Prospective 1-Year Follow-Up Study Comparing Joint Prosthesis With Tendon Interposition Arthroplasty in Treatment of Trapeziometacarpal Osteoarthritis

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Purpose Osteoarthritis of the thumb basal joint is a common and disabling condition. This clinical follow-up study compares the efficacy of total basal joint replacement surgery with that of tendon interposition arthroplasty.

Methods Ninety-eight patients (mean age, 60 years ± 1) with severe trapeziometacarpal joint osteoarthritis (Eaton-Littler stage 2.4 ± 0.1) were included in this prospective follow-up study. Based on written and verbal information, the patients could choose either a cementless, unconstrained, hydroxyapatite-coated trapeziometacarpal joint prosthesis or abductor pollicis longus tendon interposition arthroplasty. Clinical outcome parameters were determined preoperatively and at 3, 6, and 12 months postoperatively. Furthermore, osteointegration and osteo-fixation of the implants were radiologically analyzed after 12 months.

Results Joint replacement surgery resulted in faster and better pain relief, stronger grip functions, improved range of motion, and faster convalescence than did tendon interposition arthroplasty. After 12 months, patients with joint prostheses had regained the same strength and range of motion as in the asymptomatic contralateral thumb. After 12 months, osteolysis had developed in the vicinity of 2 cups, but there were no signs of implant loosening. The prosthesis surgery was not associated with more complications than occurred with tendon interposition arthroplasty.

Conclusions This study demonstrates that patients with joint prostheses achieve faster convalescence with better patient comfort and improved strength and range of motion without any increased risk of complications than do patients treated with tendon interposition arthroplasty at 1-year follow up. However, a randomized clinical trial with long-term follow-up is required. *(J Hand Surg 2008;33A:1369–1377. Copyright © 2008 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Therapeutic III.

Key words Arthroplasty, joint prosthesis, osteoarthritis, trapeziometacarpal joint.

OSTEOARTHRITIS AT THE base of the thumb is a common problem.[1–3] Moderate to severe degrees of osteoarthritis might require surgical treatment for the purpose of restoring pain-free, strong, stable, and mobile function of the thumb and to improve patient global assessment.[4,5] A broad variety of surgical methods including simple trapeziectomy and trapeziectomy with interpositional arthroplasty and/or with ligament reconstruction have been proposed to achieve all of these goals.[6–18] None of these surgical

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TABLE 1. Patient Data

	Arthroplasty	Prosthesis	p Value
Number of patients included	70	42	
One-year follow-up frequency (n)	62	36	.773
Age (y)	62 ± 1	58 ± 2	.072
Gender	59 women	37 women	.564
Eaton-Littler osteoarthritis stage	2.2 ± 0.1	2.5 ± 0.1	.237
Duration of surgery (min)	46 ± 2	39 ± 1	.006
Sick leave (wk)	14 ± 4	6 ± 1	.040
One year postoperatively: Yes, the treatment was worthwhile (n)	54	34	.317

methods for treatment of trapeziometacarpal osteoarthritis have proved to provide superior results compared with the other techniques.[19] Furthermore, all of the procedures may be associated with negative effects such as deep pain and tendon problems.[11–13,19]

Total trapeziometacarpal joint replacement surgery has been known for decades, and many designs of cemented joint prostheses have emerged.[20–24] Unfortunately, these prostheses have been associated with problems such as aseptic loosening.[25–29]

In recent years, new technologies have been applied to the design of uncemented trapeziometacarpal joint prostheses. These prostheses are made with wear-resistant materials, such as cobalt-chromium alloys at the articulating surfaces and have implant surface coating with bone-conductive materials, such as hydroxyapatite. An example of a modern joint implant is the Elektra prosthesis (Small Bone Innovations Inc., Péronnas, France), which is a semimodular, unconstrained, cementless, hydroxyapatite-coated trapeziometacarpal joint prosthesis. In 2006, the inventor of the Elektra prosthesis reported on the first 100 patients with a mean follow-up period of 53 months.[30] He demonstrated improvements of strength, range of motion (ROM), and pain relief. However, in 15% of the patients, loosening of the cup was reported (93% of cases with nonfixation of the cup developed within the first 9 months postoperatively). To explain this, the report described a number of shortcomings including use of different surgical techniques and continuous changes of the prosthesis design during the observation period. Finally, the surgeon did not use intraoperative fluoroscopy to ensure correct orientation and implantation of the trapezial cup, which might be an essential procedure in order to obtain long-term survival of the trapezial cup.

