International Orthopaedics (SICOT) (2007) 31:547–554
DOI 10.1007/s00264-006-0217-5

ORIGINAL PAPER

Long term results of surgical intervention for osteoarthritis of the trapeziometacarpal joint

Comparison of resection arthroplasty, trapeziectomy with tendon interposition and trapezio-metacarpal arthrodesis

E. E. J. Raven · G. M. M. J. Kerkhoffs · S. Rutten · A. J. W. Marsman · R. K. Marti · G. H. R. Albers

Received: 7 December 2005 / Accepted: 9 June 2006 / Published online: 22 September 2006

Abstract Trapeziometacarpal osteoarthritis is a common entity, often bilateral and predominantly affecting postmenopausal women. In the case of failure of conservative treatment, surgery is a good option. The aim of this study was to compare three surgical procedures. 63 patients (74 thumbs) with osteoarthritis of the trapezio-metacarpal joint were surgically treated; 54 patients were seen for follow-up, 7 had died and 2 were lost to follow-up. The patients were stratified according to treatment; resection arthroplasty (the joint surface's of the metacarpal and the trapezium are resected) (18 thumbs), trapeziectomy with tendon interposition (17 thumbs) or trapezio-metacarpal arthrodesis (28 thumbs). Baseline characteristics were comparable in the three groups for mean age at operation, Eaton classification, left right distribution and dominant hands operated. The average follow-up was 13 years for the resection group, 8 years for the trapeziectomy group and 9 years for the arthrodesis group. No statistically significant difference between the three groups was found for the visual analogue pain and satisfaction scale, pain frequency nor DASH score. Patients in the trapeziectomy group had significantly less pain compared to the arthrodesis group (p=0.025). Statistically, radial abduction was significantly better after trapeziectomy compared to resection arthroplasty (p<0.01) or arthrodesis (p=0.01). There was no difference among the three groups in grip and tip pinch strength nor in pain on palpation. None of the patients in the trapeziectomy group needed a re-operation, one patient in the resection arthroplasty group had a re-operation, and 22 patients in the arthrodesis group had one or more re-operations for hardware removal or because of a complication. This study shows that the resection arthroplasty has equally good long term results compared to trapeziectomy combined with tendon interposition or arthrodesis. Resection arthroplasty is performed through a single incision and is technically simple. In our clinic resection arthroplasty is therefore the preferred technique for the treatment of osteoarthritis of the trapeziometacarpal joint.

E. E. J. Raven (✉)
Department of Orthopaedics and Traumatology,
Gelre Ziekenhuizen Apeldoorn,
P.O. Box 9014, 7300 DS Apeldoorn, The Netherlands
e-mail: eej.raven@hccnet.nl

G. M. M. J. Kerkhoffs · R. K. Marti
Department of Orthopaedics and Traumatology,
Academic Medical Center,
P.O. Box 22660, 1100 DD Amsterdam, The Netherlands

S. Rutten · A. J. W. Marsman · G. H. R. Albers
Department of Orthopaedics and Traumatology,
Hilversum Hospital,
P.O. Box 10016, Hilversum, The Netherlands

Résumé L'arthrose trapézométacarpienne est fréquente, souvent bilatérale et atteint de façon prédominante les femmes post ménopausées. En cas d'échec du traitement conservateur, la chirurgie est une excellente option de traitement. Le but de cette étude est de comparer trois techniques chirurgicales.

Patients et méthode: 63 patients (74 pouces) présentant une arthrose trapézométacarpienne ont été traités chirurgicalement, 54 patients ont été suivis régulièrement, 7 sont décédés et 2 perdus de vue. Les patients ont été classés en fonction du traitement, résection arthroplastique (18 pouces) trapézectomie avec inter position tendineuse (17 pouces) et arthrodèse 28 pouces. Les données de ces patients étaient comparables dans les trois groupes en ce qui concerne l'âge, l'intervention, la classification d'Eaton, la latéralisation des lésions et la main dominante. Le suivi moyen a été de 13 ans pour le groupe résection, 8 ans pour le groupe trapézectomie et de 9 ans pour le groupe arthrodèse.

