



Special Issue Original Article

Total joint replacement of the first metatarsophalangeal joint with Roto-Glide as alternative to arthrodesis

Totalendoprothese des Großzehengrundgelenks Typ Roto-Glide als Alternative zur Arthrodesese

Martinus Richter^{*,1}

Department for Foot and Ankle Surgery Rummelsberg and Nuremberg, Germany

Received 9 November 2018; accepted 24 January 2019

Available online 14 February 2019

KEYWORDS

First metatarsophalangeal joint;
Arthrodesis;
Total joint replacement;
Roto-Glide

Summary

Background: Total joint replacement (TJR) and arthrodesis (A) are treatment options for severe osteoarthritis of the first metatarsophalangeal joint (MTP1). The aim of this study was to compare outcome (clinical and pedographic) of TJR (Roto-Glide) and A of MTP1.

Material and methods: All patients that completed follow-up of at least 24 months after TJR and A of MTP1 before November 5, 2018 were included in the study. Preoperatively and at follow-up, radiographs and/or weight-bearing computed tomographies (WBCT) were obtained. Degenerative changes were classified in four degrees. Standard dynamic pedography was performed (percentage force at first metatarsal head/sesamoids/first toe from force of entire foot). Visual-Analogue-Scale Foot and Ankle (VAS FA) and MTP1 range of motion for dorsi-/plantarflexion (ROM) were registered and compared pre-operatively and follow-up.

Results: From November 24, 2011 until October 31, 2016, 25 TJR and 49 A were performed that completed follow-up. Parameters (average values if not stated otherwise) for TJR/A were preoperatively: age 59/60 years; 7 (28%)/14 (29%) male; height 168/169 cm; weight 71/72 kg; degree degenerative changes 3.3/3.1; ROM 19.4/0/9.8°//20.3/0/9.2°; percentage force first metatarsal/first toe 7.9/14.6//8.5/15.3; VAS FA 45.9/46.2. Six wound healing delays were registered (TJR 2, A 4) as only complications. Follow-up time on average 45.7/46.2 and

* Corresponding author: Martinus Richter, MD, PhD, Department for Foot and Ankle Surgery Rummelsberg and Nuremberg, Location Hospital Rummelsberg, Rummelsberg 71, 90592 Schwarzenbruck, Germany. Tel.: +49 9128 50 43450; fax: +49 9128 50 43260.

E-Mail: martinus.richter@sana.de

¹ <http://www.foot-surgery.eu/>.

SCHLÜSSELWÖRTER

Großzehengrundge-
lenk;
Arthrodesis;
Endoprothese;
Roto-Glide

range 25.0–80.3/24.1–81.1 months. VAS FA at follow-up was 73.4/70.2; percentage force first metatarsal/first toe 15.8/5.8//12.3/10.8; ROM 35.6/0/10.5°//10.5/0/0. Parameters did not differ between TJR and A (each $p > 0.05$) except higher force percentage first toe and lower ROM for A at follow-up (each $p < 0.05$). VAS FA and pedography parameters improved for TJR and A between preoperatively and follow-up, ROM increased for TJR and decreased for A (each $p < 0.05$).

Conclusions: TJR and A were performed in similar patient cohorts regarding demographic parameter, degree of degenerative changes, ROM, pathological pedographic pattern, and VAS FA. TJR and A improved pathological pedographic pattern and VAS FA at minimum follow-up of 24 months. TJR additionally improved ROM and showed better pedographic pattern (and not different to physiological pattern) than A. Survival rate of TJR was 100% up to 6 years. In this study, TJR was a valuable alternative to A for treatment of severe MTP1 osteoarthritis.

Zusammenfassung

Hintergrund: Endoprothese (TJR) und Arthrodesis (A) sind Behandlungsoptionen für die schwere Arthrose des Großzehengrundgelenks (MTP1). Ziel dieser Studie war das Behandlungsergebnis (klinisch und pedographisch) von TJR (Roto-Glide) und A des MTP1 zu vergleichen.