The current article describes data from a prospective follow-up investigation comparing thumb function and patient global assessment during the first 12 months after either implant of an Elektra trapeziometacarpal joint prosthesis or trapeziectomy with tendon interposition arthroplasty as treatment for severe osteoarthritis in the thumb basal joint.

MATERIALS AND METHODS

Study design

This therapeutic investigation was designed as a prospective follow-up study. The inclusion criteria were isolated trapeziometacarpal osteoarthritis determined by the Eaton-Littler classification (stages 2–3)[31] in combination with presence of osteoarthritic joint pain and loss of function.[4] Patients with pan-trapezial joint osteoarthritis (such as scaphotrapezium-trapezoid joint osteoarthrosis; stage 4) were excluded from the study. Additionally, because severe osseous deterioration of trapezium such as presence of cysts and poor trabecular bone density may prohibit sufficient initial fixation of the trapezial cup, such patients were also excluded from participating in the study.

Allocation of patients was performed on a voluntary basis. Patients fulfilling the inclusion criteria received verbal and written information about both options of treatment (arthroplasty and joint prosthesis surgery). Subsequently, the patients were allowed to choose either one of the treatments. The study was approved by the Danish ethical-review board. The patients included in this study received surgery in the period June 2003 to June 2006. The outcome parameters were determined preoperatively and 3, 6, and 12 months postoperatively.

Patients

The allocation and distribution of patients and their data are given in Table 1.

Of a total of 112 patients operated on, 42 patients received joint prosthesis and 70 received resection arthroplasty and were included in the study. One year after surgery, 62 patients with arthroplasty and 36 pa-

tients with joint prostheses were still enrolled in the follow-up program (1 patient in each group died due to other reasons, and the remaining nonparticipants had moved away from the hospital district or did not respond to contact requests).

The number of women and men in the groups were equally distributed between the groups. Also, no differences were found between the groups either in age (arthroplasty vs prosthesis, 62 years ± 1 vs 58 years ± 2; p = .564) or in the degree of carpal-metacarpal-1 (CMC-1) osteoarthritis (arthroplasty vs prosthesis, 2.2 ± 0.1 vs 2.5 ± 0.1; p = .237). The preoperative severity of trapeziometacarpal osteoarthritis was determined using the Eaton-Littler radiographic classification.[31]

Operative techniques

Joint prosthesis surgery: An unconstrained, cobalt-chromium/titanium, hydroxyapatite-coated trapeziometacarpal joint prosthesis (Elektra) was implanted using cementless, press-fit technique as described previously.[30]

In brief, the osteoarthritic joint-bearing metaphysis of the metacarpal bone was resected, and manual reaming of the medullar canal was performed until stable cortical bone contact was achieved. The hydroxyapatite-coated metacarpal stem was gently impacted into the metacarpal canal until its beveled edge was flush with the surface of the osteotomy. In preparation of the trapezium, intraoperative radiographic imaging and the manufacturer's guidance system was always used on all cases to ensure correct position of the trapezial cup guide pin. Subsequently, the pin was used for reaming, tapping, and guidance of the hydroxyapatite-coated trapezial cup, which was threaded into the trapezium until firm bone contact was achieved. Sufficient neck length was determined by the manufacturer's measurer and by intraoperative stability during full range of motion.

The joint was immobilized in a cast for 3 weeks, after which unlimited active motion was permitted. Operations were performed under regional anesthesia using a tourniquet, and dicloxacillin was used intraoperatively for infection prophylaxis.

Tendon interposition arthroplasty: This technique has been described by Sigfusson and Lundborg.[32] In brief, the trapezium was removed, and a distal-based strip of one of the abductor pollicis longus tendons was tunneled through a slit in the capsular flap into the trapezial void. The tendon strip was passed anterior around the flexor carpi radialis tendon and wound around the remaining abductor pollicis longus tendon. The rest of the tendon strip was sutured into a roll and placed in the trapezial defect as a soft tissue spacer. The joint was immobilized in a cast for 4 weeks, after which hand therapy was initiated.

Subjective parameters

Discomfort was determined as preoperative and postoperative pain in rest, activity, and as the cumulative discomfort in active daily living. A continuous 100-mm visual analog scale (VAS) was used to assess the pain level (0, absence of pain; 10, severe pain).

