stability or mobility when they compared the palmar and the dorsal approaches.

Our study has shown that this new ceramic unconstrained prosthesis for replacement of the PIP joint provides considerable pain relief, improved strength, ROM, ADL, and occupational performance and satisfaction for patients with performance (COPM) in the short-term postoperatively, so further long-term studies are required.

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Table III. Grip strength preoperatively and at 12 months postoperatively.

Case No.	Pulp pinch force (N) before operation	and at follow-up	Tripod pinch force (N) before operation	and at follow-up	Key pinch force (N) before operation	and at follow-up
1	25	36	37	49	41	71
2	0	0	0	0	0	0
3	45	55	75	85	85	90
4	6	16	6	23	15	35
5	18	31	45	60	39	64
6	12	20	12	26	30	58
7	6	10	6	13	15	29
8	36	34	43	28	58	80
9	64	82	63	63	102	111
10	19	40	51	34	24	40
11	28	33	41	50	45	74
12	0	0	25	13	37	31
13	66	64	93	87	80	85
14	34	63	29	63	79	92
15	28	56	30	22	68	60
16	56	66	22	30	60	71
17	3	10	1	9	4	15
18	41	36	54	38	66	58
19	20	42	45	47	37	72
20	67	87	42	55	43	77

Discussion

This prospective study includes only a short follow-up (one year). However, other studies have indicated that the results do not deteriorate but stabilise after a year postoperatively [3,13–15]. Our results show a significant increase in ROM, different measures of grip strength, and scores for ADL and COPM. Our results confirm the early results of the use of osseointegrated prostheses reported by Möller et al. [11]. In more recent studies they have reported good long-term results for osseointegrated PIP joint prostheses, but they had problems with the mechanism of the joint [9,16].

In our series, two of 20 prostheses showed clinical and radiographical signs of loosening at the 12-month follow-up. One patient had heterotopic bone formation, subsidence of the prosthesis, and also had a stiff joint but no pain. One patient had radiolucent lines around the prosthesis, had lost grip strength and had pain on motion. Several studies have indicated that there seems to be no serious deterioration after a year postoperatively. We had few complications, which is in agreement with previous studies of PIP joint arthroplasties [11,13]. The best results were obtained in the subset of elderly women with osteoarthritis. In most reports patients with osteoarthritis and post-traumatic arthritis fare better than patients with rheumatoid arthritis [2,11,15]. Mathoulin and Gilbert [17] reported good results for Silastic Sutter arthroplasties in post-traumatic joint destruction in young patients, who were operated on within about three months of the injury. These results contrast with those of Lin et al. [2], who found no increase in ROM after silicone replacement arthroplasty of PIP joints. Hage et al. [4] also reported poor objective results after silicone arthroplasty for post-traumatic arthritis. The time lapse between injury and operation, however, was about 25 months. It is possible that early intervention is beneficial in post-traumatic cases [18] but in our series, 10 of 20 prostheses with a 40° ROM or less preoperatively seem to gain the most from operation. Similar figures have been reported by Möller et al. [11]: 14 of 22 joints improved, most with a preoperative ROM of less than 40°. In Johnstone's study [13], 11 of 20 PIP joints had a ROM of less than 40°, and only four of these did not improve at all. In 2002, Ghidella et al. [19] showed that the best responder is a patient with a preoperative maximum flexion measurement of $<43°$. We are convinced that our results show that there is a vast difference in indications for operation between those with post-traumatic arthritis and those with osteoarthritis.

Several surgical approaches, including central slip sparing, central slip splitting, dorsal chevron flap, and palmar approach, have been described [7]. We used the central slip splitting technique, which is particularly useful in cases of more severely involved joints [8]. The central slip insertion and the collateral ligaments were preserved on the dorsal rim. This was possible because of minimal bony resection from the middle phalanx. We found that lax collateral ligaments seem to improve with reconstruction of the joint architecture peroperatively. Similar findings were reported by Möller et al. [11] and Johnstone [13]. Herren and Simmen [20] found no changes in

structured interview was given in which the patient identified problems with their occupational performance and ranked them. They scored their performance within these problems, and their satisfaction with their performance. Evaluations were made both initially and after the completed period of treatment. Ten-point scales were used ranging from 1: "not able to do it" or "not satisfied at all", to 10: "able to do it extremely well" or "extremely satisfied". Postoperatively, the finger was held in a neutral position for the first day.

Postoperative rehabilitation programme

A mobilisation programme was started during the first postoperative day. A dynamic splint was used that permitted flexion under resistance, and also reinforced stability in extension in radial and ulnar deviation. This splint was removed six weeks postoperatively. Motion gradually improved and the goal for the 6-week follow-up was a range of motion of 0°–70°. Minor activities without weight loading were allowed at 8 weeks. At the 3-month follow-up, there was no restriction except pain as a limiting factor in daily activities and work. A clinical evaluation was made at 6 months, and an additional training programme or technical advice or equipment were added or optimised. At 12 months, all the preoperative investigations included were re-examined (Table II).

