

FIXATION OF FIRST METATARSOPHALANGEAL JOINT ARTHRODESIS

John Vanore, DPM

First metatarsophalangeal (MTP) joint arthrodesis is an essential procedure that every foot surgeon should be able to perform well. A varied group of clinical problems and pathology of the foot involve the forefoot and specifically disrupt the integrity and function of the first MTP joint. Arthrodesis, although a joint destructive procedure, is a very useful technique when presented with difficult situations and may provide a relatively simple solution.

Fusion procedures are often associated with nonunion rates somewhat higher compared to osteotomy of comparable bones. Today, rigid internal fixation is the standard of care for osteosynthesis of both osteotomy and fusion procedures whenever possible. Crossed inter-fragmentary screws, a screw and plate or axial Steinmann pins have been the most frequently advocated techniques of internal fixation for first MTP joint arthrodesis. This paper will present the author's experience with first MTP joint arthrodesis and in particular illustrate the efficacy of a new technique of fixation. Use of the OsStaple™ (Biomedical Enterprises, San Antonio, TX) will be illustrated and compared to traditional techniques.

METHODS AND MATERIALS

Certainly in the past, first MTP joint arthrodesis has been an underutilized procedure by podiatric surgeons. In the course of 25 years of clinical practice, the author has come to appreciate the value and utility of the procedure. First MTP joint arthrodesis is indicated for 1) hallux rigidus,¹⁻³ 2) hallux valgus^{1,2} particularly when associated with significant metatarsus adductus, neuromuscular disease⁴ or end-stage deformity in elderly patients,⁵ 3) arthritic disorders, such as rheumatoid arthritis^{1,2,6-11} or gout, 4) hallux varus,^{3,12,13} 5) chronic joint pain, 6) first ray salvage particularly for revision of failed prior surgery.^{3,7,11,14,15}

The author will review 32 procedures performed in 25 patients over the past five years by a variety of techniques, Table 1. Joint resection was performed by either planar osteotomies or curettage techniques. Fixation will be the predominant area of discussion as this may vary considerably from surgeon to surgeon. Rigid internal fixation is the general goal and may be achieved by a variety

of techniques. Most often either crossed screw fixation or use of a compression staple although other methods were employed due to the particular clinical situation. The author will review the fixation techniques and bony union in cases of primary arthrodesis. The patients ranged in age from 46 to 82 years of age with a mean age of 59. Of the 25 patients reviewed, 19 were female and 6 male. Ten of the 25 patients had prior first MTP joint surgery. Although a variety of fixation techniques were utilized, postoperative care was similar for all patients which involved use of a below-knee fracture brace for six weeks but allowing restricted weight-bearing with or without crutches.

RESULTS

Thirty-one (31) procedures were performed on 25 patients but all procedures were performed at a single surgical session. First MTP joint arthrodesis was performed most frequently for hallux valgus with a total of 26 procedures with 7 of these patients possessing deformities associated with rheumatoid arthritis, and 5 feet in 3 patients with high metatarsus adductus. Four procedures were performed for hallux varus and one for hallux rigidus. Of the 25 patients with 31 procedures, 9 feet had at least one prior surgery. The author also elected to perform 1st MTP joint

Table 1

INDICATIONS – FIRST MTP JOINT ARTHRODESIS

1. Hallux Rigidus
2. Hallux Valgus
 - + Degenerative Joint Disease
 - + Significant Metatarsus Adductus
 - + Senile or End-stage Deformity
3. Arthritis: Rheumatoid, Gout
4. Hallux Varus
5. Chronic Joint Pain
6. Failed Prior Surgery including Implant Revision



Figure 1A. Hallux Rigidus. This 53-year-old male presented with limited motion and a painful first MTP joint. The preoperative AP radiograph shows some abduction of the great toe is present, but the predominant process is one of degenerative joint disease.



Figure 1B. Preoperative lateral radiograph showing degenerative changes with loss of extension and intraarticular loose body.



Figure 1C. AP radiograph at 2 weeks postoperative illustrates planar joint resection with crossed screw fixation of the arthrodesis. Note the long screws placed to keep them some distance from the fusion interface. This is helpful in avoiding fracture adjacent to fusion. The screw purchase the lateral cortex of both the metatarsal and phalanx; the cortical bone is dense and improves stability of fixation.