Objective parameters

Strength: Strengths of the hand and thumb were determined preoperatively and postoperatively. The grip pressure was determined with a dynamometer (Jamar Hand Dynamometer, North Coast Medical, Morgan Hill, CA). Key-pinch pressure and tip-pinch pressure were determined by a goniometer (North Coast Medical). Equal strength modalities of the contralateral (asymptomatic) hand/fingers were determined as well.

Range of motion: Complete ROM in flexion–extension and abduction–adduction was measured with a goniometer preoperatively and postoperatively. Additionally, thumb opposition was determined as the minimal distance between the pulp of the thumb and the palm at the base of the fifth finger achieved by active motion.[33] Range of motion of the contralateral (asymptomatic) hand/finger was registered as well.

Radiographic parameters

At 1 week as well as at 12 months postoperatively, standardized lateral and anteroposterior radiographs of the CMC-1 with joint prosthesis were performed. The radiographs at 12 months were compared with the radiographs obtained at 1 week postoperatively. The x-rays were evaluated for evidence of periprosthetic osteolysis as a sign of failed osseous integration of the implant and gross migration of the trapezial cup/metacarpal stem as a sign of failed implant (Fig. 1).[24,29]

Complications of surgery

Complications have been logged in patient files and registered in accordance with the guidelines of the Cochrane Database Collaboration.[19]

Statistical analyses

The data were tested for normal distribution and homogeneity of variances, and when these conditions were fulfilled, parametric analyses were applied (paired Student's *t*-test for tests within groups and unpaired Student's *t*-test for tests between groups); otherwise, nonparametric analysis was used (Mann-Whitney U test). First, the joint prosthesis group was compared with the arthroplasty group preoperatively and 3, 6, and 12 months postoperatively. Then changes in outcome parameters from preoperative status to 3, 6, and 12

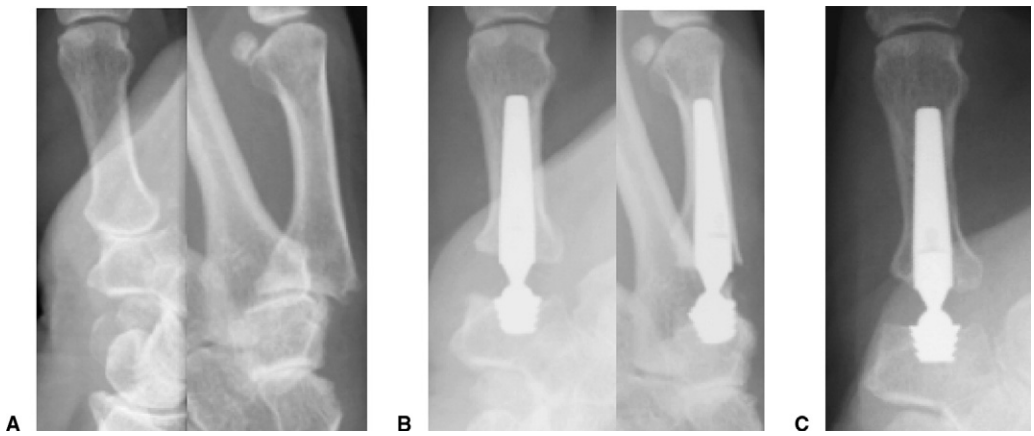

FIGURE 1: A Radiology of preoperative trapeziometacarpal joint osteoarthrosis (Eaton-Littler stage 2; anteroposterior and lateral views). **B** Radiologic confirmation of correct position of the prosthesis (postoperatively). **C** One-year postoperative status of osseous integration and fixation of the prosthetic components (measured by periprosthetic osteolysis and gross positional changes of prosthesis).

TABLE 2. Number of Patients With Complications and Implant Failures

	Arthroplasty	Prosthesis	p Value
Tendon problems	6	2	.706
Scar tenderness	1	0	1.000
Sensory changes	1	0	1.000
Neuroma	0	0	1.000
CRPS	0	0	1.000
Infections	0	0	1.000
Implant failure	—	1	—

CRPS, Complex Regional Pain Syndrome.

months postoperatively were tested within the joint prosthesis group and within the resection arthroplasty group using paired statistical methods. Fisher's exact test was used for the evaluation of gender distribution, follow-up frequency, repeated treatment, and fluorescence evaluation of prosthesis integration and fixation (Tables 1 and 2). Statistical significance was determined as $p < .05$ (2-tailed).