Résultats: il n'y a pas de différence significative entre ces trois groupes sur le plan de la douleur et de la satisfaction ainsi que du score DASH. Les patients du groupe trapézectomie, ont significativement moins de douleur si on les compare au groupe arthrodèse (p=0.025). L'abduction est de façon significative plus importante après trapézectomie si on la compare au groupe résection (p<0.01) ou arthrodèse (p=0.01). Il n'y a pas de différence significative dans les trois groupes en termes de force, de serrage, de pince, ni en termes de douleur à la palpation. Aucun de ces patients après trapézectomie n'a nécessité de réintervention alors qu'un patient du groupe résection arthroplastique a dû être réopéré et 22 patients du groupe arthrodèse ont eu une ou plusieurs réinterventions, soit pour ablation de matériel soit du fait d'une complication.

En conclusion, cette étude montre que la résection arthroplastique donne un résultat à long terme équivalent aux autres techniques. La résection arthropastique peut être réalisée par une petite incision, elle est extrêmement simple sur le plan chirurgical. Dans notre établissement, la résection arthroplastique est devenue la technique de choix pour le traitement des arthroses trapézométacarpienne. Niveau d'évidence III–Etude de cohorte rétrospective.

Introduction

Trapeziometacarpal osteoarthritis is a common entity, often bilateral and predominantly affecting postmenopausal women [2, 11]. Conservative treatment is mostly successful, and surgical treatment is only indicated in resistant cases. A number of surgical procedures have been described for basal joint osteoarthritis, whereby simple excision was first reported in 1949 [20]. Other surgical procedures for osteoarthritis of the trapeziometacarpal joint include fusion [1, 4, 7, 12, 14, 15, 25, 27, 33], trapeziectomy combined with interposition arthroplasty. For interposition two main procedures are described: soft tissue [30] or silicone [26, 32, 34]. Also, reasonable to good results of total joint replacement have been reported [9, 10]. To the best of our knowledge there have been no reports on simple excision of both joint surfaces of the trapezio-metacarpal joint. The rationale behind this simple resection was based on the experience of one of the authors (AM) that a non-union of the arthrodesis of the trapeziometacarpal joint did not result in complaints. So in the simple resection a non painful non-union is aimed for.

In this study the results of simple resection of the surfaces of the trapeziometacarpal joint are reported and compared to trapeziectomy with tendon interposition and trapeziometacarpal arthrodesis.

Operative technique

For the resection arthroplasty, the joint is approached through a straight radial incision over metacarpal I and the trapezium to the wrist. After exposure of the joint, only the joint surfaces of the trapezium and the metacarpal bone are removed, care must be taken to resect all osteophytes. A minimal distance of 1 cm under traction between the two bones is aimed for. Care is taken to resect all osteophytes but not to resect joint capsule and ligaments. Spongostan (Ferrosan A/S, Soeborg, Denmark) is used as a spacer to fill the gap, and the wound is closed in one layer. After-treatment consists of two weeks of immobilisation in a forearm splint (below the elbow) followed by functional treatment (Fig. 1a,c).

For the arthrodesis the joint space is approached in a similar way and the joint cartilage and the adjacent sclerotic subchondral bone is removed. A small laminar spreader

Fig. 1a, **b** Patient A, preoperative X-rays of a 61 year old female. Eaton stage 2 joint destruction. **c**, **d** Patient A one year postoperative, no complaints. **e**, **f** Patient A, 10 years postoperative. DASH, VAS for pain and satisfaction all 0 points (maximum score)

was interposed to achieve lengthening and correction of the adduction. A stable fixation is achieved by a special miniplate technique. The first screwhole of a 3–4 hole AO mini plate is bent 90° and sunk into the metacarpal bone, acting as a washer to achieve maximal compression with a 2.7 mm cortical screw crossing the former joint space. With a second screw at the level of the trapezium, further compression and buttressing can be achieved by asymmetric drilling [29]. In some cases a corticocancellous graft was interposed. A removable forearm splint allows partial function after treatment (Fig. 2a,c).

To perform the resection-interposition arthroplasty, a similar incision is used. A trapeziectomy is performed. Through a second small incision approximately 10 cm proximal to the wrist, the flexor carpi radialis tendon (FCR) is identified and split with a tendon stripper from its muscle belly proximally, leaving the distal insertion intact. The split tendon is rolled and stitched to form an anchovy-like structure of the appropriate size to fill the gap created to the first metacarpal base. This procedure is followed by a scaphoid type of plaster fixation for 6 weeks [33] (Fig. 3a,b).

