Osteosynthesis and Trauma Care

formerly Osteosynthese International
founded in 1993 by Vilmos Vécsei

Editorial Office

Prof. Dr. med. V. Vécsei
Universitätsklinik für Unfallchirurgie
Währinger Gürtel 18–20
1090 Vienna, Austria
Tel.: +43-1-4 04 00-59 02
Fax: +43-1-4 04 00-59 49
E-mail: vilmos.vecsei@akh-wien.ac.at

Volume 10 2002

Georg Thieme Verlag KG
Rüdigerstraße 14
70469 Stuttgart, Germany
www.thieme.de/osteotrauma
www.thieme-connect.de

S. Ruf[1]
W. Baer[2]

Arthroplasty of the Proximal Interphalangeal Joint with a New Ceramic Implant

Abstract

Background: Treatment of finger joint destruction still remains an unsolved problem in hand surgery. Arthrodesis, which restricts life quality of the patient to a large extent, is often the only therapeutic option. Numerous implants have been tested in the past decades, yet results were never really satisfactory.
Methods: Between May 1999 and December 2000 we operated 15 patients and implanted 16 newly developed total joint replacements made of ceramic (the Moje prosthesis). 13 patients and 14 joint replacements were reexamined and results were evaluated.
Results: Mean time of follow-up was 11.2 months (one to 19.5 months). Active range of motion in the operated proximal interphalangeal joint ($p < 0.001$) and grip strength compared to the contralateral side ($p = 0.011$) increased significantly. Evaluation of the postoperative outcome perceived by the patients was measured according to the DASH score and showed a significantly improved function of the hand ($p = 0.001$).
Conclusion: Our results after total joint replacement using the Moje prosthesis are highly promising. Long-term studies are necessary to confirm our very positive experiences.

Key words
Prosthesis · Moje · Total joint replacement · Finger

Introduction

In destruction of the proximal interphalangeal joint (PIP-joint) due to trauma, rheumatoid arthritis or primary arthrosis, arthrodesis remains the therapy of choice in many cases [8]. However, this means a significant loss of active function of the affected finger and the hand as a unit. Resection arthroplasties show poor results in long-term follow-up studies and are not recommended as a standard treatment of PIP-joint destruction [14]. A very common procedure includes a resection arthroplasty combined with the implantation of a Swanson silicone spacer. Yet several complications like fracture of the implant, loosening and foreign body reactions due to silicone particles are associated with this hinge prosthesis [6]. Still it remains the standard implant for destruction of the metacarpophalangeal and proximal interphalangeal joint since no superior prosthesis was available up to now. Countless designs of new total joint replacements like the Flatt prosthesis [2], the Biomeric implant [11] or the DIGITOS finger joint prosthesis [10] were not up to standard. Main goal in the treatment of finger joint replacement must be the creation of a functioning joint with a solid anchoring of the implanted prosthesis. Prerequisite is a solid compound between the surface of the prosthesis and the adjacent bone. Furthermore, the implanted prosthesis must not be a hinge design in order to minimize the resulting forces exerted on the implant. In the search for an arthroplasty that meets the necessary requirements we tested a new total ceramic joint replacement – the Moje prosthesis.

The Moje implant is a non-cemented, unguided total finger joint prosthesis named after its inventor. It has never been described in the literature before. The prosthesis is made of two components: the proximal cylinder is convex-shaped; the distal is concave shaped with the same radius (Fig. **1**). The prosthesis is implanted in press-fit technique into the medullary spaces after resection of the head of the proximal phalanx and the base of the middle phalanx. Both components of the prosthesis are made of a single block of bioinert zirconium oxide ceramic. This special

Affiliation
[1] Praxis für Plastische und Handchirurgie, Regensburg, Germany
[2] Klinik für Handchirurgie und Plastische Chirurgie (Dr. R. Martin), Kliniken Dr. Erler, Nürnberg, Germany