Material und Methoden: Alle Patienten, die vor 05.11.2018 eine Nachuntersuchung nach mindestens 2 Jahre abgeschlossen hatten, wurden in die Studie eingeschlossen. Präoperativ und zum Nachuntersuchungszeitraum wurden Röntgenaufnahmen mit Belastung oder 3D-Röntgenbildgebung mit Belastung (WBCT) durchgeführt. Die degenerativen Veränderungen wurden in vier Schweregrade eingeteilt. Eine standardisierte dynamische Pedographie durchgeführt (Prozentanteil Kraft Metatarsale-1-Kopf/Großzehe der Gesamtkraft des Fußes). Visual-Analog-Skala Fuß und Sprunggelenk (VAS FA) und Bewegungsumfang MTP1 (Dorsalextension/Plantarflexion (ROM)) wurden registriert und alle Daten zwischen präoperativ und Nachuntersuchungszeitpunkt verglichen.

Ergebnisse: Von 24.11.2011 bis 31.10.2016 wurden 25 TJR und 49 A durchgeführt die nachuntersucht wurden. Präoperative Parameter (Mittelwerte wenn nicht abweichend bezeichnet) für TJR/A: Alter 59/60 Jahre; 7 (28%)/14 (29%) männlich; Körpergröße 168/169 cm; Gewicht 71/72 kg; Arthrosegrad 3,3/3,1; ROM 19,4/0/9,8//20,3/0/9,2; Kraftanteil Metatarsale-1-Kopf/Großzehe 7,9/14,6//8,5/15,3; VAS FA 45,9/46,2. Als Komplikationen wurden sechs Wundheilungsstörungen registriert (TJR 2, A 4). Nachuntersuchungszeitpunkt 45,7/46,2 mit Spannweite 25,0–80,3/24,1–81,1 Monate. VAS FA zum Nachuntersuchungszeitpunkt 73,4/70,2; Kraftanteil Metatarsale-1-Kopf/Großzehe 15,8/5,8//12,3/10,8; ROM 35,6/0/10,5//10,5/0/0. Die Parameter unterschieden sich nicht zwischen TJR und A (jedes $p > 0,05$) außer höherer Kraftanteil Großzehe und geringerer ROM für A zum Nachuntersuchungszeitpunkt (jedes $p < 0,05$). VAS FA und Pedographieparameter verbesserten sich für TJR und A von präoperativ zum Nachuntersuchungszeitpunkt, ROM stieg für TJR und fiel für A (jedes $p < 0,05$).

Schlussfolgerungen: TJR und A wurden bei nicht unterschiedlichen Patientenkohorten hinsichtlich demographischer Parameter, Arthrosegrad, ROM, Pedographieparameter und VAS FA durchgeführt. TJR und A verbesserten VAS FA und Pedographieparameter zum Nachuntersuchungszeitpunkt von mindestens 24 Monaten. TJR verbesserte zusätzlich ROM und zeigte bessere Pedographieparameter (kein Unterschied zur physiologischen Kraftverteilung) als A. Die Überlebensdauer von TJR war 100% bis zu 6 Jahren Standzeit. In dieser Studie war TJR eine mindestens gleichwertige Alternative zu A für die operative Behandlung schwerer degenerative Veränderungen von MTP1.

Introduction

Total joint replacement of the first metatarsophalangeal (MTP1) joint has been in use for about 30 years [1]. It has never reached a standard

where it could compete with other treatments like osteotomy, cheilectomy, arthroplasty, or arthrodesis [2–6]. The latest results especially of the Roto-Glide (Implants International, Cleveland, UK) have been very promising [7–10]. The aim of the current

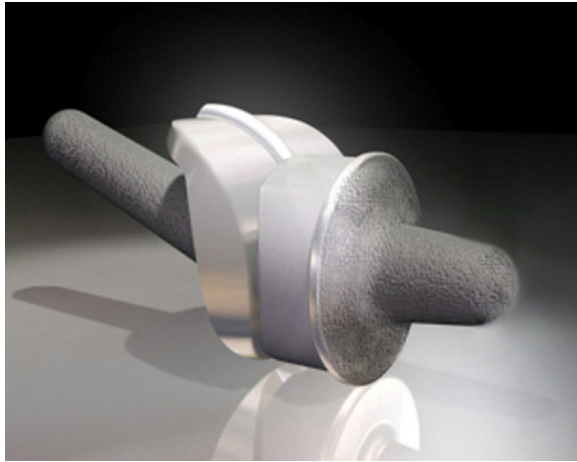


Fig. 1. The Roto-Glide®. A three-component non-cemented device with a mobile bearing.

study was to compare outcome (clinical and pedographic) of total joint replacement with Roto-Glide (TJR) and arthrodesis (A). In addition, the surgical technique of TJR with Roto-Glide is described.