Patients and methods

In 63 consecutive patients with osteoarthritis of the trapezio-metacarpal joint 74 thumbs were surgically treated at the Hilversum Hospital and the Academic Medical Centre in Amsterdam between 1977 and 2000. The indication for surgical intervention was failure of conservative treatment with idiopathic degenerative osteoarthritis, except for one case of posttraumatic osteoarthritis. 54 patients (63 thumbs) were seen for follow-up, 7 patients (9 thumbs; 12%) had died and 2 patients (2 thumbs; 3%) were lost to follow-up (see Table 1). According to the preference of the surgeon, either resection arthroplasty, trapeziectomy with tendon interposition or trapezio-metacarpal arthrodesis was performed (Table 1). The resection arthroplasty was only performed by one surgeon, the other two techniques were performed by several surgeons but each surgeon performed only one of the techniques. All surgeons were experienced and fully qualified orthopaedic surgeons. At follow-up the patients were evaluated by one independent researcher. The results of the patients seen for follow-up were analysed: 18 thumbs (7 male and 11 female patients) had a resection arthroplasty, 17 thumbs (3 male and 14 female) had a trapeziectomy with tendon interposition and 28 thumbs (4 male and 24 female) had a trapezio-metacarpal arthrodesis. The average age was 58 years in the resection group (range 38–76 years), 65 years in the trapeziectomy group (range 47–80) and 61 years in the arthrodesis group (range 46–78 years). The average follow-up was 13 years (range 3–23 years) for the resection group, 8 years (range 5–12 years) for the trapeziectomy group and 9 years (range 4–27 years) for the arthrodesis group (p=0.025 for resection versus trapeziectomy and trapeziectomy versus arthrodesis, p=0.046 for resection versus arthrodesis). Thirteen dominant hands were operated on in the resection group, with 6 and 12 in the trapeziectomy and arthrodesis groups, respectively. The average preoperative Eaton stage was 2.6 (2–3) in the resection group, 2.4 (0–4) and 1.6 (0–4) in the trapeziectomy and arthrodesis groups, respectively.

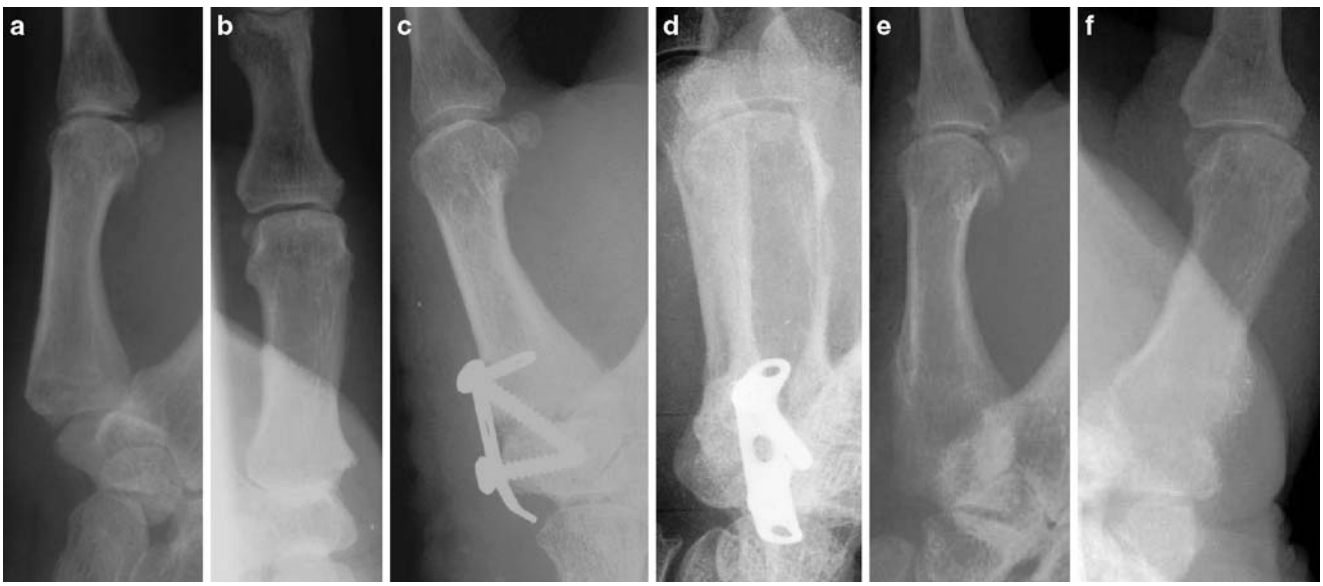

Fig. 2a, **b** Patient B, preoperative X-rays of a 61 year old female. Eaton stage 2 joint destruction. **c**, **d** Patient B, direct postoperative X-rays showing the trapezio-metacarpal arthrodesis with the plate washer technique. **e**, **f** Patient B, X-rays after five years of follow-up showing a completely united arthrodesis. DASH 54, VAS for pain 30 and for satisfaction 25