Correspondence
Dr. Stefan Ruf · Praxis für Plastische und Handchirurgie · Ludwigstrasse 8 · 93047 Regensburg · Germany ·
Tel.: +49-941/586250 · Fax: +49-941/586251 · E-mail: stefan.ruf@plastische-und-handchirurgie.de

Bibliography
Osteo Trauma Care 2002; 10: 155–159 © Georg Thieme Verlag Stuttgart · New York · ISSN 1618-971X

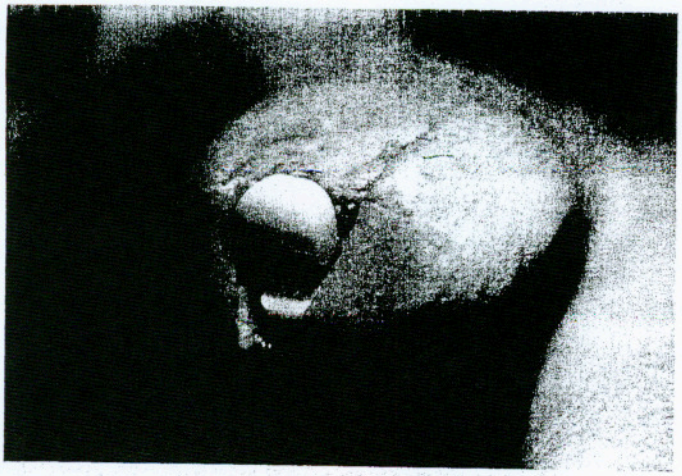

Fig. 1 Intraoperative situs with implanted Moje prosthesis.

form of ceramic is increasingly used in total joint replacement of the hip, the knee, the toes and the shoulder [15]. Zirconium oxide ceramic is a biocompatible material, which is not toxic or allergenic and shows no signs of immune response.

The contact area between the prosthesis and the corticalis of the bones is coated with a special apatite ceramic called Bioverit I, which is sintered on the surface of the implant at a temperature above 1200 °C. This unique coating is bioactive and forms an interfacial bond with the tissue. This way the implant is anchored in the medullary spaces by press-fit technique and in the contact area with bone by osseointegration.

Animal studies with Wistar rats showed a good biocompatibility and no adverse effects like necrosis, interposition of connective tissue, degenerative changes or foreign body reactions. The gap between prosthesis and bone was filled with new bone material by true osseointegration and not by connective tissue or giant cells as a sign of foreign body reaction. The purpose of the present study was to determine efficacy, functionality and applicability of this prosthesis in the human PIP-joint.

Patients, Materials and Methods

We performed a prospective study concerning the clinical value of a new design for PIP-joint replacement. Indications included pain or loss of motion due to posttraumatic, postinfectious or primary joint destruction. The prosthesis was also implanted in patients with a previous arthrodesis to regain PIP-joint motion. Prerequisites were an intact overlying soft tissue and the absence of an acute or chronic infection in the operation area.

Postoperative care included immobilization of the PIP-joint with a dorsally placed aluminum splint in intrinsic plus position for one week. Passive movements out of the splint were allowed for the following three weeks. After this time the splint was removed and active mobilization was initiated.

Patients were examined in a standardized fashion preoperative and at the time of follow-up. Check-up controls were performed on a regular bases after initial operation.

The standardized examinations included evaluation of finger motion, grip and pinch strength, measured with a dynamometer and compared to the contralateral side, completeness of hand flexion (measured by the distance between fingertip and palm in centimeters) and standard X-rays in two planes. Reduction of pain was measured with the visual analog scale. Postoperative outcome as perceived by the patients was evaluated with the help of the DASH score (**D**isability of **A**rm, **S**houlder, **H**and) [4].

Between May 1999 and December 2000 we operated 15 patients and implanted 16 prostheses. 13 patients and 14 implants could be reevaluated according to our study protocol. One patient moved due to a new employment and could not be reached. In another recently operated patient the prosthesis was dislocated at the time of follow-up examination after having started physiotherapy immediately after operation, so no control results of value could be obtained.