Material and methods

Roto-Glide

The Roto-Glide (Implants International, Cleveland, UK) is a non-cemented TiCaP surfaced three-component device for total replacement of MTP1. It allows for normal mobility in the joint. The metatarsal implant has a rather long intramedullary stem. The upper part of the metatarsal head has an anatomical flange. In the middle it has a crest which corresponds to the natural crest in the lower part of the head. The phalangeal implant also has a stem.

This stem is hollow and has a flat surface toward the metatarsal head. Between the metal pieces a poly meniscus is inserted. This meniscus has a peg corresponding to the hollow phalangeal implant. The cranial surface of the meniscus is congruent with the metatarsal's surface. It should correspond to the crest for sideboard stability. Thus, extension/flexion takes place between the meniscus and the metatarsal implant, whereas rotation takes place between the meniscus and the phalangeal implant. The prosthesis comes with different interchangeable sizes and a set of instruments for precise cutting and drilling.

Preoperative diagnostics, surgical technique and postoperative care

- Radiography. Arthrosis in MTP1 is graded into four stages (Figs. 2a and 3a, b).
- Pedography. Unloading under MTP1 with decreased contact area and decreased force percentage. Lateral shift of the centre of gravity especially during the second half of the gait stance phase (Fig. 3c).
- Instruments (Fig. 4a) with trial implants (Fig. 4b).
- Positioning (Fig. 4c). Supine position, leg elevated, tourniquet at thigh.
- Approach (Fig. 4d). Medial approach with straight incision.
- Joint preparation (Fig. 4e). The medial joint capsule is incised. The entire joint including the sesamoids is exposed. The flexor hallucis tendon is released but not cut. Synovectomy follows if needed.
- Osteophyte removal (Fig. 4f). Osteophytes as the metatarsal head are remove dorsally, medially



Fig. 2. (a) Grades of arthrosis in MTP1 [11]. Grade 1, dorsal osteophyte; grade 2, dorsal arthrosis; grade 3, obliterated joint; grade 4, ankylosis.