Fig. 3a, **b** Patient C, preoperative X-rays of a 62 year old female. Eaton stage 2 joint destruction. **c**, **d** Patient C, X-rays after five years follow-up of trapeziectomy with tendon interposition showing a slight calcification on the lateral X ray. DASH 10 points, VAS for pain and for satisfaction both 0 points

At follow-up all patients were asked to complete a visual linear analogue scale (VAS) for satisfaction with the result of the operation and persisting pain from the thumb. These scales were graded from 0 to 100 millimeters with "0" indicating high satisfaction and no pain. At follow-up pain relief after operation and pain frequency were scored (never pain, pain sometimes during heavy work, frequent pain and continuous pain). The Dutch validated Disability of Arm Shoulder and Hand questionnaire was used to evaluate function of the affected limb [24, 36].

Range of motion was measured with the neutral-zero method. Grip strength was measured with the use of a Jamarmeter (Therapeutic instrument™, Clifton, N.J. 07012, U.S.A.). Also tip pinch strength was recorded (see Table 2). Pressure pain on the trapezio metacarpal joint was noted at follow-up. Instability of the joint in the resection arthroplasty and the trapeziectomy group was recorded.

Table 1 Patients

	Resection arthroplasty	Trapeziectomy	Arthrodesis
Patients (thumbs)	16 (19)	17 (20)	30 (35)
Dead (thumbs)	1 (1)	2 (3)	4 (5)
Lost to FU (thumbs)	0	0	2 (2)
Remaining for FU (thumbs)	15 (18)	15 (17)	24 (28)
Age (years)	58 (38–76)	65 (47–80)	61(46–78)
Male/ female	7/11	3/14	4/24
Left/right	7/11	12/5	12/16
Bilateral	6	4	8
Dominant	13	6	12
FU (years)	13 (3–24)	8 (5–12)	9(4–27)

The pre-operative X-rays were scored according to the Eaton classification [17, 18] (Table 3). At follow-up the fusion status of the arthrodesis was recorded.

The patients records were used for the evaluation of complications. This was also checked at follow-up.

Statistical analysis was performed with an unpaired 2-tailed Student t-test (confidence level was set at 0.05) and the Pearson's correlation coefficient was calculated (relevant > 0.7) using Microsoft Excel XP.

Results

Results resection arthroplasty (n=18)

The visual analogue scores for pain and satisfaction were 14 and 8, respectively. Compared to preoperative, 16 thumbs (89%) were significantly improved and 2 thumbs (11%) were slightly improved. At follow-up 8 thumbs (44%) never had pain, 7 thumbs (39%) had some pain during heavy work, 2 thumbs (11%) had frequent pain and 1 (6%) had continuous pain. The average score on the DASH was 26 points (range 0–70).

The radial abduction of the thumb was 45°. The average grip strength with the Jamar-meter was 22 kg (range 6–39 kg). The average tip pinch strength was 3. In 4 thumbs (22%) there was pressure pain at follow-up while pressing on the trapeziometacarpal. No instability was found.

Sensory deficit due to damage to terminal branches of the radial nerve was experienced in 2 thumbs (11%). There was no sensory alteration on the tip of the thumb in any of the groups (compromising the tip pinch). One patient was

Table 2 Scoring tip pinch strength

Scoring tip pinch strength	Thumb to index finger not possible (0)
	Possible no strength (1)
	Possible normal strength (2)

Table 3 Eaton classification [17, 18]

Stage	Eaton classification	I (n=7*)	II (n=12*)	III (n=16*)
I	Normal appearance of articular surface and slight joint space widening			19%
II	Minimal sclerotic changes of subchondral bone. Osteophytes and loose bodies less than 2 mm	43%	58%	44%
III	Trapeziometacarpal joint space markedly narrowed and cystic changes present. Subluxation of the metacarpal may have occurred. Osteophytes and loose bodies greater than 2 mm	57%	25%	31%
IV	Presence of scaphotrapezial joint disease with narrowing and cystic changes		17%	6%

(I) resection arthroplasty group, (II) trapeziectomy group, (III) arthrodesis group
*Number of X-rays preoperative available for analysis

treated with re-resection for recurrent symptoms 8 years after initial surgery with a good result.

