-Vinther et al., 2008). We believe that the simplicity of the procedure, the good results and the low rate of complications observed in a large series make the proposed technique an attractive alternative to existing surgical treatments.

A limitation of our study was that we have not assessed how much movement is maintained at the CMC joint, and how much is owing to increased movement in the neighbouring joints with associated increased loading. In the 185 cases that had both pre-operative and final follow-up radiographs, we did not observe any further deterioration of the STT joint. Further prospective long-term studies are necessary to ascertain if any joint degeneration develops.

In summary, our technique aims to produce a stable, new fibrous CMC joint that allows a near normal painless functionality of the thumb. The procedure is easy to perform and the post-operative care is minimal. As the patient is encouraged to move their thumb freely there is no requirement for post-operative physiotherapy, and normal activity can swiftly be resumed. The creation of a pseudoarthrosis seems to be useful in patients of all ages as it does not preclude any future treatment. As we have been using this procedure for a relatively short period of time it does require further validation, but according to our preliminary results, the pseudoarthrosis technique successfully treats pain, and gives good functional results.

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Conflict of interests

None declared.

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