Original Article

Arthrodesis for Advanced Arthritis

First Metatarsophalangeal Joint Arthrodesis Using Flat Cut Technique and Fixing With Staples: A Review of Outcome

Muhammed Ahmed Mansoor and Muhammad Ehtesham Siddiqui

ABSTRACT

Objective: First metatarsophalangeal joint (MTPJ) arthrodesis is a gold standard procedure for advanced arthritis of the first MTPJ. The purpose of this study is to determine clinical, radiological, functional outcomes and complications of first MTPJ arthrodesis using flat on flat cut and fixing with two Shape-Memory Nitinol staples.

Study Design: Retrospective study

Place and Duration of Study: This study was conducted at the Department of Trauma and Orthopaedics Surgery, Solihull hospital, part of the University Hospitals Birmingham, UK from 2014 to 2018.

Materials and Methods: Patients who underwent first MTPJ arthrodesis for primary osteoarthritis by the single surgeon (main author) from 2014 to 2018 were selected for the study. Preoperative and post-operative clinical and radiological findings, AOFAS Foot and Hallux scores, patient satisfaction rating and any complications were noted.

Results: Thirty fivepatients, 37 feet, 2 patients had bilateral foot surgery at two different occasions, were found after the selection and exclusion criteria. 22 (63%) females and 13 (37%) males. Mean age was 63 years (range 35-8). The mean follow up of was 11 weeks (range 8-32 weeks). Union occurred in 33 cases including 3 cases of delayed union. 4 cases developed non-union, of these, 1 case was infective non-union. Average improvement in AOFAS score was 45(23-70). 42 (70%) of patient rated their outcome as Excellent, 14(20%) as good, 2(5 %) as fair and 2 (5%) rated as poor.

Conclusion: First MTPJ arthrodesis using Shape-Memory Nitinol staples resulted in 89% union rate. Patients had average of improvement 44 points on AOFAS score and 90% rated good to excellent satisfaction. These results are comparable with national average results.

Key Words: Metatarsophalangeal joint arthrodesis staples

Citation of article: Mansoor MA, Siddiqui ME. First Metatarsophalangeal Joint Arthrodesis Using Flat Cut Technique and Fixing With Staples: A Review of Outcome. Med Forum 2020;31(6):35-39.

INTRODUCTION

Arthrodesis of the first metatarsophalangeal joint (MTPJ) has been reported as gold standard for the treatment of advanced hallux rigidus.[1]

The aims of first MTPJ arthrodesis are to improve pain, function, and achieve optimum toe alignment. There are many surgical techniques described in the literature to achieve bony union at the fused joint, but no single technique is considered to be exclusive[2-11]. The surgical technique used for the joint fusion depends upon surgeon's preference and the availability of the hardware.

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Received: January, 2020
Accepted: February, 2020
Printed: June, 2020

The reported union rates with different techniques vary from 88% to 100%[12-14]. The purpose of this study is to determine the clinical, radiological, functional outcomes and complications of first metatarso-phalangeal joint fusion using flat cut technique and fixing with Shape-Memory Nitinol staples.

MATERIALS AND METHODS

This retrospective study was conducted at the Department Trauma and Orthopaedics, Solihull hospital, part of the University Hospitals Birmingham, UK. Clinical data was retrieved for the cases which had first MTPJ arthrodesis for primary osteoarthritis of the first MTPJ operated by the main author during the period 2014 to 2018 and have at least 8 weeks of follow up before discharge or change in management due to any complication. All cases which had concomitant any other painful condition of the involved foot was excluded from the study. Based on the above criteria 35 patients (37 feet, 2 patients had bilateral surgery) were available for the study. Their clinical records, radiological studies and Outcome results were collected. A modification of American Orthopaedic Foot and Ankle Society (AOFAS) clinical rating system for the Hallux Metatarsophalangeal-Interphalangeal

Scale, has been used by the operating surgeon at the time of pre-operative assessment on the day of surgery and then at the time of final clinic consultation before discharge or when there was change in patient management due any complication noted. The standard AOFAS score has 100 points which include MTPJ range of movement domain carrying 10 points. However, for the purpose of this study as the MTPJ range of movement domain was not applicable in the final outcome assessment, this domain was omitted in both pre-operative and final outcome assessments, giving maximum score of 90 points. The patients were asked to rate their overall satisfaction as poor, fair, good or excellent.