Follow-up assessments of the patients and data evaluation were performed by a blinded, independent examiner.

RESULTS

Subjective parameters

Preoperatively, the study groups (trapeziometacarpal joint prosthesis vs interposition arthroplasty) had similar pain scores in the 3 pain modalities.

Postoperatively, patients with a trapeziometacarpal joint prosthesis had much lower VAS scores in pain at rest, pain in activity, and discomfort in active daily living than did the patients with tendon interposition arthroplasty (Fig. 2).

After 3 months, patients with trapeziometacarpal joint prostheses had experienced a rapid and dramatic reduction of both pain in rest (an 8-fold reduction from 3.8 ± 0.3 to 0.5 ± 0.1; $p < .001$), pain in activity (a 7-fold reduction from 8.2 ± 0.2 to 1.1 ± 0.2; $p < .001$), and discomfort in active daily living (a 6-fold reduction from 6.6 ± 0.2 to 0.8 ± 0.2; $p < .001$) (Fig. 2). The data demonstrate that patients with trapeziometacarpal joint prostheses had reached the end point of pain reduction as early as after 3 months.

Tendon interposition arthroplasty also led to a reduction in all pain parameters. However, the effect of tendon interposition arthroplasty on pain reduction was much lower than in patients with trapeziometacarpal joint prostheses.

Objective parameters

Strength: Preoperatively, the study groups (trapeziometacarpal joint prosthesis vs interposition arthroplasty) had similar strength in tip-pinch pressure, key-pinch pressure, and hand-grip modalities.

At all postoperative visits, patients with trapeziometacarpal joint prostheses achieved more strength in tip-pinch pressure, key-pinch pressure, and hand-grip pressure compared with those in patients with interposition arthroplasty (Fig. 3). The patients with a trapeziometacarpal joint prosthesis gained progressively higher strength in all 3 parameters compared with the preoperative values, whereas the patients with a tendon interposition arthroplasty markedly lost strength in tip-

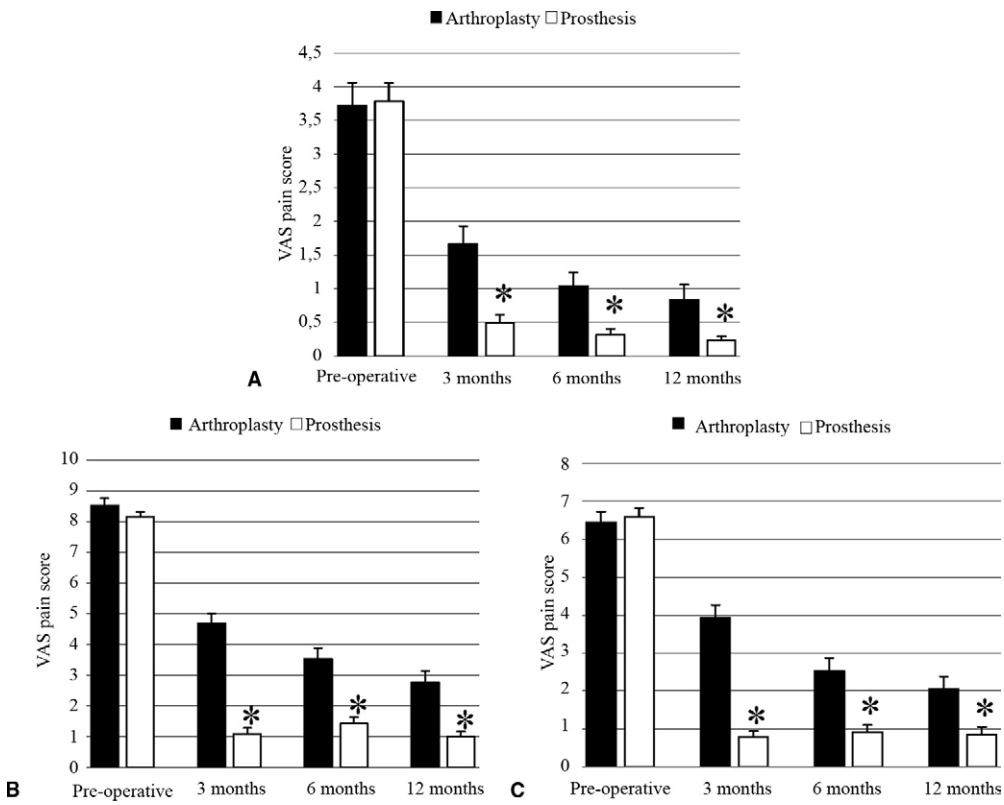

FIGURE 2: A Pain at rest, **B** pain in activity, and **C** pain related to active daily living were determined by the VAS score. All of these parameters were improved by both treatments. However, joint replacement surgery resulted in faster and more pronounced pain relief than did tendon interposition arthroplasty (∗, $p < .05$).

pinch pressure and key-pinch pressure strength compared with the preoperative values.