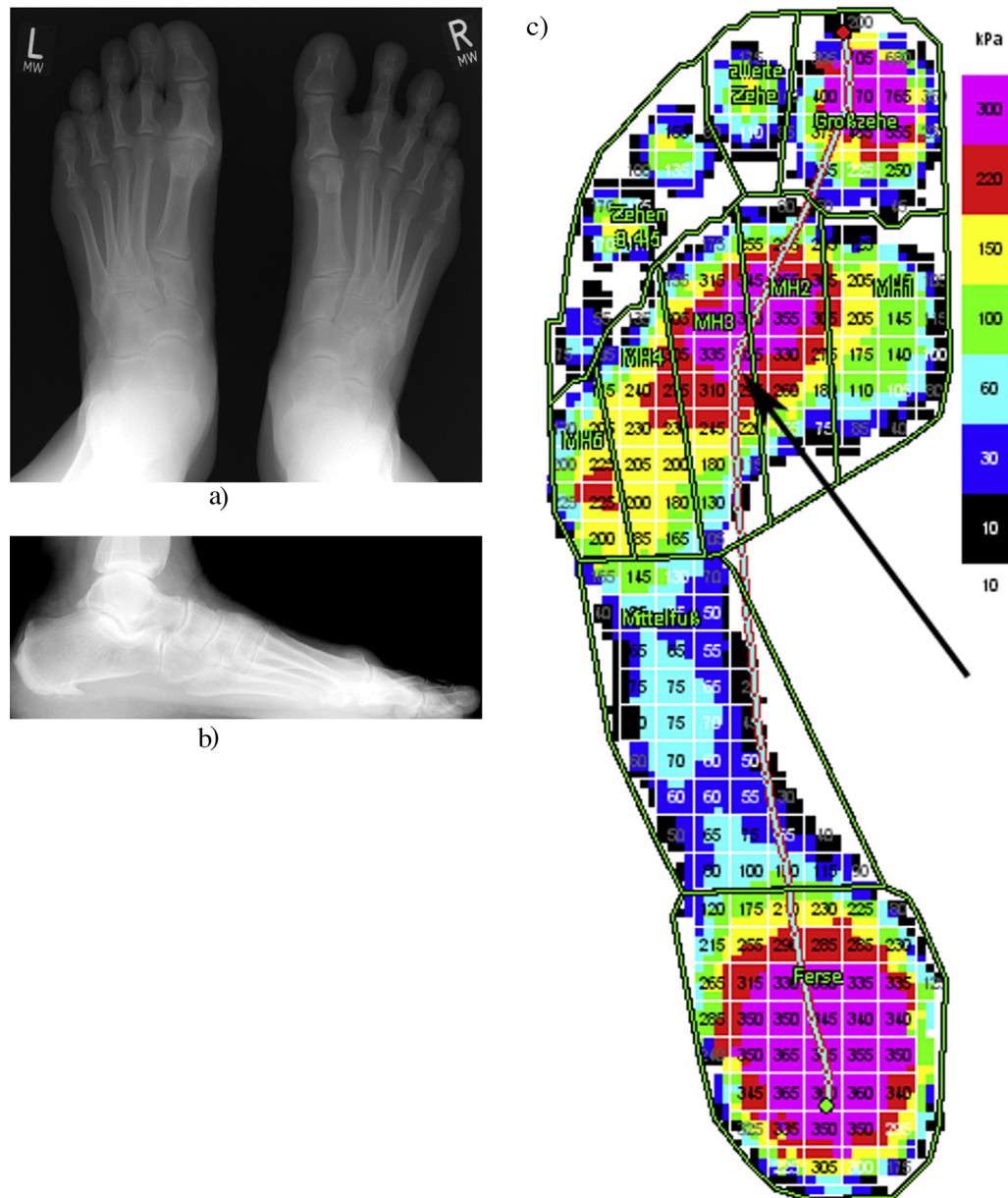


Fig. 3. (a–c) Preoperative radiographs and pedography. Dorsoplantar (a) and lateral (b) radiographs with weight bearing showing a Hallux rigidus grade 3. Pedography (c). Increased pressure under first toe and decreased pressure under metatarsal head/sesamoids. Lateral shift of the course of the centre of gravity (black arrow) especially during the second half of the gait stance phase, and consequently increased pressure under second and third metatarsal heads.

and laterally. The osteophytes at the base phalanx do not need to be removed since they were cut away anyhow. Osteophytes at the sesamoids should also be removed if present.

- Metatarsal cut (Fig. 4g and h). The metatarsal jig is applied taking care it is in the normal rotation (Fig. 4g). The angulated cut removes the dorsal osteophyte and the upper half of the metatarsal head is sliced off at 60° similar to a cheilectomy (Fig. 4h).

- Phalangeal cut (Fig. 4i and j). Another jig is applied for the cutting of the phalangeal joint surface (Fig. 4i). Care must be taken to secure the plantar structures (capsule and the short flexor tendon). About 2–3 mm of the upper phalanx is resected perpendicular to the phalanx's axis (Fig. 4j).
- Preparation of intramedullary canals (Fig. 4k and l). Instruments for drill guides to the medullary canals are used. Make sure the holes are