Results trapeziectomy (n=17)

The visual analogue scores for pain and satisfaction were 10 and 2, respectively. Compared to preoperative, 16 thumbs (94%) were significantly improved and 1 thumb (6%) was slightly improved. At follow-up 10 thumbs (59%) never had pain, 5 thumbs (29%) had some pain during heavy work, 2 thumbs (12%) had frequent pain and no patient had continuous pain. The average score on the DASH was 27 points (range 0–73).

The radial abduction of the thumb was 64°. The average grip strength with the Jamar-meter was 20 kg (range 8–37 kg). The average tip pinch strength was 3. In 4 thumbs (24%) there was pressure pain at follow-up while pressing on the trapeziometacarpal. No instability was found.

Sensory alteration due to damage to terminal branches of the radial nerve was experienced in 4 thumbs (24%). There was 1 patient with Sudeck's dystrophy. None of the patients had reoperations due to complications.

Results arthrodesis (n=28)

The visual analogue score for pain and satisfaction was 23 and 10. Compared to preoperative, 20 thumbs (71%) were significantly improved, 6 thumbs (21%) were slightly improved and 2 thumbs (7%) unchanged. At follow-up 8 thumbs (29%) never had pain, 11 thumbs (39%) had some pain during heavy work, 2 thumbs (7%) had frequent pain and 7 (25%) had continuous pain. The average score on the DASH was 25 points (range 0–83). The radial abduction of the thumb was 50°. The average grip strength with the Jamar-meter was 17 kg (range 3–41 kg). The average tip pinch strength was 3. Six thumbs (21%) had pain at follow-up while pressing on the trapeziometacarpal joint.

Sensory alteration due to damage to terminal branches of the radial nerve was experienced in 5 thumbs (18%). Seven out of 28 patients had an arthrodesis with a cortico-cancellous bone graft at the primary operation; non-unions were not seen in those patients. In the patients who did not have a corticocancellous bone graft in the primary operation, six non-unions were seen. Three patients had a stiff non-union without complaints, the other 3 patients had a re-arthrodesis which proved to be unsuccessful. All 3 patients had a further re-arthrodesis at that time combined with a corticocancellous bone graft which was successful in 2 out of 3 patients. The last patient still has a very poor result and a non-union after 4 operations. Fifteen out of 28 patients had hardware removal due to local complaints. Three patients developed dystrophy. The total number of reoperations due to complaints or due to a complication was 22 (79% of the patients).

Statistics

There was no statistical difference when comparing the resection and trapeziectomy groups and the resection and the arthrodesis groups concerning the VAS for pain and satisfaction, the pain frequency and the pain compared to preoperative levels. Comparing the trapeziectomy and the arthrodesis group a statistical difference was observed concerning the VAS for pain (p=0.02) and satisfaction (p=0.04), the pain frequency (p=0.01) and the pain compared to preoperative (p=0.03). There was no statistical difference in the DASH scores among the groups (Table 4).

The radial abduction in the resection arthroplasty versus the arthrodesis was not significantly different, while trapeziectomy compared to resection arthroplasty was significantly better (p=0.0001) and also compared to arthrodesis (p=0.0046). There was no difference of grip strength and pressure pain. The tip pinch was best in the trapeziectomy group compared to resection (p=0.03) and arthrodesis (p=0.02), while between the resection and the arthrodesis there was no difference (Table 4).

No significant correlations were found in any of the group comparing age, duration of follow-up, preoperative Eaton classification, sex, dominant side and bilateral operation compared to the VAS for pain and satisfaction and the DASH score (see Table 5).

