

First Metatarsophalangeal Joint Replacement with Modular Three-Component Press-Fit Implant. Preliminary Report

Náhrada prvního metatarzofalangeálního kloubu modulární trojdílnou press-fit endoprotézou. První zkušenosti

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ABSTRACT

PURPOSE OF THE STUDY

The aim of this retrospective study was to assess functional and radiographic results of the first metatarsophalangeal joint replacement with use of unconstrained, modular, three components, porous titanium and hydroxyapatite coated, press-fit METIS® prosthesis. According to author's knowledge, results of that type of prosthesis have never been published before.

MATERIAL AND METHODS

25 prosthesis were implanted in 24 patients between February 2009 and May 2011. American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal Interphalangeal scoring system (AOFAS-HMI) was used to assess functional results. Patients were also asked if they would undergo procedure again or recommend it to other people. Weight bearing radiographs were made at final follow up and analyzed for presence of osteolysis and radiolucencies. In 8 patients total joint replacement was introduced as a salvage after failure of previous surgery like Keller resection arthroplasty, failed arthrodesis, avascular necrosis and postoperative arthritis. In 11 patients the reason for prosthetic replacement were hallux rigidus, in 4 cases rheumatoid arthritis and gout in one patient. In two patients additional procedures like Akin phalangeal osteotomy and in one case fifth metatarsal osteotomy, was performed. There were 20 females and 4 males in presented group. The mean age at the operation was 56 years. The average follow up period was 18 months (from 12 to 36 months).

RESULTS

The median postoperative value of AOFAS-HMI scores was 88 points (from 75 to 95 points). First metatarsophalangeal joint motion (dorsiflexion plus plantarflexion) was classified according to AOFAS-HMI ranges as: moderately restricted (between 30 to 70 degrees) in 19 patients 80% (20 prosthesis) and severely restricted (less than 30 degrees) in 5 patients (20%). 15 (64%) patients were completely satisfied, 5 (20%) reported moderate satisfaction and (16%) 4 were totally disappointed and would not undergo this procedure again. A limited hallux dorsiflexion was the main dissatisfaction reason. Partial radiolucent line was seen in one patient (4%). Authors noticed two serious complications. In one patient, with rheumatoid arthritis, deep infection occurred 12 months after prosthesis implantation. In second case phalangeal implant was revised due to misalignment.

CONCLUSIONS

METIS® metatarsophalangeal joint replacement allows alleviate of pain relating to hallux rigidus and partial restoration of joint movement, even in patients after failures of primary metatarsophalangeal joint surgery. AOFAS-HMI results are better than previously reported in the literature in assessment of the first metatarsophalangeal joint replacement. Radiographic results imply satisfactory bone ingrowth into the cementless implants.

Key words: great toe, metatarsophalangeal total joint replacement, hallux rigidus, arthrodesis.

INTRODUCTION

The role and usefulness of arthrodesis of the first metatarsophalangeal joint (MTPJ) for the treatment of primary foot problems and as a salvage procedure cannot be overestimated but improved understanding of the first MTPJ function leads to reassessment the role of implant arthroplasty. Fixed hallux position after MTPJ fusion has powerful impact on footwear, occupational and sport activities. First MTPJ mobility is vital for normal gait pattern, impact reduction, activation of windlass mechanism, assistance in balance and normal stance. Since total hip and knee replacement are among the most common and successful orthopaedic operations there is natural tendency among orthopaedic surgeons to introduce MTPJ replacement in the treatment primary and secondary osteoarthritis. The purpose of this retrospective study was to assess early functional and radiographic results, including perioperative complications during learning curve period, of the first metatarsophalangeal joint reconstruction with use of unconstrained, modular, three components, press-fit METIS[®] prosthesis. Porous titanium and hydroxyapatite coating of phalangeal and metatarsal elements promotes osteointegration. According to author's knowledge, results of that type of prosthesis have never been published before.

MATERIAL AND METHODS

25 consecutive MTPJ replacement performed between February 2009 and May 2011 by one surgeon in 24 patients with use METIS[®] replacements were included in the study. In order to eliminate surgeon bias independent senior clinical resident performed all measurements. To compare the results with those presented in the literature an American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal Interphalangeal (AOFAS HMI) scoring system was used. This outcome-scoring tool is referenced frequently in papers regarding MTPJ implant arthroplasty and allows comparing across studies (5, 16). The AOFAS-HMI questionnaire was distributed to patients, as a part of routine assessment before surgery in author's institution and during the last follow up. The passive range of motion (ROM) of the first metatarsophalangeal joint was measured with a goniometer. Patients were also asked if they would undergo procedure again or recommend it to other people.