Figure 1D. Lateral radiograph at 2 weeks postoperative illustrate position of arthrodesis and orientation of screws.



Figure 1E. AP radiograph at 18 months postoperative illustrate complete bony consolidation of arthrodesis site.

arthrodesis in the geriatric population with severe, end stage hallux valgus deformity.

Joint resection is generally one of preference. In this series, 8 procedures were performed by curettage technique and 21 with planar joint resections. Fixation was achieved by a variety of techniques often dependent upon the quality of the patient's bone. Crossed² screw fixation, (Figure 1) was performed in 8 feet while dual staple fixation was utilized in 12 feet (Figure 4). The remainder had a variety of techniques including: 5 procedures with multiple kirschner wires, 1 procedure was performed with one screw and a kirschner wire, (Figure 3), and a second with one screw, one wire and a staple (Figure 2). A plate was utilized in 2 procedures, one a specialized plate for first MTP joint fusion and a second, an OsPlate™ (Biomedical Enterprises, San Antonio, TX).

Of the 31 procedures, three nonunions developed. One patient (OsStaple™) underwent revisionary fusion with plate fixation, one rheumatoid (Kirschner wires) was treated with noninvasive electrical bone stimulation, and the other was asymptomatic (single screw + Kirschner wire) and did not require any further treatment. Further, there were three additional procedures that showed delayed union, radiographic lucency at the three month radiograph, but eventually proceeded to consolidate.

Primary arthrodesis utilizing crossed screw fixation was performed 8 times while 12 procedures were performed with the OsStaple™. The crossed screw technique usually consisted of two 4.0mm cannulated screws. One was placed



Figure 1F. Lateral radiograph at 18 months postoperative illustrate bony union and maintenance of position of the arthrodesis with bony remodeling.

from proximal medial in the metatarsal and the other distal medial to proximal lateral from the phalanx. Screw osteosynthesis is somewhat simplified with a medial incisional approach although this is strictly the surgeon's preference.

Staple fixation involved two OsStaples™, one placed from dorsal to plantar and the other from medial to lateral. The dorsal staple was generally a larger diameter staple with long legs in an effort to achieve bicortical fixation, Figure 4. This allowed for compression fixation across the entire fusion interface and proved useful even in osteopenic individuals. The second staple was to provide for additional stability through a second point of fixation. The fixation techniques and success in achieving timely bony union of the arthrodesis are the particular focus of this discussion.

DISCUSSION

Arthrodesis eliminates first MTP joint motion yet provides for a stable medial column and weight-bearing through the great toe. Most studies illustrate reduction of metatarsalgia and high patient satisfaction.^{16,17} First MTP joint arthrodesis is an extremely versatile procedure that is useful in both common pathologies such as hallux rigidus and hallux valgus as well as difficult situations in the presence of chronic joint pain, osseous defects, prior infection, and revision of joint implants or prior surgery.

This study involved 31 procedures performed on 25 patients. First MTP joint arthrodesis was performed most frequently for hallux valgus 20 procedures with 7 patients possessing deformities associated with rheumatoid arthritis, and 3 patients, 5 feet with high metatarsus adductus. Four procedures were performed for hallux varus, 1 for hallux rigidus and 2 for chronic joint symptoms associated with prior surgery. Of the 31, 10 feet in 9 patients had prior first MTP joint surgery.

Late stage III or stage IV hallux rigidus is a disorder



Figure 2A. Rheumatoid with Hallux Valgus. This 58-year-old female was also diabetic as well as a rheumatoid. Note the severe bunion deformity with a high intermetatarsal angle and lateral subluxation of the first MTP joint.



Figure 2B. Radiograph at 3 months postoperative illustrates effective reduction of the intermetatarsal angle and curettage joint resection. The hallux is generally fused in a degree of abduction so the hallux is parallel to the 2nd toe. Initially, fixation was attempted with a 4.0mm cannulated bone screw but purchase was less than ideal. Intraoperatively, this was felt to be the result of the poor bone quality but more likely due to failure to obtain purchase of the screw within the lateral cortical wall of the metatarsal. Fixation was augmented with two compression staples.