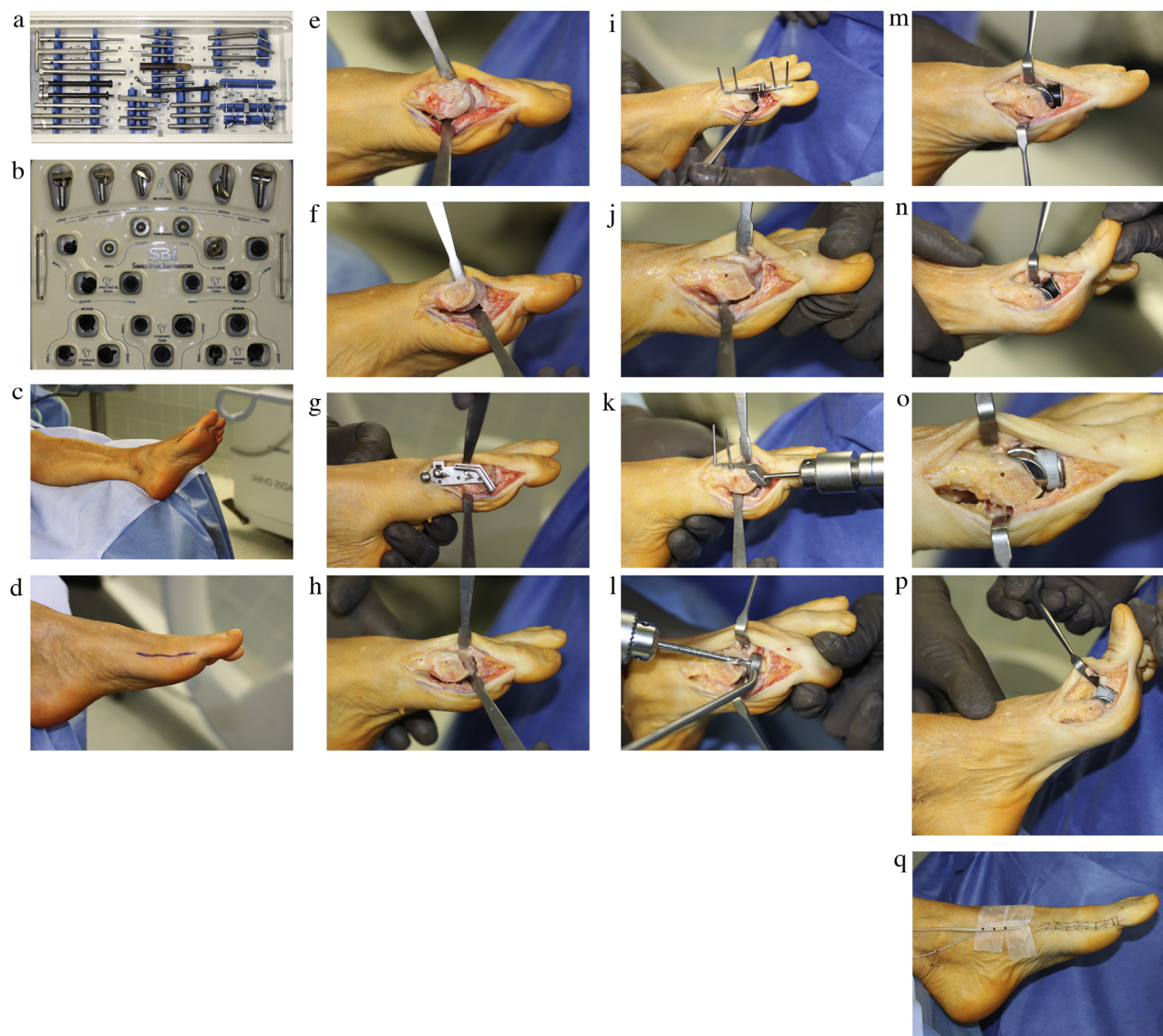


Fig. 4. (a–q) Operative technique. Detailed description in the text.

centralized and that the hole in the metatarsal head corresponds to the crest.

- Trial prosthesis insertion (Fig. 4m and n). Trial prostheses are inserted, and the best fitting meniscus is inserted, and checked fluoroscopically. The joint should be a little slack, but not sideboard unstable.
- Definite prosthesis insertion (Fig. 4o and p). The definite prosthesis is coated and the stems are minimally thicker than the trial prosthesis. This allows for press-fit fixation but might hinder the insertion. The joint should be a little slack, but not sideboard unstable. If the joint cannot move to 80° dorsiflexion fasciotomy of the flexor muscles are performed.
- Closure (Fig. 4q). The wound is closed in anatomical layers (joint capsule, subcutaneous, skin) following the local standard. A drainage and pain control catheter are inserted. A dressing is applied. No orthosis or cast is needed.
- Intraoperative fluoroscopic imaging (Fig. 5a, b). Intraoperative imaging included dorsoplantar (Fig. 5a) and lateral (Fig. 5b) views, and lateral view with dorsiflexion to confirm adequate range of motion and missing dorsal (sub)luxation during dorsiflexion (Fig. 5c).
- Postoperative care. Full weight bearing is allowed in cases with normal bone situations, i.e. normal or moderately decreased bone density. Partial weight bearing is safer and recommended in cases with significantly decreased bone density. The same strategy is recommended for postoperative physiotherapy. In stable situations, the postoperative care includes direct toe standing exercises. In less stable situations, motion could be limited until osseous integration at 6 weeks. Radiographs are taken at 6 weeks to confirm osseous integration (Fig. 6). The patient is also taught to load on the medial side of the foot over the hallux (the former habit of walking on the lateral side of the foot should be abandoned from day one. Skin sutures or staples are removed 18 days postoperatively, and the instructions on how to walk correctly are re-instructed. Pedography at 3 months is recommended to confirm adequate loading of the first ray.