In 8 (9 prosthesis) patients total joint replacement was introduced as salvage after failure of previous surgery like failed arthrodesis, avascular necrosis, and postoperative arthritis. In one this patient total MTPJ replacement was performed bilaterally, after failed Keller resection arthroplasty. In 11 patients the reason for prosthetic replacement was hallux rigidus, in 4 cases rheumatoid arthritis and gout in 1 patient. There were 20 females and 4 males in presented group. The mean age at the operation was 56 years. The average follow up period was 18 months (from 12 to 36 months). Standard antero-posterior and lateral weight bearing radiographs were made at final follow up and analyzed for presence of osteolysis and radiolucencies. A similar operative

technique was performed in all patients. Author always used a medial incision. Postoperatively patients were asked to wear heel weight bearing shoes until complete wound healing and sutures removal and then full weight bearing was allowed. Patients were encouraged to perform maximal joint movements several times a day, and hill rising exercises while sitting, to increase dorsiflexion. Patients were routinely controlled 3, 6 and 12 weeks after surgery and then at final follow up. None of the patients was lost in follow up. All patients were treated with low molecular weight heparin injections for 14 days postoperatively. All data were collected and analyzed on Microsoft Excel software for mean scores, range and standard deviations. Mann Whitney's test was used for analysis of non-normally distributed data. The paired t-test was used to assess the mean scores pre and post treatment. All tests were done using a priori level of significance of 0.05.

RESULTS

The average preoperative value of AOFAS-HMI score was 40 points (from 15 to 67 points) and increased postoperatively to 88 points (from 75 to 95 points) ($p < 0,005$). Average preoperative, passive range of motion (ROM) was 10 degrees (from 0 to 17 degrees) and increased up 40 degrees (range from 10 to 55 degrees). Authors prefer to present data according to ranges in AOFAS-HMI scoring system. First MTPJ motion was classified as: moderately restricted (ROM between 30 to 70 degrees) in 19 patients 80% (20 prosthesis) and in 5 patients (20%) MTPJ motion was graded as severely restricted (ROM less than 30 degrees). Normal passive MTPJ motion was not restored in any case. 15 patients (64%) were completely satisfied, 5 (20%) reported moderate satisfaction, including one female with bilateral replacement and 4 (16%) were totally disappointed and would not undergo this procedure again. 16 joints (64%) were described as completely painless, 7 (28%) have mild, occasional pain and 2 patients (8%) suffered from moderate, daily pain. Radiographic assessment revealed consistent evidence of bone ingrowth. No radiolucent lines were identified, except one female (4%) with partial, narrow (less than 2 mm) radiolucent line at the tip of phalangeal component. That patient was asymptomatic and remained under regular control. In some cases some additional surgical procedures were performed. In 2 patients simultaneous Akin phalangeal osteotomy, located distal to phalangeal implant, was performed to correct interphalangeal valgus (Fig. 1 and Fig. 2). In one foot, the fifth metatarsal SCARF osteotomy was performed, to correct bunionette deformity.

Two serious complications occurred. In one patient with rheumatoid arthritis and previous history of septic metatarsophalangeal joint arthritis, deep infection occurred 12 months after prosthesis implantation. One attempt of irrigation and debridement was performed but finally, prosthesis needed to be removed. Full osseous osteointegration was observed in metatarsal and phalangeal prosthesis elements during implant removal. In one



1 | 2a
2b



Fig. 1. Antero-posterior weight bearing radiograph of a 63-year-old female patient with failure of metatarsophalangeal joint arthrodesis.

Fig. 2. Antero-posterior and lateral weight bearing radiographs of the patient from figure 1 after metatarsophalangeal joint replacement with concomitant Akin-type proximal phalangeal osteotomy.

case phalangeal implant was revised due to misplacement. Another, bigger size was implanted successfully without further complications.