Pre-operative X-rays were studied to note the grading of the osteoarthritis of the first MTPJ and hallux alignment. The MTPJ arthritis was graded according to Coughlin and Shurnas system.[6] (Table 1, Fig 1). Radiographic union was defined as osseous bridging of 3 out of 4 cortices on AP and lateral radiographs. The union was considered a delayed union if it occurred between 3 to 6 months. If there was no union according to the above definition by the end of 6 months, the case was diagnosed as non-union and different management strategy was used. Post-operative x-rays were studied to assess the union of arthrodesis and hallux alignment. (Fig 2).

Operative Technique: All patients underwent a standard operative technique and postoperative regimen. The patient was positioned supine on the operating table with a sandbag under the buttock on the operative side. Prophylaxis antibiotics were given at the time of induction. A padded thigh tourniquet was applied with pressure at 300 mmhg. A standard dorsal longitudinal incision centred over the MTPJ about 4cm was made, just medial to the Extensor Hallucis Longus tendon (EHL). A deeper dissection was done down to the joint capsule protecting the EHL tendon on the lateral side of the wound. A longitudinal capsulotomy incision was made in the line of skin incision, to open the joint. The capsule edges are preserved for later closure after fixing the joint.The articular surfaces of the joint were examined regarding extent and severity of the arthritis. All osteophytes and any inflamed synovial tissue were removed. Flat biplanar cuts weremade with saw on the metatarsal head and phalanx base taking into account the extent and direction of the deformity so that after the cut surfaces were opposed the hallux would have a valgus of about 5-10 degrees and extension from the floor of about 5-10 degree. The fresh cut bony surfaces were prepared with pepper potholes with a 2mm k wire or a drill bit to encourage bone fusion. The position was held with a K-wire passed obliquely across the opposed joint surfaces from proximal medial metatarsal shaft to distal lateral into proximal phalanx. The joint was held using two Shape-Memory Nitinol staples fixing at right angle to each other, one vertical in dorsal midline across the joint and the other mid horizontal along the medial side. Wound was closed in layers with absorbable sutures. Patients were discharged home mobilising in flat stiff sole post op surgical shoe. All the patients had their first post-operative review by the GP or Nurse for wound check and removal of any sutures, ten days after discharge.

The patients were followed in the hospital clinic at six weekly intervals until union was confirmed and patient mobilizing full weight bearing in their standard footwear. In case of non-union, patient was further investigated with a CT scan to assess the status of union or non-union. At the final consultation patients were re assessed according to the AOFAS score and Satisfaction rating.

RESULTS

Thirty five patients involving 37 feet, 2 patients had bilateral foot surgery, were found after the selection and exclusion criteria. There were 23 (62%) female feet and 14 (38%) male feet. The mean age for both male and female patients was 63 years (range 35-85). Among the male patients 4 had surgery on the left,8 had surgery on the right foot and 1 patient had surgery on both feet. Among the female patients 13 left and 8 right foot was operated, and 1 patient had surgery on both feet. The patients who had bilateral surgery, each foot was operated at different occasion with time difference of 14 months to 2 years between surgery on the two sides. 13 cases were graded as 3 on Coughlin Shurna's grading system and 24 case of grade 4.

All the patients had their first post-operative review by the GP or Nurse for wound check and removal of any sutures, 10 -14 days after discharge from the hospital. The patients were then reviewed in the hospital orthopaedic clinic at six weeks having clinical assessment and x-rays. The patients were then followed up at six weekly intervals until both clinical and radiological union was confirmed and patients were able to mobilise full weight bearing in their own standard footwear.

The average follow up period was 11 weeks (8-32). Average time to union of arthrodesis for males was 11 weeks (8-20) and in females was 11weeks (12-28). There were two cases of delayed union in females which took 16 and 28 weeks to unite and one case of delayed in a male patient which took 20 months to unite.

Union occurred in 33 feet including 3 cases of delayed union. There were 4 cases of non-union (10%) one male and threefemales. One male non-union was due to infection.One female patient with non-union had a broken vertical staple at 10 weeks. 3non-union cases were revised with plate fixation and bone graft. One female case with non-union was asymptomatic and the patient decided not to have any revision surgery.

There were two cases of low grade superficial wound infection noticed at the first check at 2 weeks by the GP. These were treated with a course of oral antibiotics for 5 days resulting in complete resolution of infection and wound healing. Both these cases had complete union.