At 3 months postoperatively, the trapeziometacarpal joint prosthesis patients had increased tip-pinch pressure from 4.0 kg ± 0.2 to 5.2 kg ± 0.2 ($p = .024$). This strength was not increased markedly during the next 9 months, and the tip-pinch strength did not reach the strength of the nonsymptomatic contralateral side. Concerning key-pinch pressure and hand-grip pressure, the patients with a trapeziometacarpal joint prosthesis demonstrated marked increases in both parameters from preoperatively to 3 months, from 3 months to 6 months, and from 6 months to 12 months. At 12 months postoperatively, the hand with a joint prosthesis showed the same key-pinch pressure and hand-grip pressure as did the asymptomatic contralateral hand.

Three months after surgery, patients with tendon interposition arthroplasty demonstrated decrease in tip-pinch pressure (from 4.0 kg ± 0.2 to 3.1 kg ± 0.1; $p = .02$) and key-pinch pressure (from 5.2 kg ± 0.2 to 4.1 kg ± 0.1; $p = .04$) compared with preoperative values. However, these patients subsequently demonstrated an increase in tip-pinch pressure and in key-pinch pressure from 6 months to 12 months ($p = .005$) but did not reach the levels of preoperative strength or similar strength as in the contralateral hand.

Range of motion: Preoperatively, the study groups (trapeziometacarpal joint prosthesis vs interposition arthroplasty) had similar amplitudes of motion in trapeziometacarpal joint flexion–extension, abduction–adduction, and thumb opposition in both hands.

At all the postoperative evaluations, patients with the trapeziometacarpal joint prosthesis had larger amplitudes of motion in all dimensions compared with that of interposition arthroplasty patients (Fig. 4). In trapeziometacarpal joint flexion–extension, prosthesis patients had significantly increased ROM 6 months postoperatively ($p = .043$), and after 12 months ROM had reached the amplitude of the asymptomatic contralateral hand ($p = .406$). Similarly, the abduction–adduction was improved after 6 months ($p = .012$) and was comparable with that of the asymptomatic contralateral hand after 12 months ($p = .988$). During the first 6 months postoperatively, thumb opposition was dramatically improved and had reached the values of those of the contralateral thumbs ($p = .794$).