DISCUSSION

Arthrodesis of the first metatarsophalangeal joint (MTPJ) remains the gold standard for advanced

arthritis and salvage procedure after failure of previous surgical treatment (7, 8, 12, 22). Orthopaedic and podiatric literature, regarding MTPJ arthrodesis, focus on non-union rates, position of the hallux and technical aspects of the surgical procedure. Arthrodesis results are graded as excellent or good when bony fusion is achieved or even in asymptomatic, painless

nonunion (25, 26). According to some authors fusion of an osteoarthritic MTPJ improves gait, medial arch stability and weight bearing on the medial part of the foot (1, 11, 14, 20). Powerful biomechanical changes following MTPJ arthrodesis were confirmed with plantar pressure measurements and on weight bearing radiographs (2, 18, 19). Surprisingly there is lack of studies comparing osteoarthritis in other major joints, like knee, hip and low back pain with changes in foot biomechanics after fusion MTPJ. Altered foot posture affects kinematics of the knee, hip, spine and thorax, medial knee osteoarthritis and low back pain are significantly associated with foot pain and function (17, 23, 24, 28). The increased recognition of the MTPJ function in achieving normal gait, turned interest of researchers into development functional joint replacement. Double stemmed, silicone Swanson type designed resulted in joint stiffness, reactive bone response and periarticular bone loss (27,30). Radiolucency and lytic bone areas decreased with addition of press-fit titanium grommets, to protect silicone from sharp bone edges, implant abrasion and reactive synovitis but a functional outcome of silicone implants, assessed by AOFAS HMI scored up to 83 points (29). Results of ceramic total MTPJ arthroplasty are worse and mean values of AOFAS HMI are up to 74 points, with 30 % of patients suffering from moderate, daily pain and 50% have severely restricted, with ROM less than 30 degrees MTPJ motion (6). New implants introduced in last decade, using two non cemented, pressfit components with polyethylene inlay, seemed to offer markedly increase in MTPJ movements. Average postoperative ROM presented into two recent reports was 38 and 52 degrees and slight general improvement was observed up to 18 months after surgery. Daniilidis et al. achieved one of the biggest prosthesis movements but he selected only grade III hallux rigidus patients excluding those with failed previous surgery where stiffness is more likely to occur (4, 9).

Implant presented in these paper is one of the most recent designs with bone preserving feature or rather resurfacing instead osteotomizing the first metatarsal head, and enables arthrodesis as a salvage procedure. In case, with recurrent periprosthetic infection, perfect osteointegration was observed during implant removal. As that patient has very active form of rheumatoid arthritis further surgical treatment is postponed. In two cases an Akin-type phalangeal osteotomy was performed to correct interphalangeal valgus and rotation. Additional procedure performed on proximal phalanx did not interfere with prosthesis osteointegration and these patients are among very satisfied group. No signs of phalangeal implant loosening were observed in these patients in more than 24 months follow up (Fig 1 and 2). Gibson and Thomas in randomized control trial reported higher patients satisfaction after arthrodesis than total arthroplasty (82% versus 58% of satisfied patients after 12 months follow up). Authors, as a part of surgical technique in total MTPJ arthroplasty, rou-

tinely performed lateral sesamoid resection in order to prevent impingement against the prosthesis (13). Lateral sesamoidectomy significantly decreases the effective flexor hallucis longus tendon moment arms, is known as cause of post-surgical hallux varus and alone could be the source of pain, hallux malalignment and further movement limitation (3). Gibson and Thomas report more than 15% loosening of the uncemented, plasma spray phalangeal component and in order to avoid further failures started to cement phalangeal implant in next and revision cases (13). Double-coated hip prosthesis stems, in comparison with plain porous femoral components has demonstrated better results with hydroxyapatite than porous alone in terms of quality of bone remodelling, and the potential migration and subsidence of the stem (10). These may indicate that addition of hydroxyapatite coatings can promote earlier and stronger fixation in metatarsal and phalangeal bone and this type of fixation between the bone and the prosthesis is used in most recent metatarsophalangeal implant designs (15).