Table 4 Results of the operated thumbs

	I	II	III	*p* I vs. III	*p* I vs. II	*p* II vs. III
Pain frequency (%)						
Never	44	59	29	ns	ns	0.01
During heavy labour	39	29	39			
Frequent in daily activity	11	12	7			
Continuous	6	0	25			
Pain compared to preoperative (%)						
Significantly improved	89	94	71	ns	ns	0.03
Improved	11	6	21			
Unchanged			7			
VAS for pain	4	10	23	ns	ns	0.02
VAS for satisfaction	8	2	10	ns	ns	0.04
DASH	26	27	25	ns	ns	ns
Eaton stage	2.6	2.4	1.6	0,006	ns	0.046
Radial abduction CMC(°)	45	64	50	ns	0.0001	0.0046
Pressure soreness CMC (%)	22	24	21	ns	ns	ns
Grip strength Jamar	22	20	17	ns	ns	ns
Tip pinch strength	2.7	3	2.8	ns	0.029	0.017

(I) resection arthroplasty group, (II) trapeziectomy group, (III) arthrodesis group
(ns) not significant
(*p*) p-value of student t-test

Table 5 Pearson's correlation coefficient

	I	II	III
Age versus			
VAS for pain	-0.02	0.20	-0.39
VAS for satisfaction	−0.02	0.04	−0.42
DASH	−0.25	0.17	−0.01
Eaton score versus			
VAS for pain	−0.47	0.32	−0.31
VAS for satisfaction	−0.47	0.46	0.02
DASH	−0.25	0.11	−0.04
FU duration versus			
VAS for pain	−0.10	−0.04	−0.08
VAS for satisfaction	0.12	0.44	−0.15
DASH	0.12	0.52	−0.19
Gender versus			
VAS for pain	0.41	−0.12	0.20
VAS for satisfaction	0.32	0.14	0.08
DASH	0.57	0.14	0.35
Dominant side versus			
VAS for pain	0.36	−0.44	−0.16
VAS for satisfaction	0.35	0.33	−0.09
DASH	0.33	0.08	−0.20
Bilateral versus			
VAS for pain	−0.13	−0.04	0.18
VAS for satisfaction	−0.31	0.41	−0.04
DASH	−0.19	0.51	0.17

(I) resection arthroplasty group, (II) trapeziectomy group, (III) arthrodesis group

Discussion

Osteoarthritis of the basal joint of the thumb commonly affects middle aged women [2]. There is a disabling pain and swelling of the base of the thumb associated with deformity, instability, crepitus and loss of motion. If conservative treatment fails surgical intervention usually has good results and leads to satisfied patients independent of the technique used, either trapeziectomy with tendon interposition or arthrodesis [1, 4, 7, 12, 14, 15, 20, 21, 25, 27, 30, 33].

Simple trapeziectomy introduced by Gervis [20] is also an easy and quick procedure which is still favoured [19, 21, 33]. The results are comparable with the results we found for all three procedures. To overcome problems of instability and shortening, interposition of a rolled flexor carpi radialis tendon in the space of the removed trapezium was introduced [19]. In more recent literature ligament reconstruction-tendon-interposition arthroplasties are popular [35]. Although, in the randomised studies of Belcher and Nichol [3] and Davis et al. [13], no statistical difference for trapeziectomy alone or combined with ligament reconstruction and tendon interposition was found. Manske [28] raised the question whether any of the stabilising procedures proposed by Eaton and Littler [16], and Burton and Pelligrini [5] are in fact necessary after trapeziectomy, and whether splinting alone might be sufficient. In our study we did not immobilise the thumb with a K-wire; all patients with a resection arthroplasty were immobilised for two weeks in a splint and for 6 weeks if they had a trapeziectomy with tendon interposition. The results of the trapezectomy might have been better if no tendon interposition had been performed.

Arthrodesis of the trapeziometacarpal joint proved to be a reliable procedure with good long term results. In the literature different methods of fixation have been described [1, 4, 6–8, 12, 15, 25, 27, 33]. The problems of the arthrodesis are failure of the hardware and non-union. Also, complaints of pain due to the thin skin overlying the hardware are frequent. In our series these problems were also noticed resulting in a high rate of re-intervention. Most of the patients with a non-union, however, did not have complaints of pain and therefore had no re-intervention. No non-unions were observed in the cases were a cortico-cancellous bone graft was used. Better results could possibly have been observed if all patients had a cortico-cancellous bone graft.

Until now there have been no reports of simple resection of the joint surfaces of the metacarpal bone and the trapezium. This study shows that this procedure leads to good results and satisfied patients in the long term. An explanation can be found in the early functional treatment after a short period of immobilisation. This is in accordance with the results presented by Horlock and Belcher who also advocate early functional treatment [23]. The procedure itself is very simple since no hardware is used; this reduces risk of a re-interventions for hardware failure or complaints.