Study design

All patients that completed follow-up of at least 24 months after TJR and A of MTP1 before November 5, 2017 were included in the study. The data was extracted from a prospectively acquired database starting November 1, 2011 including all operatively treated patient at the authors' institution. The single inclusion criteria

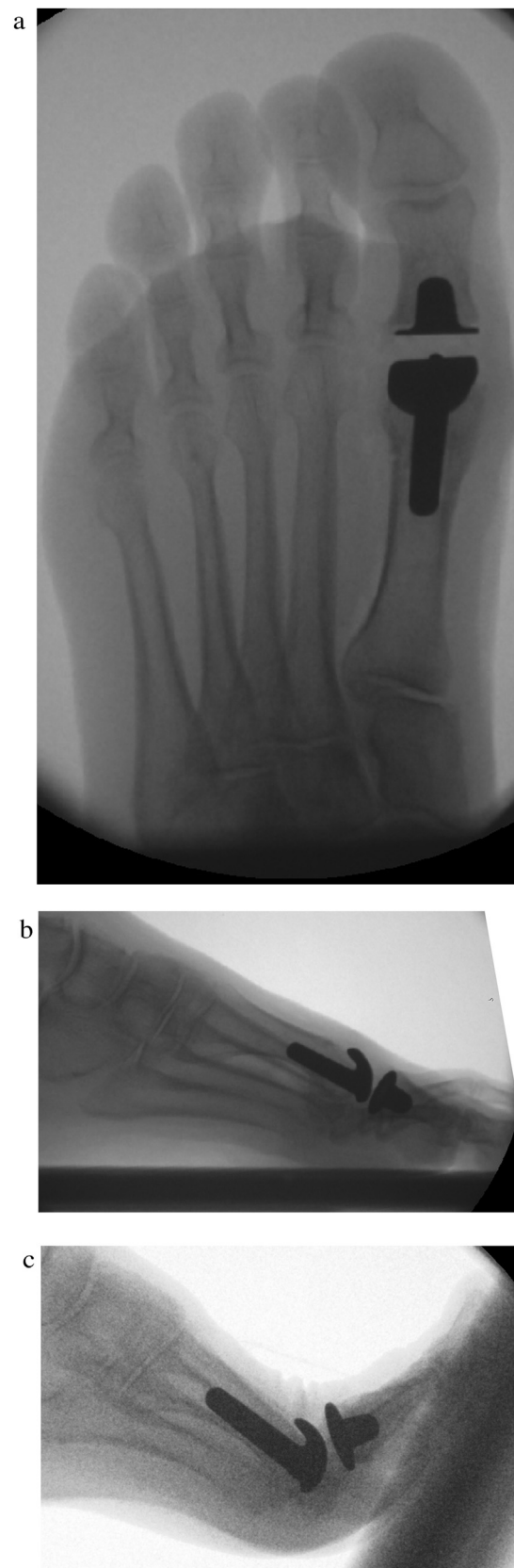


Fig. 5. Intraoperative imaging included dorsoplantar (a) and lateral (b) views, and lateral view with dorsiflexion to confirm adequate range of motion and missing



Fig. 6. (a and b) Postoperative radiographs and pedography. Dorsoplantar (a) and lateral (b) views with weight bearing. Same patient as in [Figs. 3 and 5](#).

for the study was the operative procedure. Patients with bilateral treatment ($n=21$), with additional corrective osteotomies in the forefoot ($n=23$), with TJR revision and/or exchange ($n=5$) or with A after TJR removal ($n=7$) were excluded. No other exclusion criteria were defined. Preoperatively and at follow-up, radiographs and/or weight-bearing computed tomographies (WBCT) were obtained. Degenerative changes were classified in four degrees [\[11\]](#). Standard dynamic pedography was performed (percentage force at first metatarsal/first toe from force of entire foot) [\[12\]](#). Visual-Analogue-Scale Foot and Ankle (VAS

FA) and first metatarsophalangeal joint range of motion for dorsi-/plantarflexion (ROM) were registered [\[12–14\]](#). All parameters were compared between TJR and A and between preoperatively and follow-up.

Results

From November 24, 2011 until October 31, 2016, 25 TJR and 59 A were performed that completed follow-up. Parameters did not differ between TJR and A (each $p > 0.05$) except higher force percentage first toe and lower ROM for A at follow-up (each $p < 0.05$) ([Table 1](#)). VAS FA and pedography parameters improved for TJR and A between preoperatively and follow-up, ROM increased for TJR and decreased for A (each $p < 0.05$).

dorsal (sub)luxation during dorsiflexion (c). Same patient as in [Fig. 3](#).

Table 1 Study results.