Preoperative and follow-up results were compared and the following criteria were tested upon statistical significance:

- Pinch strength compared to the contralateral side.
- Grip strength compared to the contralateral side.
- Range of motion in the PIP-joint.
- Distance between fingertip and palm of the involved finger (FPD).
- DASH score values.
- Visual analog scale in rest, in motion and under stress.

Pairs were examined according to the Kolmogorov-Smirnov test for normal distribution. Statistical significance was then tested in normally distributed values with the Student's t-test and in not normally distributed values with the Wilcoxon test for matched pairs. Significance was accepted at a level of $p < 0.05$.

Results

13 patients and 14 implants were reexamined according to a standardized study protocol. Average follow-up was 11.2 months (range one to 19.5 months). Male to female ratio was eight to five. Mean age at the time of operation was 44 years (range 20 to 60 years). The mean time of hospitalization amounted to 5.86 days (range four to eight days). Implantation was performed six times in primary arthrosis, four times in posttraumatic joint destruction, twice in postinfectious joint destruction and twice to regain function after previous arthrodesis.

Improvement of finger motion

Postoperative active flexion in the PIP-joint increased from 51.92° (range 20° to 80°) preoperative to 76.07° (range 59° to 95°). Active range of motion increased from 24.23° (range 0° to 65°) to 58.93° (range 20° to 95°) in the operated PIP-joint ($p < 0.001$). The distance between the fingertip and the palm of the affected finger measured in centimeters as the degree for complete ability of grasping decreased from 3.89 cm (range 0 cm to 9 cm) to a postoperative mean value of 0.75 cm (range 0 cm to 4 cm), which was statistically significant ($p < 0.001$).

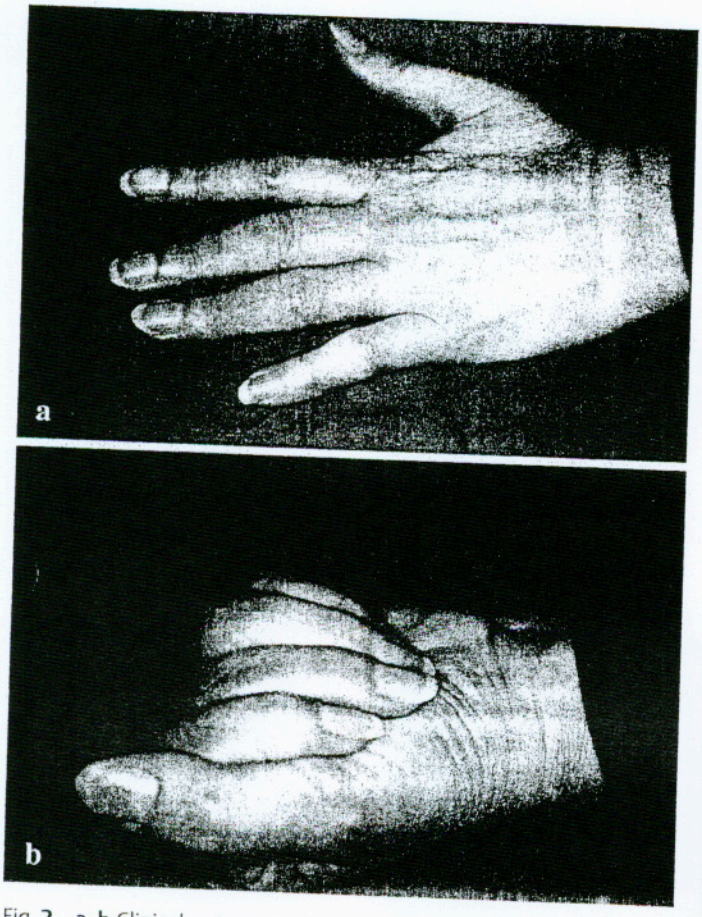

Fig. 2 **a, b** Clinical outcome with complete range of motion after the implantation of two prostheses. Patient is highly satisfied with her total joint replacements.