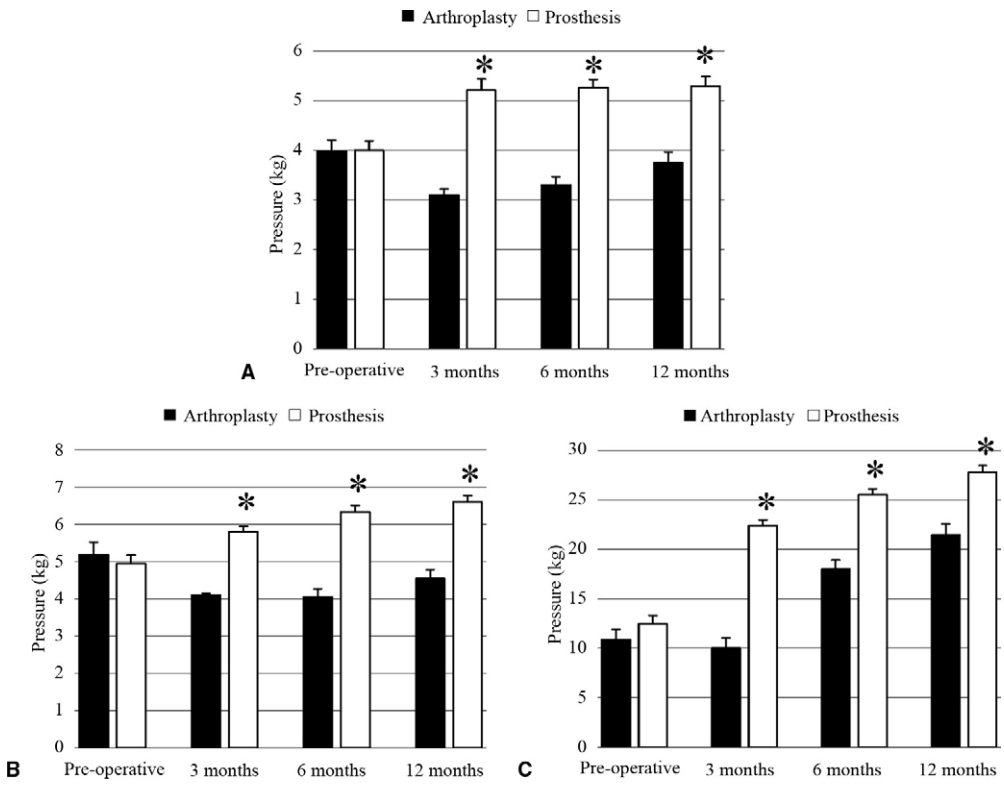

FIGURE 3: A Tip-pinch pressure, **B** key-pinch pressure, and **C** hand-grip pressure were measured. Joint replacement surgery resulted in increased strength in all 3 parameters. Twelve months postoperatively, the hands with a joint prosthesis had the same strength as the nonsymptomatic contralateral hand. Tendon interposition arthroplasty immediately resulted in decreases of both tip-pinch pressure and key-pinch pressure, whereas the hand-grip strength was not improved until after 6 months postoperatively. At all time points, patients with joint prosthesis had faster improvements and had more strength than did patients with tendon interposition arthroplasty (*, $p < .05$).

Patients with interposition arthroplasty did not improve flexion–extension function. The abduction–adduction ROM was transitionally decreased in the interposition arthroplasty group. However, 12 months postoperatively, the abduction–adduction function had returned to the preoperative level, which was still inferior to the ROM of the contralateral hand ($p < .01$).

Radiographic parameters

Twelve months postoperatively, there was no evidence of osteolysis around the metacarpal stems (Table 3). Two patients demonstrated small (2–3 mm) areas of less-dense bone matrix at the bottom of the trapezial cups. In both patients, the areas could only be demonstrated in only 1 radiologic projection, and they were not related to any clinical complaints.

Comparing radiographs obtained 1 week postoperatively with those obtained 12 months postoperatively, we were not able to demonstrate gross macroscopic migration of metacarpal stems and trapezial cups (Table 3). Thus, we conclude that the prosthesis components are well integrated and fixated in the bone.

Complications and implant failures

Tendon problems were the most frequent complication (Table 2). Within the first 5 months after surgery, 2 patients with a joint prosthesis and 5 patients with an interposition arthroplasty developed de Quervain's tenosynovitis. No patients with a joint prosthesis had tendon ruptures or adhesion problems. Two months after operation, 1 patient in the interposition arthroplasty group had a rupture of the flexor carpi radialis anchorage. Thus, there were no statistical differences between the groups in complication rates.

One patient had implant failure of the cup. Five weeks after surgery, this patient pulled the cup out of the trapezium as a result of repeated heavy work using a heavy sledgehammer. The operation was converted to a tendon interposition arthroplasty with a good result.

Study groups

There were no differences in age, gender, or degree of trapeziometacarpal joint osteoarthritis of the patients included in the 2 study groups (Table 1).