Figure 2C. This patient did go on the successful consolidation as the radiographs at 11 months post-operative show complete bony union.



Figure 2D. Lateral postoperative view.

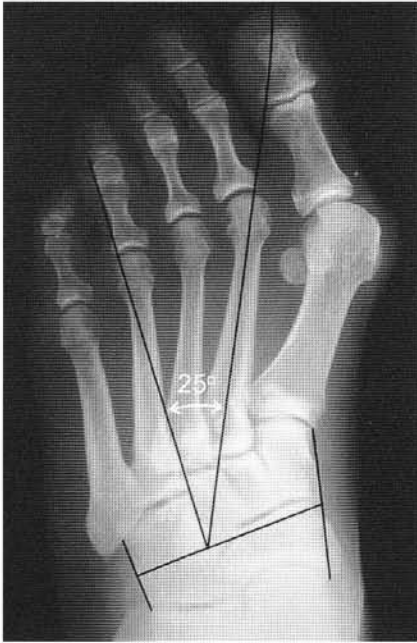


Figure 3A. Hallux Valgus with metatarsus adductus. This is 56-year-old female who presented with severe deformity and a large medial bunion. Preoperative AP radiograph shows the metatarsus adductus angle which measured at 25 degrees. A first MTP joint arthrodesis was performed with curettage joint resection.



Figure 3B. Radiograph at 2 weeks postoperative shows fixation with one interfragmentary compression screw and a kirschner wire.

of arthrosis deformans and arthrodesis is a proven procedure in these patients, Figure 1. Arthrodesis provides a durable reconstruction and has been advocated by the author for younger patients requiring a joint destructive procedure. Arthrodesis provides a stable foot allowing rigorous activities while minimizing lateral metatarsalgia. Any patient who has had prior surgery for hallux rigidus or degenerative joint disease of the first MTP joint is a candidate for arthrodesis.

First MTP joint arthrodesis is a useful procedure for patients presenting with hallux valgus. In older patients with severe deformities, arthrodesis provides correction of severe deformity with a high intermetatarsal angle and is applicable even in patients with osteoporosis. These patients generally heal well as long as adequate stability of the arthrodesis site is secured. Arthrodesis may also be useful in patients with severe metatarsus adductus where bunion procedures may fail with frequent recurrence. The rheumatoid forefoot reconstruction may be one of the most useful indications for first MTP joint fusion as it provides a stabilizing influence over the entire forefoot as well as maintenance of first MTP joint position, Figure 2. In both end-stage hallux valgus and rheumatoid deformities a large intermetatarsal angle is often seen. First MTP joint arthrodesis is an extremely effective technique



Figure 3C. Radiograph at 9 months postoperative shows radiolucency around the screw. Clinically there was movement at the fusion site although the patient was completely satisfied and asymptomatic.



Figure 4A. Hallux Varus. This 82-year-old female presented with chronic pain and an adduction deformity at the first MTP joint.



Figure 4B. Preoperative radiograph shows a hallux varus with degenerative joint disease. She had undergone bunionectomy 10 years prior.

for reduction of the intermetatarsal angle that will not deteriorate with time.¹⁸

Arthrodesis is useful as a salvage procedure in a host of clinical problems from recurrent hallux valgus to the patient with overcorrection and hallux varus. Arthrodesis takes on all pathologies whether the toe is long and requires bone resection or bone graft is required to repair an osseous defect in the case of a short and unstable toe, Figure 5.

Varied techniques of joint resection have been advocated but all must expose healthy subchondral bone with good vascularity that allows primary bony union. In the presence of a short toe, curettage resection may be appropriate. Generally, bone resection provides for laxity at the joint and allows for correction for even severe degrees of hallux valgus deformity. Planar resections have been found simple and applicable to most clinical situations and may be supplemented with bone graft as necessary. The author has utilized various hand and power reamers but has not found these useful and only complicates the surgical technique.

Position of the fusion is paramount. The hallux should be placed in 20-30° of extension to allow the toe positioned just above the weight-bearing surface in stance. The hallux should be placed parallel to the 2nd toe in the transverse plane with a neutral axial position. Generally, a great toe that is just short of the 2nd toe will limit postoperative great toe irritation and IPJ degenerative changes.