Statistical analyses

Statistical analyses were made preoperatively and at the 12-month follow-up with multiple repeated measures MANOVA to compare pain during different activities and at rest, in active daily living, and correlate it to age, sex, and diagnosis. For example, we compared osteoarthritic joints and rheumatoid arthritic joints. Repeated-measures ANOVA were used for the COPM, grip strength, and range of motion.

Results

Range of motion

The mean active range of motion (ROM) of the PIP joint improved significantly from 43° active arc of motion preoperatively to 60° postoperatively ($p = 0.001$). The total ROM including the MCP (metacarpophalangeal joint), PIP (proximal interphalangeal joint), and DIP (distal interphalangeal joint) improved significantly, from 163° to 181° postoperatively ($p < 0.001$) (Table II). The extension lag decreased significantly, from 17° to 9.5°. Multivariate analysis of variance (MANOVA) showed a significantly better outcome in osteoarthritic joints compared to rheumatoid joints in relation to pain during activities of daily living (ADL) ($p = 0.004$), and grip strength and ADL ($p = 0.01$). Similar results were noted in the subset of older patients (>60 years) compared with younger ones in relation to grip strength and ADL ($p = 0.02$) and COPM scoring ($p = 0.004$) and women had significantly better results than men for grip strength and ROM ($p = 0.03$), and COPM scores ($p = 0.001$) postoperatively.

Grip strength

Mean grip strength ($p = 0.002$), pulp pinch ($p < 0.001$), and key pinch force ($p < 0.001$) increased significantly postoperatively, and tripod pinch force ($p = 0.217$) increased, though not significantly so (Table III).

COPM scores

The patients' perception of their occupational performances, as assessed by COPM improved significantly from a preoperative mean score of 3.6 (range 1.4–6.6) for satisfaction, to a postoperative score of 6.6 (range 2.8–9) postoperatively ($p < 0.001$), and in performance from a preoperative score of 3.8 (range 1.8–7.2) to a postoperative score of 6.3 (range 2.6–10) ($p < 0.001$) (Table II).

Radiography

Two loose implants were found with a subsidence of the distal implant. In one case, additional heterotopic bone formation surrounded the implant.

ADL scoring

There were significant improvements postoperatively in each score for pain at rest ($p = 0.003$) and during different activities ($p = 0.005$). There was also significant improvement in each score for different daily activities, leisure, housekeeping, and at work (Table I).

Complications

No infective or healing complications were seen and no reoperation was required during the follow-up period.

One patient had severe osteoarthritic pain in the first carpometacarpal joint and could therefore not participate in the measurements of grip strength.

Two patients lost grip strength and ROM but scored better for ADL and COPM scoring.

Table II. Functional scoring, grip strength, and range of motion preoperatively and 12 months postoperatively.

Case No.	Performance before operation and at follow-up on COPM*		Satisfaction before operation and at follow-up on COPM*		Range of motion (PIP joint) before operation and at follow-up		Range of motion (MCP, PIP, DIP joints) before operation and at follow-up		Grip strength (N) before operation and at follow-up	
1	3.6	6.2	4.8	7.8	20–70	30–80	150	170	159	149
2	2.0	4.6	1.4	4.6	40–80	20–85	170	205	56	54
3	1.8	5	2.4	6	5–55	0–60	170	185	371	437
4	3.2	4	2.7	4	30–90	15–75	190	205	16	72
5	3.8	8.4	2.6	9	30–70	30–80	150	190	209	256
6	5.2	7.4	4	7.4	0–100	0–90	225	225	100	184
7	3	7	2.3	8.3	25–45	0–20	155	145	31	43
8	4	8	4	8	0–60	0–90	210	220	117	144
9	6	7.6	6.6	7.3	30–55	30–65	115	130	383	432
10	4	10	3.7	9	10–55	0–75	140	175	85	117
11	4.3	7	3.6	7	5–65	0–70	200	230	140	170
12	3	7.6	3.3	8.3	20–80	0–90	205	210	123	114
13	5	5.7	5.7	6.2	30–80	20–60	210	190	465	455
14	7.2	8.3	5.5	8.3	15–90	0–85	210	225	305	349
15	3	6.3	3	6.3	20–40	15–55	90	120	29	105
16	2.6	4.2	2.6	4	25–40	0–65	120	145	105	169
17	2.6	2.6	2.8	2.8	0–0	25–40	60	90	17	27
18	4.4	4.4	2.8	3.6	15–70	5–70	225	210	288	217
19	3.1	6	3.5	6.5	0–0	0–50	120	160	83	127
20	3.6	6.6	4.3	7.9	20–60	0–80	140	190	305	365

*COPM =The Canadian Occupational Performance Measure (Ten point scale 0–10).

proximal components and the biconcave distal components.