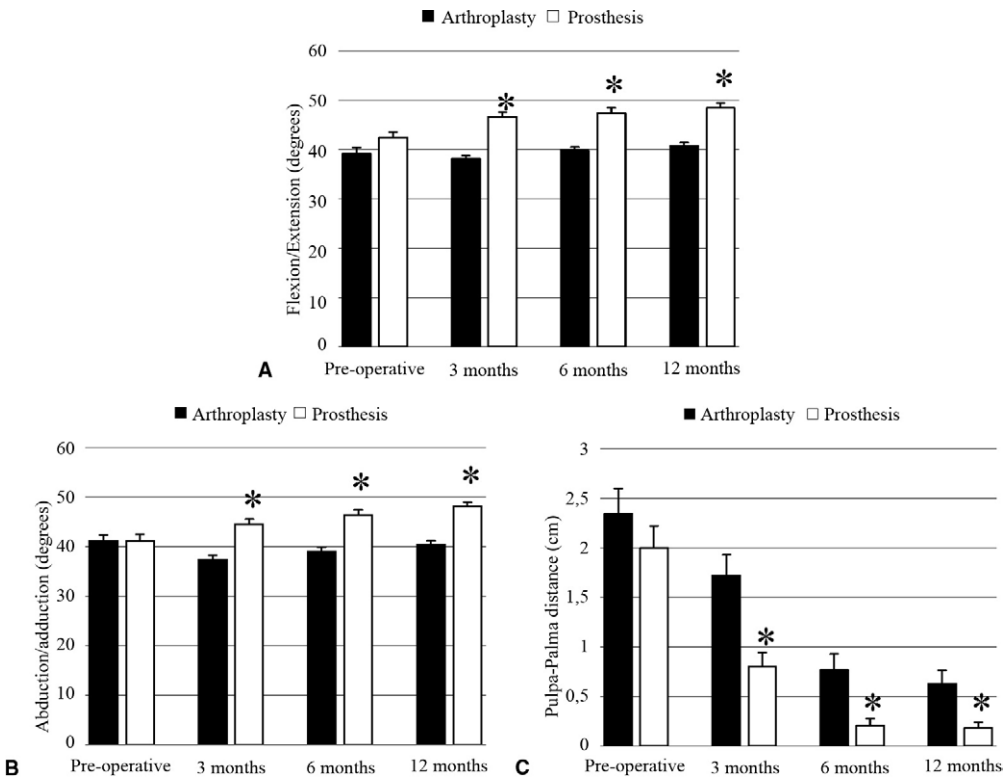

FIGURE 4: Range of motion in **A** flexion–extension, **B** abduction–adduction, and **C** thumb opposition was determined. Joint replacement surgery resulted in restoration of normal ROM in all modalities. Tendon interposition arthroplasty improved thumb opposition, but neither flexion–extension nor abduction–adduction amplitudes were enhanced. Joint replacement surgery resulted in superior ROM compared with that of tendon interposition arthroplasty (*, $p < .05$).

TABLE 3. Radiologic Evaluation of Prosthesis Osseous Integration and Fixation After 1 Year

	Metacarpal Stem	Trapezial Cup	p Values
Integration			
Periprosthetic osseous contact	36	34	
Periprosthetic osteolysis	0	2	<.001
Fixation			
No gross movements	36	36	
Presence of gross movements	0	0	<.001

The majority of patients in both groups are satisfied with the results of treatment. Hence, 87% of the patients with interposition arthroplasty and 94% of the patients with the joint prosthesis found that the surgery and the postoperative rehabilitation were worthwhile ($p = .317$).

Patients with a joint prosthesis return more quickly to usual working level with shorter sick leave than do patients with an interposition arthroplasty (6 weeks ± 1 vs 14 weeks ± 4, respectively; $p = .040$).

DISCUSSION

The current study demonstrates that an uncemented, hydroxyapatite-coated, ball-in-socket designed trapeziometacarpal joint prosthesis as a treatment for thumb basal joint osteoarthritis provides (1) faster and better pain relief, (2) stronger grip functions, (3) improved ROM, and (4) faster convalescence than does traditional tendon interposition arthroplasty. Additionally, we did not find differences in complication rates between the 2 groups. However, in this report, a total number of 37 patients with implants were included; 36 with good/excellent results and 1 failure. The investigation was performed as a prospective clinical therapy investigation with a follow-up period of 12 months.

Various surgical procedures have been described for treatment of stage 3 and 4 osteoarthritis of the basal joint of the thumb.[19] A recent meta-analysis of surgery of trapeziometacarpal joint osteoarthritis by the Co-

chrane Database of Systemic Reviews analyzed the results of 5 surgical procedures including joint replacement with Swanson silicone prosthesis.[19] Despite diversity in study designs, materials, and methods, the conclusion was that none of the techniques were superior to the others.[19] The literature regarding total trapeziometacarpal joint prosthesis arthroplasty is rather limited, and comparisons between studies are impossible because of unclear indications and nonhomogeneities of outcome parameters. The de la Caffiniere prosthesis, which is a cemented total joint prosthesis developed in the late 1970s, is probably the most widely used and studied of the trapeziometacarpal joint prostheses.[20,24,28,34–38] The de la Caffiniere prosthesis has demonstrated a tendency to aseptic loosening in active patients younger than 60 years (failure rates from 18% to 44%).[28,35,38] The aseptic loosening of the cup might be a result of aggressive reaming of the trapezium and use of cement, which compromises the blood circulation of the trapezium.[34] Furthermore, the de la Caffiniere prosthesis does not restore basal joint stability, thumb strength, and ROM but is described to be associated with joint stiffness and (sub)luxations.[20,24,28,34–38] Even though a broad spectrum of other joint prostheses have been used, the indications and outcomes of the implants are not reported frequently, and hence their clinical implications are not based on adequate levels of evidence.[21–29]