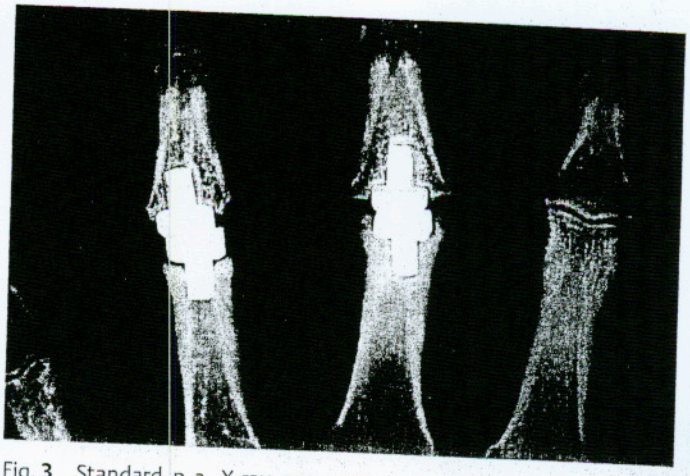

Fig. 3 Standard p.a. X-ray one year postoperative after total joint arthroplasties. Indications were painful primary arthrosis.

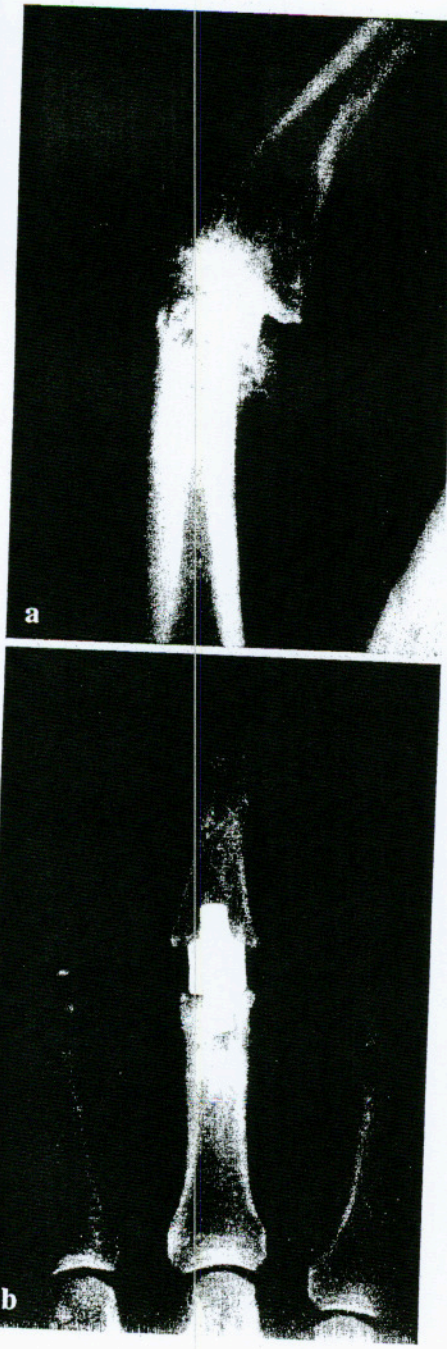

Fig. 4 **a, b** Standard radiographs preoperative and one year postoperative.

These results show a significant improvement of finger and hand function (Figs. **2a**, **b**).

Increase in strength

Grip strength compared to the contralateral side increased significantly ($p = 0.011$) from an average of 51.19% (range 54.19% to 104.44%) to 73.61% (range 14.29% to 124.44%). Pinch strength compared to the contralateral side rose from 76.36% (range 0% to 114.29%) to 86.43% (range 44.44 to 114.29%). This was statistically not significant ($p = 0.236$).

Previous injuries

In seven patients previous lesions like nerve injuries, capsule contractures, tendon ruptures, injuries of vessels or open fractures of the affected finger had been treated.

Satisfaction of the patient

Evaluation of pre- and postoperative pain according to the visual analog scale (VAS) showed a significant reduction of pain in rest ($p = 0.012$), in motion ($p = 0.013$) and under stress ($p = 0.001$). The DASH score as a tool to assess the postoperative outcome showed a significant improvement ($p = 0.001$) with a score reduction from 47.56 points (range 47.56 to 71.67 points) to 23.69 points (range 3.33 to 64.17 points).