Although there were some differences in the baseline characteristics, concerning Eaton stage, dominant side and length of follow-up, we consider the groups as comparable since we did not find positive correlations for those characteristics.

Because of the small number of patients we could not establish significant differences between the patient groups comparing satisfaction, pain experience and functional outcome. Comparing the complication and re-intervention rates we noticed considerable differences with worse results in the arthrodesis patients. In the published comparative studies no differences were found between trapeziectomy with or without the addition of ligament reconstruction [3, 13]. Also, comparison of arthrodesis with ligament reconstruction revealed no differences except for a higher complication rate [22]; apart from the publication of Mureau et al. [31] who found that patients undergoing tendon interposition arthroplasty had better thumb opposition, interphalangeal joint mobility, and radial and palmar TMC joint range of motion.

Conclusion

Although we have a small number of patients we show that the resection arthroplasty is a simple procedure and has equally good long term results compared to trapeziectomy combined with tendon interposition and arthrodesis. The trapezectomy with tendon interposition requires one extra incision for harvesting the tendon in comparison with resection arthroplasty. Therefore we consider resection arthroplasty to be the most simple procedure. Resection arthroplasty has less complications and less re-interventions compared to arthrodesis.

The resection arthroplasty is the most simple procedure in our clinic, and is therefore the treatment of choice for osteoarthritis of the trapeziometacarpal joint. We consider this a reasonable alternative to the “gold standard” of the trapezectomy in the treatment of osteoarthritis of the trapeziometacarpal joint. Further randomised trials of the resection arthroplasty and trapezectomy should answer the question as to the outcome compared to the gold standard and if the results remain as good with different surgeons.

References

1. Alberts KA, Engkvist O (1989) Arthrodesis of the first carpometacarpal joint. 33 cases of arthrosis. Acta Orthop Scand 60:258–260
2. Armstrong AL, Hunter JB, Davis TR (1994) The prevalence of degenerative arthritis of the base of the thumb in post-menopausal women. J Hand Surg [Br] 19:340–341
3. Belcher HJ, Nicholl JE (2000) A comparison of trapeziectomy with and without ligament reconstruction and tendon interposition. J Hand Surg [Br] 25:350–356
4. Burton RI (1986) Basal joint arthritis. Fusion, implant, or soft tissue reconstruction? Orthop Clin North Am 17:493–503
5. Burton RI, Pellegrini VD Jr (1986) Surgical management of basal joint arthritis of the thumb. Part II. Ligament reconstruction with tendon interposition arthroplasty. J Hand Surg [Am] 11:324–332
6. Caputo RJ, Bennett JB (1993) Power staple fixation in trapeziometacarpal arthrodesis. J Hand Surg [Am] 18:926–929
7. Chamay A, Piaget-Morerod F (1994) Arthrodesis of the trapeziometacarpal joint. J Hand Surg [Br] 19:489–497
8. Clough DA, Crouch CC, Bennett JB (1990) Failure of trapeziometacarpal arthrodesis with use of the Herbert screw and limited immobilization. J Hand Surg [Am] 15:706–711
9. Comtet JJ, Rumelhart C (2001) Total trapezometacarpal prostheses: concepts and classification study. Chir Main 20:48–54
10. Cooney WP, Linscheid RL, Askew LJ (1987) Total arthroplasty of the thumb trapeziometacarpal joint. Clin Orthop 35–45
11. Damen A, van der Lei B, Robinson PH (1997) Bilateral osteoarthritis of the trapeziometacarpal joint treated by bilateral tendon interposition arthroplasty. J Hand Surg [Br] 22:96–99
12. Damen A, Dijkstra T, van der Lei B, den Dunnen WF, Robinson PH (2001) Long-term results of arthrodesis of the carpometacarpal joint of the thumb. Scand J Plast Reconstr Surg Hand Surg 35:407–413
13. Davis TR, Brady O, Dias JJ (2004) Excision of the trapezium for osteoarthritis of the trapeziometacarpal joint: a study of the benefit of ligament reconstruction or tendon interposition. J Hand Surg [Am] 29:1069–1077
14. Doyle JR (1991) Sliding bone graft technique for arthrodesis of the trapeziometacarpal joint of the thumb. J Hand Surg [Am] 16:363–365
15. Eaton RG, Littler JW (1969) A study of the basal joint of the thumb. Treatment of its disabilities by fusion. J Bone Joint Surg Am 51:661–668
16. Eaton RG, Littler JW (1973) Ligament reconstruction for the painful thumb carpometacarpal joint. J Bone Joint Surg Am 55:1655–1666
17. Eaton RG, Lane LB, Littler JW, Keyser JJ (1984) Ligament reconstruction for the painful thumb carpometacarpal joint: a long-term assessment. J Hand Surg [Am] 9:692–699
18. Eaton RG, Glickel SZ, Littler JW (1985) Tendon interposition arthroplasty for degenerative arthritis of the trapeziometacarpal joint of the thumb. J Hand Surg [Am] 10:645–654
19. Froimson AI (1970) Tendon arthroplasty of the trapeziometacarpal joint. Clin Orthop 70:191–199
20. Gervis WH (1949) Excision of the trapezium for osteoarthritis of the trapezio-metacarpal joint. J Bone Joint Surg Br 31:537–539
21. Gervis WH, Wells T (1973) A review of excision of the trapezium for osteoarthritis of the trapezio-metacarpal joint after twenty-five years. J Bone Joint Surg Br 55:56–57
22. Hartigan BJ, Stern PJ, Kiefhaber TR (2001) Thumb carpometacarpal osteoarthritis: arthrodesis compared with ligament