The object of fixation is to maintain the position of the toe until bony union is complete. It should also provide stability so that fusion proceeds in an expedient manner. Fixation should be rigid but due to the multiplicity of indications varied osteosynthesis constructs may be considered. Simplicity with limitation of fixation hardware should be considered. There have been advocates of combinations such as screw and plate fixations although this is not considered necessary unless a bone graft is utilized or in the case of a revision.

This author has good success in cases of primary joint arthrodesis without the use of a plate. Either crossed screw fixation, cannulated 4.0 mm screws are preferred, or two (2) compression staples (OsStaples™). Figure 1 is an example of screw fixation in showing good placement distant from the joint so as to avoid fracture and loss of fixation. The distal screw from the phalanx to the metatarsal should perforate and purchase the lateral cortical wall of the metatarsal. Loss of stability may be seen if the threads of the screw do not purchase good bone. Figure 4 illustrates the technique of compression staple fixation. The OsStaple™ has been used extensively and an offset staple design developed in an effort to achieve compressive forces across the entire fusion interface. The larger primary staple is placed from dorsal to plantar while a secondary staple is inserted from medial to lateral. This construct has shown to be straightforward and efficient. Some difficulties have also been witnessed if the staple legs



Figure 4C. First MTP joint arthrodesis was performed with planar joint resection and dual staple fixation.



Figure 4D. Radiograph at 3 months postoperative illustrates good position of staples, with larger one dorsal to plantar and smaller one inserted medial.

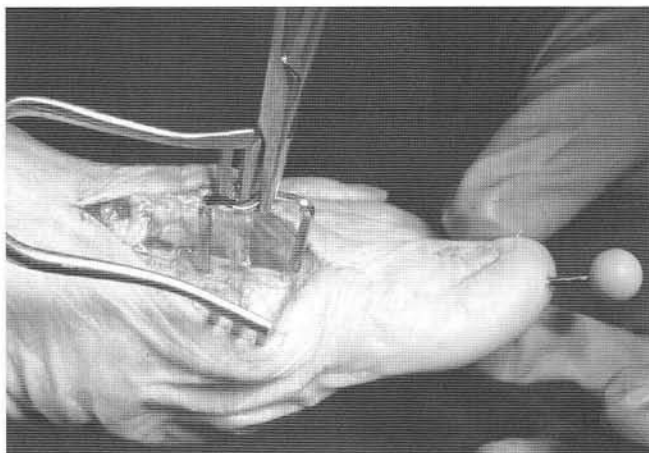


Figure 4E. Intraoperative view of insertion of the larger asymmetrical staple, with an 18 mm proximal leg, 15 mm distal leg, and 18 mm bridge.



Figure 4F. Lateral radiograph at 3 months postoperative illustrating ideal bicortical orientation of the larger dorsal to plantar staple.

are not placed a nominal distance from the fusion interface.

Both techniques, screws or staples, provide for rigid internal fixation by interfragmentary compression although the compressive nature of the OsStaple™ may be more prolonged than that of a screw counterpart that gradually dissipates due to the viscoelastic nature of bone. Even in cases of revisionary surgery and osteoporotic bone, the OsStaple™ has been shown to be effective.

In the present study primary arthrodesis utilizing crossed screw fixation was performed 8 times while 12 procedures were performed with the OsStaple™. Eight patients underwent arthrodesis for failed prior surgery; 9

procedures. Only 1 required bone graft and was fixated with the OsStaple™ (Figure 5). The OsStaple™ was effective for both primary arthrodesis as well as revisionary procedures.

CONCLUSIONS

First MTP joint arthrodesis is versatile procedure for a variety of pathologies involving the first MTP joint. Arthrodesis is a joint destructive procedure but should be considered when other procedures are less likely to produce a successful outcome. Success of the procedure is



Figure 5A. Failed Prior Surgery. This 48-year-old female had been subjected to 5 prior first MTP joint surgeries and presented with chronic joint pain. She had a history of diabetes as well as prior deep wound infection. Preoperative radiograph shows a mild varus deformity with loss of defined joint margins and an interval radiolucency.