In this study, the Elektra joint prosthesis has been used, as it accomplishes the criteria of modern prosthesis design. Previously, this prosthesis has only been evaluated by the inventor in a report presenting the results of his first 100 patients with an average follow-up period of 54 months.[30] Parameters of pain, ROM, and strength were improved by the joint prosthesis, and the overall success rate was 83%. The major complication was lack of osteointegration of the trapezial cup, resulting in aseptic loosening in 15 patients. In 14 of these cases, the aseptic loosening had developed within the first 9 months after surgery.[30] This indicates problems with the initial anchorage of the trapezial implant. This might be due to suboptimal orientation and bone-embedment of the trapezial cup. An early trapezial cup without hydroxyapatite coating had been used in some of these patients (Regnard PJ, personal communication). In the current study, we have used the latest version of the Elektra prosthesis with hydroxyapatite coating of the trapezial cup and of the metacarpal stem.

The results of our clinical study demonstrate that the unconstrained, uncemented, hydroxyapatite-coated total joint prosthesis quickly restores pain-free, stable motion at the basal joint of the thumb with improved strength at levels of the asymptomatic contralateral thumb. Within the first year postoperatively, the uncemented, hydroxyapatite-coated joint prosthesis did not seem to be associated with major complications (Tables 2 and 3).

Even though patients with a tendon interposition arthroplasty benefited from surgery in terms of reduced pain, there was no evidence of improvements of either thumb ROM or strength. These results are analogous with previous investigations of this treatment.[39–41] Hence, patients with a tendon interposition arthroplasty demonstrated decrease in tip-pinch pressure, key-pinch pressure, and hand-grip pressure 3 months after surgery compared with preoperative values. This could be explained by residual pain and/or the fact that the thumb is shorter because of the trapeziectomy.

Our data indicate that the improvements in the outcome parameters seem to have a more rapid onset in patients with a joint prosthesis than in patients with a tendon interposition arthroplasty. Prosthesis surgery seems to offer rapid recovery and minimal need for rehabilitation. Even though the joint prosthesis surgery per se is more expensive because of the costs of the prosthesis (the "retail" price for the Elektra prosthesis is approximately €1,600), the patients require less hand therapy and fewer postoperative analgesics, and they return to their jobs earlier than do patients with a tendon interposition arthroplasty. This implies that there might be a socioeconomic benefit for both the individual patient and for society in favor of the prosthesis surgery.

We have compared the results of joint prosthesis surgery with tendon interposition arthroplasty in a prospective follow-up study. After having received verbal and written information regarding the 2 operative procedures, the patients were allowed to choose freely between the 2 types of treatment. Important patient characteristics such as gender, age, and severity of osteoarthritis (Table 1) as well as the preoperative values of the outcome parameters of the 2 study groups were similar in the 2 groups. However, the current study was not designed as a randomized clinical trial; thus, there might be unequal distribution of unknown biases, which may conflict with the results. Therefore, high-quality prospective, randomized clinical trials are required.

In Table 1, the follow-up frequency 1 year after surgery is given. One patient in each group had died from reasons not related to surgery. Five of the 7 patients with interposition arthroplasty and 4 patients with trapeziometacarpal joint prosthesis did not answer calls for evaluation. We have no information on the

reasons for these dropouts that might imply a bias to the study. However, there was no statistical difference between the groups in the follow-up frequencies. The remaining 3 patients were prohibited from participation in evaluation due to serious illness or change of address.

In this article, our data describe results during the first year postoperatively. Data from our first 6 joint prosthesis patients, which have approximately 4 years of follow-up, still demonstrate excellent pain-free full-range motion with no radiologic signs of implant loosening or periprosthetic osteolysis (data not shown). Finally, in case of insufficiency of the joint prosthesis, the classic tendon interposition arthroplasty[32] is available as a salvage procedure with an acceptable clinical outcome.

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