Surgical technique

Patients were operated on under intravenous regional anaesthesia with tourniquet control. One author (KP) did the whole operation through a dorsal approach, splitting the extensor tendon longitudinally. The central slip was not detached but peeled off so that most of its insertion was spared. The collateral ligament was peeled off its attachment around the head of the proximal phalanx, but preserved more proximally. The head of the proximal phalanx was excised with a small oscillating saw. The base of the middle phalanx was then removed tangentially, and the central slip insertion preserved at the dorsal rim. A small Kirschner wire was driven along the central axis of the middle phalanx through the distal interphalangeal joint, and then back again along the proximal phalanx, as a guide for the cannulated drill so that it would be centred as well as possible under fluoroscan control. The Kirschner wire was then cut in the joint space, and the medullar canal was drilled in both directions. The wires were removed and the canal was put under pressure with a punch. The distal prosthesis was first inserted with a press-fit technique, the gap was estimated and, if necessary, the proximal phalanx was resected further. The proximal component was then inserted in a similar way. The extensor mechanism was sutured after the joint had been locked in position and checked radiographically. Neither the collateral ligaments nor the central slip had to be repaired in any case. Partial ruptures of the collateral ligaments and the central slip do not affect stability; on the contrary, reinforced ligaments may result in restricted flexion [11].

Protocol follow-up

Patients were followed up at 2 weeks, 6 weeks, 8 weeks, 3 months, 6 months, and 12 months' postoperatively. An independent physiotherapist and an occupational therapist examined all patients preoperatively. Grip strength, pulp pinch, key pinch, and tripod pinch were measured with Grippit (AB Detektor, Göteborg, Sweden) [12]. A questionnaire was used with different visual analogue scales that were graded 0–10 that comprised four different pain scales that assessed pain during different activities and at rest; six scales that assessed the performance of different daily activities; and four scales that assessed activities of daily living, work, housekeeping, and leisure time.

Additional scores were used to evaluate patients' participation in the goal formulation process, the Canadian Occupational Performance Measure (COPM). In this patient-centred outcome instrument, patients evaluated their occupational performance and satisfaction with their performance in areas of self-care, productivity, and leisure. A semi-

permanent fixation of the prosthesis to adjacent bone [9]. However, postoperative complications still remain to be solved, e.g. stiffness, pain, heterotopic bone formation, subsidence, prostheses breakage, and loosening [6].

In this prospective study, we investigated the clinical value of a new PIP prosthesis (MOJE-Prosthesis). Our assumption was that this unconstrained design would give more physiological articulation and divert part of the transverse and axial torque [10] from the endosteal interface of the prosthesis to the collateral ligaments and the extensor mechanism. This ceramic prosthesis with an hydroxyapatite coating in contact with the cortex is thought to encourage fixation of bony ingrowths and to prevent further loosening of the prosthesis.

Patients and methods

Patients

Twenty consecutive PIP joints were replaced between November 2000 and November 2002. All patients were followed up for a minimum of a year postoperatively and were assessed preoperatively and postoperatively by an independent physiotherapist and an occupational therapist who evaluated grip strength, range of motion, pain at rest and during different activities of daily living (ADL), and occupational scoring (COPM Canadian Occupational Performance Measure) (Tables I, II). All patients were re-examined 12 months postoperatively. All patients had radiographs taken preoperatively, postoperatively, and at 12-months' follow-up. Twelve women, mean age 59 years (range 50–72) and eight men, mean age 50 years (range 38–68) were included in the study. Indications for operation were destruction of the joint with pain, instability, or stiffness. Thirteen of the patients had osteoarthrosis, five had rheumatoid arthritis, one had a post-traumatic infection, and one had traumatic arthrosis.

Implant

The new ceramic unconstrained two-component implant (MOJE) with a hydroxyapatite coating was designed to require minimal resection of bone, and intended to improve fixation of bony ingrowth, but it has still not proved to be effective in small hand bones [6]. The unguided implant is a press-fit unconstrained prosthesis that allows lateral movement but is stable in radial and ulnar tilt. This also enables the joint to rotate a little during flexion and imitates its natural joint motion [10]. This might produce fewer resulting forces in the stem of the cortase of the prostheses [6]. This early model of the prosthesis was available in only one size; this has now been replaced by a modular system with differently sized stems and biconvex heads of the

Table I. Pain at rest and during different activities preoperatively and 12 months postoperatively. Visual analogue scales 0–10 (0 = best possible and 10 = worst possible).