	Roto-Glide	Arthrodesis	<i>p</i>
<i>n</i>	25	49	
Surgery			
Age at time of surgery (years)	59	60	0.8
Male (%)	7 (28%)	14 (29%)	0.9
Height (cm)	168.2	169.1	0.9
Weight (kg)	71.4	72.1	0.9
Hallux rigidus Stadium (0–4)	3.3	3.1	0.7
Range of motion (ROM) dorsiflexion/plantarflexion (°)	19.4/0/9.8	20.3/0/9.2	0.9
Force percentage 1st metatarsal head/sesamoids/great toe (%)	7.9/14.6	8.5/15.3	0.8
VAS FA	45.9	46.2	0.7
Wound healing delay	2 (8%)	4 (8%)	0.9
Follow-up			
Revisions (<i>n</i>)	0	0	—
Follow-up time (months)	45.7 (25.0–80.3)	46.3 (24.1–81.1)	0.2
Range of motion (ROM) dorsiflexion/plantarflexion (°)	35.6/0/10.5	10.5/0/0	0.01
Force percentage 1st metatarsal head/sesamoids/great toe (%)	15.8/5.8	12.3/10.8	0.05
VAS FA	73.4	70.2	0.8

VAS FA: Visual Analog Scale Foot and Ankle.

Discussion

While stemmed silicone prostheses have been rather successful in hand surgery, it led to a significant number of failures in the great toe replacement [1]. The reasons were the greater forces in MTP1 and the inability for the device to rotate the joint [1]. This gave rise to breakage of the implant at the joint space level, followed by severe synovitis and eventually removal of the implant leaving severe bone losses [1]. Metal implants have been and are still used either as hemi-prosthesis or total prosthesis. The total joints are all two piece devices [1]. While uncemented hemi-prosthesis may be useful in grade 1 and 2 arthrosis, they have no place in grade 3 and 4 arthrosis [1]. Originally the two piece metal devices were cemented [1]. Those with short pegs in the medullary canal loosened [1]. The same has been reported about the uncemented device [15,16]. Modern two-piece devices have used metal on polyethylene (Fig. 1). At 3 years follow-up Fuhrmann et al. found radiographic loosening in 1/3 of their cases [17]. In a recent study, Bartak et al. found 16% failures after 24 months which confirms the results of Kundert and Zollinger-Kies [4,16]. Ceramics–ceramics (Fig. 8) have no real long-term results, but the results that have been published are not encouraging with short-term loosening between 12.5% and 18% after respectively 26 months and 3 years [18,19]. The only attempt of a randomized prospective study comparing arthrodesis versus total replacement of the

first metatarsophalangeal joint unfortunately had serious flaws [1,15]. There was change of the procedure in the replacement group from uncemented to cemented implantation because of loosening of the uncemented devices [1]. The author used the implant for arthrosis stage 1, 2 and 3, and there were bilateral cases, and cases that got both arthrodesis on one side and replacement on the other side [1]. Furthermore the authors claimed that the arthrodesis group got normal loading of the great toe [1]. This is contradictory to what all others have found, and at the same time the replacement group did not get any loading on the great toe [1]. Using the knowledge of the biomechanics of the different devices there would be room for a new device which takes into consideration the failure modes of the current devices [1,10].

The author has used the Roto-Glide for 9 years. At present (February 2019) 87 cases have been treated. A prospective review of the series is continuously being undertaken. Currently, there has been no aseptic loosening, that it gives excellent pain relief and sufficient mobility for normal daily activities. The author does not recommend running and jumping (for any prosthesis for that matter), but all daily life activities can otherwise be performed. At the author's institution, 2–3 times more A than TJR have been performed so far. In the current comparative study, TJR and A were performed in similar patient cohorts regarding demographic parameter, degree of degenerative changes, ROM, pathological pedographic pattern, and VAS FA. TJR and A improved pathological pedographic pattern

and VAS FA at minimum follow-up of 24 months. TJR additionally improved ROM and showed better pedographic pattern (and not different to physiological pattern) than A. Survival rate of TJR was 100% up to 6 years. In this study, TJR was a valuable alternative to A for treatment of severe MTP1 osteoarthritis.

Conflict of interest

None of the authors or the authors' institution received funding in relation to this study. The corresponding author is consultant of Curvebeam, Geistlich, Intercus, Ossio, shareholder of Curvebeam, and proprietor of R-Innovation.