reconstruction and tendon interposition. J Bone Joint Surg Am 83-A:1470–1478
23. Horlock N, Belcher HJ (2002) Early versus late mobilisation after simple excision of the trapezium. J Bone Joint Surg Br 84:1111–1115
24. Hudak PL, Amadio PC, Bombardier C (1996) Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper Extremity Collaborative Group (UECG). Am J Ind Med 29:602–608
25. Ishida O, Ikuta Y (2000) Trapeziometacarpal joint arthrodesis for the treatment of arthrosis. Scand J Plast Reconstr Surg Hand Surg 34:245–248
26. Kessler I (1973) Silicone arthroplasty of the trapezio-metacarpal joint. J Bone Joint Surg Br 55:285–291
27. Lisanti M, Rosati M, Spagnolli G, Luppichini G (1997) Trapeziometacarpal joint arthrodesis for osteoarthritis. Results of power staple fixation. J Hand Surg [Br] 22:576–579
28. Manske PR (2004) Commentary: Excision of the trapezium. J Hand Surg [Am] 29:1078–1079
29. Marti RK (1999) The plate washer technique for carpometacarpal arthrodesis of an old unreduced Bennet's fracture. In: Ten Duis HJ, Marti RK, van der Werken CH (eds) Problem solving in traumatology. Amsterdam: van der Wees 1: 104–105
30. Menon J (1995) Partial trapeziectomy and interpositional arthroplasty for trapeziometacarpal osteoarthritis of the thumb. J Hand Surg [Br] 20:700–706
31. Mureau MA, Rademaker RP, Verhaar JA, Hovius SE (2001) Tendon interposition arthroplasty versus arthrodesis for the treatment of trapeziometacarpal arthritis: a retrospective comparative follow-up study. J Hand Surg [Am] 26:869–876
32. Pellegrini VD Jr, Burton RI (1986) Surgical management of basal joint arthritis of the thumb. Part I. Long-term results of silicone implant arthroplasty. J Hand Surg [Am] 11:309–324
33. Schroder J, Kerkhoffs GM, Voerman HJ, Marti RK (2002) Surgical treatment of basal joint disease of the thumb: comparison between resection-interposition arthroplasty and trapezio-metacarpal arthrodesis. Arch Orthop Trauma Surg 122:35–38
34. Swanson AB (1972) Disabling arthritis at the base of the thumb: treatment by resection of the trapezium and flexible (silicone) implant arthroplasty. J Bone Joint Surg Am 54:456–471
35. Tomaino MM, Pellegrini VD Jr, Burton RI (1995) Arthroplasty of the basal joint of the thumb. Long-term follow-up after ligament reconstruction with tendon interposition. J Bone Joint Surg Am 77:346–355
36. Veehof MM, Sleegers EJ, van Veldhoven NH, Schuurman AH, van Meeteren NL (2002) Psychometric qualities of the Dutch language version of the disabilities of the arm, shoulder, and hand questionnaire (DASH-DLV). J Hand Ther 15:347–354