Figure 5B. Radiograph at a week postoperative shows first MTP joint arthrodesis with a single staple and a Kirschner wire. An autogenous calcaneal bone graft provided length, osteogenic stimulation and correction of angular deformity.



Figure 5C. Union preceded in a routine manner as verified in radiograph at 3 months.



Figure 5D. Radiograph at 3 years postoperative shows bony union and subsequent remodeling. Good position was maintained and symptoms resolved.

dependent upon achieving bony consolidation of the fusion site in a clinically tolerable position. This paper reviews the author's five year experience and compares fixation with the OsStaple™ to that of the traditional forms of rigid internal fixation. The OsStaple™ has shown to be as effective as crossed screw fixation with interfragmentary compression. The technique is technically fast and simple to perform. Foot surgeons should consider the OsStaple™ for fixation in patients requiring first MTP joint arthrodesis.

REFERENCES.

1. Groulier P, et al. Arthrodesis of the first metatarsophalangeal joint. *Rev Chir Orthop Reparatrice Appar Mot* 1994;80:436-44.
2. Lipscomb PR. Arthrodesis of the first metatarsophalangeal joint for severe bunions and hallux rigidus. *Clin Orthop* 1979;142:48-54.
3. Trnka HJ. Arthrodesis procedures for salvage of the hallux metatarsophalangeal joint. *Foot Ankle Clin* 2000;5:673-86.
4. Goldner JL. Hallux valgus and hallux flexus associated with cerebral palsy: analysis and treatment. *Clin Orthop* 1981;157:98-104.
5. Dayton P, Lopiccio J, Kiley J. Reduction of the intermetatarsal angle after first metatarsophalangeal joint arthrodesis in patients with moderate and severe metatarsus primus adductus. *J Foot Ankle Surg* 2002 41:5:316-9.
6. Beauchamp CG, et al. Fusion of the first metatarsophalangeal joint in forefoot arthroplasty. *Clin Orthop* 1984;190:249-53.
7. Mann RA, Oates JC. Arthrodesis of the first metatarsophalangeal joint. *Foot Ankle* 1980;1:159-66.
8. Mann RA, Thompson FM. Arthrodesis of the first metatarsophalangeal joint for hallux valgus in rheumatoid arthritis. *J Bone Joint Surg Am* 1984;66:687-92.
9. Maynou C, et al. Surgical Treatment of the rheumatoid forefoot by realignment using the dorsal approach. *Rev Chir Orthop Reparatrice Appar Mot* 1997;83:734-8.
10. Niskanen RO, et al. Arthrodesis of the first metatarsophalangeal joint in rheumatoid arthritis. Biodegradable rods and Kirschner-wires in 39 cases. *Acta Orthop Scand* 1993;64:100-2.
11. Smith RW, Joanis TL, Maxwell PD. Great toe metatarsophalangeal joint arthrodesis: a user-friendly technique. *Foot Ankle* 1992;13:367-77.
12. Mills JA, Menelaus MB. Hallux varus. *J Bone Joint Surg Br* 1989;71:437-40.
13. Coughlin MJ. Rheumatoid forefoot reconstruction: a long-term follow-up study. *J Bone Joint Surg Am* 2000;82:322-41.
14. Hecht PJ, et al. Arthrodesis of the first metatarsophalangeal joint to salvage failed silicone implant arthroplasty. *Foot Ankle Int* 1997;18:383-90.
15. Coughlin MJ, Mann RA. Arthrodesis of the first metatarsophalangeal joint as salvage fore the failed Keller procedure. *J Bone Joint Surg Am* 1987;69:68-75.
16. Henry AP, Waugh W, Wood H. The use of footprints in assessing the results of operations for hallux valgus: a comparison of Keller's operation and arthrodesis. *J Bone Joint Surg Br* 1975;57:478-81.
17. Lampe HI, Fontijne P, van Linge B. Weight Bearing after arthrodesis of the first metatarsophalangeal joint: a randomized study of 61 cases. *Acta Orthop Scand* 1991;62:544-5.
18. Mann RA, Katcherian DA. Relationship of metatarsophalangeal joint fusion on the intermetatarsal angle. *Foot Ankle* 1989;10:8-11.