References

- [1] Kofoed H. Is total replacement of the first MTP-joint for arthrosis an option? An overview. *Fuss Sprungg* 2011;9(39–45).
- [2] Brewster M. Does total joint replacement or arthrodesis of the first metatarsophalangeal joint yield better functional results? A systematic review of the literature. *J Foot Ankle Surg* 2010;49(6):546–52.
- [3] Lam A, Chan JJ, Surace MF, Vulcano E. Hallux rigidus: how do I approach it? *World J Orthop* 2017;8(5):364–71.
- [4] Kundert HP, Zollinger-Kies H. [Endoprosthetic replacement of hallux rigidus]. *Orthopade* 2005;34(8):748–57.
- [5] Claassen L, Plaass C, Pastor MF, Ettinger S, Wellmann M, Stukenborg-Colsman C, et al. First metatarsophalangeal joint arthrodesis: a retrospective comparison of crossed-screws, locking and non-locking plate fixation with lag screw. *Arch Bone Jt Surg* 2017;5(4):221–5.
- [6] Baumhauer JF, Singh D, Glazebrook M, Blundell CM, De Vries G, Le IL, et al. Correlation of hallux rigidus grade with motion, VAS pain, intraoperative cartilage loss, and treatment success for first MTP joint arthrodesis and synthetic cartilage implant. *Foot Ankle Int* 2017;38(11):1175–82.
- [7] Tunstall C, Laing P, Limaye R, Walker C, Kendall S, Lavalette D, et al. 1st metatarso-phalangeal joint arthroplasty with ROTO-glide implant. *Foot Ankle Surg* 2017;23(3):153–6.
- [8] Karpe P, Killen MC, Chauhan A, Pollock R, Limaye R. Early results of Roto-glide joint arthroplasty for treatment of hallux rigidus. *Foot (Edinb, Scotl)* 2018;34(58–62).
- [9] Wetke E, Zerahn B, Kofoed H. Prospective analysis of a first MTP total joint replacement. Evaluation by bone mineral densitometry, pedobarography, and visual analogue score for pain. *Foot Ankle Surg* 2012;18(2):136–40.
- [10] Kofoed H, Danborg L, Grindsted J, Merse S. The Rotoglide total replacement of the first metatarsophalangeal joint. A prospective series with 7–15 years clinico-radiological follow-up with survival analysis. *Foot Ankle Surg* 2017;23(3):148–52.
- [11] Shereff MJ, Baumhauer JF. Hallux rigidus and osteoarthritis of the first metatarsophalangeal joint. *J Bone Jt Surg Am* 1998;80(6):898–908.
- [12] Richter M, Zech S, Andreas Meissner S. Matrix-associated stem cell transplantation (MAST) in chondral defects of the 1st metatarsophalangeal joint is safe and effective-2-year-follow-up in 20 patients. *Foot Ankle Surg* 2017;23(3):195–200.
- [13] Stuber J, Zech S, Bay R, Qazzaz A, Richter M. Normative data of the Visual Analogue Scale Foot and Ankle (VAS FA) for pathological conditions. *Foot Ankle Surg* 2011;17(3):166–72.
- [14] Richter M, Zech S, Geerling J, Frink M, Knobloch K, Krettek C. A new foot and ankle outcome score: questionnaire based, subjective, Visual-Analogue-Scale, validated and computerized. *Foot Ankle Surg* 2006;12(4):191–9.
- [15] Gibson JN, Thomson CE. Arthrodesis or total replacement arthroplasty for hallux rigidus: a randomized controlled trial. *Foot Ankle Int* 2005;26(9):680–90.
- [16] Bartak V, Popelka S, Hromadka R, Pech J, Jahoda D, Sosna A. [ToeFit-Plus system for replacement of the first metatarsophalangeal joint]. *Acta Chir Orthop Traumatol Cechoslov* 2010;77(3):222–7.
- [17] Fuhrmann RA, Wagner A, Anders JO. First metatarsophalangeal joint replacement: the method of choice for end-stage hallux rigidus? *Foot Ankle Clin* 2003;8(4):711–21, vi.
- [18] Brewster M, McArthur J, Mauffrey C, Lewis AC, Hull P, Ramos J. Moje first metatarsophalangeal replacement – a case series with functional outcomes using the AOFAS-HMI score. *J Foot Ankle Surg* 2010;49(1):37–42.
- [19] Barwick TW, Talkhani IS. The MOJE total joint arthroplasty for 1st metatarso-phalangeal osteoarthritis: a short-term retrospective outcome study. *Foot (Edinb, Scotl)* 2008;18(3):150–5.