Radiological findings

In one patient the proximal prosthesis caved in by 1 mm radiologically. However, this finding did not impair clinical function. In another patient with a chain saw injury a radial deviation due to scar tissue occurred, which was corrected postoperatively by interdigital taping. Another patient showed an asymptomatic exostosis. No signs of infection, implant fracture, dislocation or bone resorption were found in reexamined patients (Figs. **3** and **4a, b**).

Complications

Evaluating all implants (n = 16) one prosthesis had to be removed. In the patient we operated last, too early mobilization was performed which led to a local wound dehiscence and luxation of the prosthesis. Unfortunately this patient could not be assessed in our standardized way due to the described findings at the time of our follow-up examination. In another patient we had to perform a revision of the proximal implant and had to resect more of the head of the proximal phalanx. After a more proximal osteotomy the proximal prosthesis was reimplanted. This patient moved to an unknown location so no follow-up examination could be performed. In one patient an intraoperative fracture of the corticalis caused by the pestle occurred. However, the fracture healed without any problems. Some patients perceived a certain sound of friction in the operated joint. This phenomenon ceased about six months postoperation. No other complications were encountered.

Discussion

Total joint replacement has become a common procedure for the treatment of joint destruction in hip, knee and shoulder surgery. In the hand and especially in the finger joints, numbers of joint replacements worldwide are still small due to unsatisfactory long-term results of the available implants. Still, arthrosis of the PIP-joint remains an indication for surgery since conservative methods of treatment are very limited. Current surgical options in the treatment of PIP-joint destruction include resection arthroplasty with or without the interposition of a Swanson silicone spacer, vascularized joint transfer of the toe, arthrodesis or total joint replacement. While the solitary resection arthroplasty not recommended due to unsatisfactory results [14], resection arthroplasty with a Swanson spacer is still very popular in the treatment of rheumatoid arthritis. Although many complications are associated with this prosthesis like implant failure, dislocation, foreign body reactions due to silicone debris and metallosis of the joint capsule [9], it remains the most popular finger joint prosthesis due to the lack of a superior alternative. We tested a new PIP-joint implant, the Moje prosthesis, which is in contrast to the Swanson spacer an unguided implant. Active range of motion achieved with the Moje implant is higher (58.93°) than with the Swanson implant (26°) [3]. In contrast to many other implants that are designed as hinge joints or guided implants [14], the Moje prosthesis is unguided and imitates the normal physiology of the PIP-joint more than a guided prosthesis. Resulting forces often leading to loosening of the implant are minimized with this non-joined design [8]. Different sizes of the prosthesis, which can also be manufactured upon request, are available to enable a size-adapted implantation.

Many different materials have been tested as total joint replacements in fingers. Silicone elastomers and polypropylenes are not recommended in hand surgery [13]. Metal-metal articulation guarantees high endurance and stability. However, friction over many years with the release of metal particles leads to a metallosis with consecutive synovialitis and loosening of the implant [5]. An ideal material seems to be ceramic. The Moje implant fulfills this requirement since it is made of bioinert zirconium oxide ceramic. It possesses a high biocompatibility with no allergic, inflammatory or toxic potential. The amount of released particles through friction is less than in metal-metal articulations [12]. Another advantage of the Moje prosthesis lies in its press-fit technique for implantation in the area of the medullary spaces. No cement is necessary and revision of the implant can be performed if necessary without extensive damage to bone structures. In the contact area between corticalis and implant a tight union develops by means of true osseointegration. The innovative coating of the prosthesis with the bioreactive ceramic Bioverit I in the contact area is responsible for this unique phenomenon. This leads to a higher stability of the joint. In contrast to other total joint replacements only marginal resection of articulating bones is necessary. This way the collateral ligaments remain intact in most cases and joint stability is maintained [7].