The range of sagittal MTPJ motion is the main reported outcome in assessments the results of total joint replacement. In presented paper postoperative MTPJ movements were restricted in every case although more than 80% of patients were completely or moderately satisfied from performed surgery. These could be explained by that motion requirement during normal walking, are smaller than passive, non weight bearing measurements (21). Performed surgeries have powerful effect on pain release. More than 90% of patients are completely pain free or have only mild, occasional pain what is close to results obtained after arthrodesis of the MTPJ, procedure regarded as a gold standard regarding pain relief (1, 11, 14, 20, 25, 26). Functional results assessed with AOFAS-HMI scoring system are among the highest results published in the literature (4, 5, 6, 9, 13, 29). Authors did not record any implant breakage or dislocations like reported in other series (5, 6, 29, 30). A presented series showed no early failure of bone ingrowth into prosthesis components.

The main limitations of present study are retrospective nature and relatively short follow up period although several reports with similar length of follow up period are published (4, 5, 9). According to author's knowledge, this is the first, preliminary report on METIS® total metatarsophalangeal joint arthroplasty and await the results of other prospective investigation.

CONCLUSIONS

METIS® metatarsophalangeal joint replacement allows alleviate of pain relating to hallux rigidus and partial restoration of joint movement, even in patients after failures of primary metatarsophalangeal joint surgery. AOFAS-HMI results are better than previously reported in the literature in assessment of the first metatarsophalangeal joint replacement. Radiographic results imply satisfactory bone ingrowth into the cementless implants.