Case No.	Indication*	Joint	Pain at rest before operation	Pain at rest at follow-up	Pain after repeated movements before operation	Pain after repeated movements at follow-up	Pain after lifting before operation	Pain after lifting at follow-up	Maximum pain before operation	Maximum pain at follow-up
1	OA	dig III dx	5	0	5	0	8	4	8	2
2	OA	dig IV sin	4	0	6	1	6	1	8	1
3	PTA	dig IV sin	1	0	2	0	4	3	5	3
4	OA	dig IV dx	8	1	8	4	8	2	8	6
5	OA	dig II dx	0	0	7	1	10	0	10	0
6	RA	dig III dx	2	0	3	4	4	2	6	4
7	OA	dig III sin	6	1	10	8	10	10	10	10
8	RA	dig III dx	4	0	8	2	9	3	9	3
9	OA	dig III sin	1	0	2	0	3	0	5	0
10	OA	dig III sin	0	0	2	0	0	0	0	0
11	OA	dig IV sin	0	1	2	1	7	3	8	3
12	RA	dig II sin	3	3	3	3	2	4	3	5
13	OA	dig V dx	0	2	3	5	6	7	8	8
14	OA	dig III sin	2	0	0	0	6	1	9	1
15	OA	dig III sin	4	0	6	0	7	0	7	0
16	OA	dig IV sin	2	1	1	1	5	1	8	1
17	RA	dig IV dx	2	1	0	0	7	3	8	1
18	RA	dig III dx	3	6	7	8	8	8	8	9
19	PTA	dig V sin	8	0	8	0	7	1	8	2
20	OA	dig III sin	5	0	6	0	8	1	8	1

*PTA = post-traumatic arthrosis, OA = osteoarthrosis, RA = rheumatoid arthritis.

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ORIGINAL ARTICLE

Replacement of proximal interphalangeal joints with new ceramic arthroplasty: A prospective series of 20 proximal interphalangeal joint replacements

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Abstract

A prospective consecutive series of 20 proximal interphalangeal (PIP) joints replaced with a new ceramic unconstrained prosthesis (MOJE) included 13 patients with osteoarthrosis, five with rheumatoid arthritis, and one each with post-traumatic infection and traumatic arthrosis. All patients were assessed preoperatively and postoperatively at one year by an independent physiotherapist and an occupational therapist who evaluated grip strength, range of motion, activities of daily living (ADL) and occupational scores (COPM Canadian Occupational Performance Measure). The mean range of motion of the PIP joint improved from 43° to 60° ($p = 0.001$), and the mean grip strength from 169–199 N ($p = 0.002$). The patients' self-perception of occupational performance, assessed by the COPM, improved significantly from 3.6–6.6 ($p < 0.001$) for satisfaction, and 3.8–6.3 ($p < 0.001$) for performance. The MOJE PIP joint replacement provides significant pain relief, improved strength and range of motion, and short-term satisfaction. Further long-term studies are therefore advocated.

Key Words: *PIP joint replacements, arthroplasty, unconstrained, ceramic*

Introduction

The proximal interphalangeal (PIP) joint has long been a challenge in arthroplastic surgery. However, joint replacement is nowadays an established way of treating destroyed and painful PIP joints. A joint can be destroyed as a result of inflammatory joint disease, osteoarthritis, intra-articular fractures, or infection, and the most common treatment for such a joint, with limited motion, is still arthrodesis, even though the lost mobility results in considerably impaired function of the hand, and the reason for that might be that the few publications about PIP joint replacements have not been encouraging. The most widely used implant for arthroplasty is the flexible silicone rubber Swanson implant, which is the most studied prosthesis for reconstruction of rheumatoid PIP joints. Swanson et al. [1] reported a series of 424 PIP joint arthroplasties in 183 patients, and showed quite promising results, but only 52% were available for review; such good results have not been repeated in other studies [2–4]. Adamson et al. concluded that Silastic prostheses have a limited role in the treatment of PIP joints in patients with osteoarthritis or rheumatoid arthritis [5]. Since then several anatomical semi-constrained prostheses made of various materials have been introduced with varying results [6,7]. The rationale behind the new generation PIP arthroplasty is that an unconstrained, unlinked prosthesis imitates the normal anatomy and physiology of the joint. The collateral ligaments are preserved and, with the extensor tendon, they balance the flexion and rotational forces. In theory, this increases the stability of the arthroplasty in a way that cannot be done with Silastic spacers alone. In papers published more recently, Swanson and de Groot Swanson have advocated fusion of the PIP joint of the index finger for disabled index as well as middle fingers [8]. Greater durability can now be expected than in the case of earlier designs. Today's osseointegration principle may offer

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