The limited length of the plug-in cylinder of the Moje prosthesis makes it possible to replace the metacarpophalangeal joint as well as the PIP-joint in one finger. This plays a major role in patients with rheumatoid arthritis where replacement of the PIP-joint was not possible after total joint replacement of the metacarpophalangeal joint due to the length of the implanted prosthesis [1].

Many others demand intact flexor and extensor tendons as prerequisites for the implantation of a joint prosthesis [8]. In our patients previous injuries did not pose a problem. Five patients had suffered severe hand injuries. Still all had a major benefit concerning improvement of finger and hand function after joint replacement. A primary implantation is, however, not recommended due to wound contamination.

Conclusion

As shown in the present study the Moje prosthesis is a newly developed prosthesis, which is stable, biocompatible, and flexible and has an excellent clinical outcome after surgery. We did not operate patients with rheumatoid arthritis so far, however, we speculate that this patient population would also benefit from this implant. We even showed that the implantation into the PIP-joint of the small finger was successful. We thus conclude that the Moje prosthesis represents a new clinical approach to improve mobility and strength while reducing pain. Simultaneously arthrodesis is avoided.

References

[1] Beckenbaugh RD, Linscheid RL. Arthroplasty in the Hand and Wrist. In Green DP (ed). Operative Hand Surgery (3rd ed.). Churchill Livingstone, New York 1993; 143–187

[2] Flatt AE, Ellison MR. Restoration of rheumatoid finger joint function. JBJS [Am] 1972; 54: 1317–1322
[3] Foucher G, Hoang P, Citron N, Merle M, Dury M. Joint reconstruction following trauma: Comparison of microsurgical transfer and conventional methods: A report of 61 cases. J Hand Surg [Br] 1986; 11: 388–393
[4] Germann G, Wind G, Harth A. Der DASH-Fragebogen – Ein neues Instrument zur Beurteilung von Behandlungsergebnissen an der oberen Extremität. Handchir Mikrochir Plast Chir 1999; 31: 149–152
[5] Higuchi F, Inoue A, Semlitsch M. Metal-on-metal CoCrMo McKee-Farrar total hip arthroplasty: Characteristics from a long-term follow-up study. Arch Orthop Trauma Surg 1997; 116: 121–124
[6] Iselin F, Conti E. Long-term results of proximal interphalangeal joint resection arthroplasties with a silicone implant. J Hand Surg [Am] 1995; 20: 95–97
[7] Kiefhaber TR, Stern PJ, Grood ES. Lateral stability of the proximal interphalangeal joint. J Hand Surg [Am] 1986; 11: 661–669
[8] Lang W, Schmidt A, Ishida A, Baumgärtler H. Erfahrungen mit dem alloplastischen Gelenkersatz am Mittelgelenk. Handchir Mikrochir Plast Chir 2000; 32: 44–50
[9] Lin HH, Wyrick JD, Stern PJ. Proximal interphalangeal joint silicone replacement arthroplasty: Clinical results using an anterior approach. J Hand Surg [Am] 1995; 20: 123–132
[10] Mentzel M, Hoss H, Ebinger T, Halder A, Kinzl L, Wachter NJ. DIGITOS Fingermittelgelenkprothesen – Zweijahresergebnisse. Handchir Mikrochir Plast Chir 2000; 32: 347–352
[11] Pellegrini VD Jr, Burton RI. Osteoarthritis of the proximal interphalangeal joint of the hand: arthroplasty or fusion? J Hand Surg [Am] 1990; 15: 194–209
[12] Rieu J, Goeuriot P. Ceramic composites for biomedical applications. Clin Mat 1993; 12: 211–217
[13] Savory KM, Hutchinson DT, Bloebaum R. Materials testing protocol for small joint prostheses. J Biomed Mater Res 1994; 28: 1209–1219
[14] Schmidt K, Miehlke RK, Witt K. Stand der Endoprothetik des Fingergrundgelenkes beim Rheumatiker. Handchir Mikrochir Plast Chir 1996; 28: 254–264
[15] Willman G. Normen für keramische Implantate. Keramische Zeitschrift 1996; 48: 306–313