References

1. AAS, M., JOHNSEN, T. M., FINSSEN, V.: Arthrodesis of the first metatarsophalangeal joint for hallux rigidus--optimal position of fusion. *Foot*, 18:131–135, 2008.
2. AGOROPOULOS, Z., EFATHOPOULOS, N., MATALIOTAKIS, J.: Long-term results of first metatarsophalangeal joint fusion for severe hallux valgus deformity. *Foot Ankle Surg.*, 7: 9–13, 2001.
3. APER, R. L., SALTZMAN, C. L., BROWN, T. D.: The effect of hallux sesamoid excision on the flexor hallucis longus moment arm. *Clin Orthop Relat Res.*, 325:209–217, 1996.
4. BARTÁK, V., POPELKA, S., HROMÁDKA, R., PECH, J., JAHODA, D., SOSNA, A.: ToeFit-Plus system for replacement of the first metatarsophalangeal joint. *Acta Chir orthop. Traum. čech.*, 77:222–227, 2010.
5. 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.*, 49:546–552, 2010.
6. BREWSTER, M., MC ARTHUR, J., MAUFFREY, C., LEWIS, A. C., HULL, P., RAMOS, J.: Moje first metatarsophalangeal replacement- a case series with functional outcomes using the AOFAS-HMI score. *J. Foot Ankle Surg.*, 49: 37–42, 2010.
7. COUGHLIN, M. J., SHURNAS, P. S.: Hallux rigidus. Grading and long-term results of operative treatment. *J. Bone Jt Surg.*, 85-A:2072–2088, 2003.
8. COUGHLIN, M. J., SHURNAS, P. S.: Hallux rigidus. *J. Bone Jt Surg.*, 86-A :119–130, 2004.
9. DANIILIDIS, K., MARTINELLI, N., MARINOZZI, A., DEN-ERAIO, V., GOSHEGER, G., PEJMAN, Z., BUCHHORN, T.: Recreational sport activity after total replacement of the first metatarsophalangeal joint: a prospective study. *International Orthopaedics*, 34: 973–979, 2010.
10. EPINETTE, J. A., MANLEY, M. T.: Uncemented stems in hip replacement--hydroxyapatite or plain porous: does it matter? Based on a prospective study of HA Omnifit stems at 15-years minimum follow-up. *Hip Int.*, 18:69–74, 2008.
11. FUHRMANN, R. A.: First metatarsophalangeal arthrodesis for hallux rigidus. *Foot Ankle Clin.*, 16:1–12, 2011.
12. GIANNINI, S., CECCARELLI, F., FALDINI, C., BEVONI, R., GRANDI, G., VANNINI, F.: What's new in surgical options for hallux rigidus? *J. Bone Jt Surg.*, 86-A (suppl. 2): 72–83, 2004.
13. GIBSON, J. N., THOMSON, C. E.: Arthrodesis or total replacement arthroplasty for hallux rigidus: a randomized controlled trial. *Foot Ankle Int.*, 26:680–690, 2005.
14. HAMILTON, G. A., FORD, L. A., PATEL, S.: First metatarsophalangeal joint arthrodesis and revision arthrodesis. *Clin. Podiatr. Med. Surg.*, 26:459–473, 2009.
15. HROMÁDKA, R., BARTÁK, V., SOSNA, A., POPELKA, S.: MEDIN implant of the first metatarsophalangeal joint. *Acta Chir. orthop. Traum. čech.*, 79:124–130, 2012.
16. KITAOKA, H. B., ALEXANDER, I. J., ADELAAR, R. S., NUNLEY, J. A., MEYERSON, M. S., SANDERS, M.: Clinical rating system for the ankle, hindfoot, midfoot, hallux and lesser toes. *Foot Ankle Int.*, 15: 349–353, 1994.
17. LEVINGER, P., MENZ, H. B., FOTOHABADI, M. R., FELLER, J. A., BARTLETT, J. R., BERGMAN, N. R.: Foot posture in people with medial compartment knee osteoarthritis. *J. Foot Ankle Res.*, 16: 29, 2010.
18. LOMBARDI, C. M., SILHANEK, A. D., CONNOLLY, F. G., DENNIS, L. N.: The effect of first metatarsophalangeal joint arthrodesis on the first ray and the medial longitudinal arch: a radiographic study. *J. Foot Ankle Surg.*, 41:96–103, 2002.
19. LUNINGHAKE, F., TILLMANN, K., RUSSELLS, M.: Biomechanical changes following surgical treatment of MTP-I-osteoarthritis. *Foot*, 12:171–181, 2002.
20. MAHER, A. J., METCALFE, S. A.: First MTP joint arthrodesis for the treatment of hallux rigidus: results of 29 consecutive cases using the foot health status questionnaire validated measurement tool. *Foot*, 18:123–130, 2008.
21. NAWOCZENSKI, D. A., BAUMHAUER, J. F., UMBERGER, B. R.: Relationship between clinical measurements and motion of the first metatarsophalangeal joint during gait. *J. Bone Jt Surg.*, 81-A:370–376, 1999.
22. NUNEZ-SAMPER, M. N., KUBBA, M. N., PALOMO, R., PEREZ, P.: Metatarsophalangeal arthrodesis of the first ray. When is it indicated? *Foot*, 15: 123–132, 2005.
23. REILLY K., BARKER, K., SHAMLEY, D., NEWMAN, M., OSKROCHI, G. R., SANDALL, S.: The role of foot and ankle assessment of patients with lower limb osteoarthritis. *Physiotherapy*, 95:164–169, 2009.
24. REILLY, A. K., BARKER, L. K., SHAMLEY, D., SANDALL, S.: Influence of foot characteristics on the site of lower limb osteoarthritis. *Foot Ankle Int.*, 27:206–211, 2006.
25. SHAHANE, S. A., VEDANTAM, R., BHADRESHWAR D. R.: Arthrodesis of the first metatarsophalangeal joint using AO tension band wire. *Foot*, 11: 15–18, 2001.
26. SHARMA, V., GEARY, N. P. J.: Long term retrospective analysis of the first metatarsophalangeal joint arthrodesis with two crossed screws. *Foot*, 11: 199–204, 2002.
27. SMETANA, M., VENCÁLKOVÁ, S.: Use of a silicone metatarsophalangeal joint endoprosthesis in hallux rigidus over a 15-year period. *Acta Chir. orthop. Traum. čech.*, 70:177–181, 2003.
28. SURI, P., MORGENROTH, D. C., KWONG, C. K., BEAN, J. F., KALICHMAN, L., HUNTER, D. J.: Low back pain and other musculoskeletal pain comorbidities in individuals with symptomatic osteoarthritis of the knee: data from the osteoarthritis initiative. *Arthritis Care Res.*, 62:1715–1723, 2010.
29. TER KEURS, E. W., WASSINK, S., BURGER, B. J., HUBACH, P. C.: First metatarsophalangeal joint replacement: long-term results of a double stemmed flexible silicone prosthesis. *Foot Ankle Surg.*, 17: 224–227, 2011.
30. WEIL, L. S., POLLAK, R. A., GOLLER, W. L.: Total first joint replacement in hallux valgus and hallux rigidus. Long-term results in 484 cases. *Clin. Podiatry*, 1:103–29, 1984.

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