The average AOFAS score at before surgery was 42 (range 15-67). The AOFAS average score at final assessment after the surgery was 87 (range 77-90). The improvement in AOFAS score averaged at 45 (range 20-70). On satisfaction rating 22 (60%) of patient rated their outcome as Excellent, 11(30%) as good and 2(5 %) as fair and 2 (5%) rated as poor. There was on mild difference between male and female patient satisfaction rating. Table 2.

Table No.1: Coughlin and Shurnas Classification

Grade	Clinical Findings	Radiological Findings
Grade 0	Stiffness	Normal
Grade 1	mild pain at extremes of motion	mild dorsal osteophyte, normal joint space
Grade 2	moderate pain with range of motion increasingly more constant	moderate dorsal osteophyte, <50% joint space narrowing
Grade 3	significant stiffness, pain at extreme ROM, no pain at mid-range	
Grade 4	significant stiffness, pain at extreme ROM, pain at mid-range of motion	

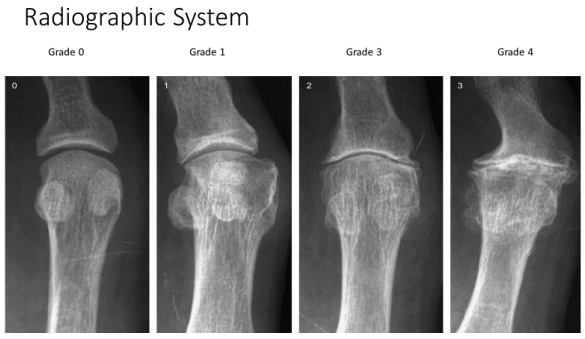

Figure No.1: Radographic system.

Table No.2 Patient Satisfaction Rating

	Male	Female	Combined
Excellent	50% (n=14)	67% (n=28)	60% (n=42)
Good	43% (n=12)	19% (n=8)	29% (n=20)
Fair	7% (n=2)	7% (n=3)	7% (n=5)
Poor	0% (n=0)	7% (n=3)	4% (n=3)

AP View Oblique View

Figure No.2: Postoperative Foot X-rays

DISCUSSION

Hallux rigidus is a progressive condition that leads to osseous and soft tissue changes causing stiffness, inflammation, and pain.[15] Patients complain of pain with weight bearing particularly during the push-off phase of the gait. Examination confirms dorsal tenderness and restricted dorsiflexion of the first MTPJ. In extreme cases where the joint has become completely stiff, the patient may complain very little or no pain at all.

The management of symptomatic hallux rigidus begins with nonsurgical treatments. Nonsteroidal anti-inflammatory drugs (NSAIDs), intra-articular steroid injections, orthotics, and shoe modifications designed to limit MTP joint motion can all be used.[16]

First metatarsophalangeal joint fusion is a gold standard procedure for the treatment of advanced arthritis of the first MTPJ which has not responded to non-operative measures. There are many techniques described in the literature to prepare the joint surfaces and various methods of fixation to achieve fusion. These include planar flat cuts, cup cone reaming and arthroscopic removal of articular cartilage. The prepared joint surfaces are then fixed with different techniques, including staples, K wires, Cross screws, Plate fixation with or without lag screw.[17-22]

Flat on flat planar cuts for preparing joint surface for the purpose of arthrodesis can be done through a relatively smaller exposure as compared to cup and cone reaming technique. The flat cut technique requires complete understanding of the MTPJ shape and toe alignment. The cuts are usually biplanar and are made to correct the deformity in both the sagittal and coronal

axis keeping the neutral rotation of the hallux. It is important to align the toe in 5-10 degree dorsiflexion from the floor to ensure adequate flexion of the interphalangeal joint for comfortable walking. The final valgus angle of the hallux is kept at 5 to 15 degrees.[23] Any varus alignment of the toe must be avoided as this would cause difficulty in wearing dress shoes and transfer pain in the forefoot.

The main advantage of the staples used in this study is their low profile hence less irritant to soft tissues which is a concern around the big toe. The Shape-Memory Nitinol staples provides continuous compression across the fused joint surfaces.

In this series, an overall radiological union rate of 89.2%. The radiological non-union rate of 10.8% is within the range reported in the literature ranging from 8% to 14%.[13,26-30]

The patients are encouraged for early weight bearing in the immediate postop period using stiff soled post op surgical shoes. Many patients can mobilise in these shoes without any walking aid; however, some may need one or two crutches in the initial post-operative period. The clinical and radiological union rate in this series is comparable as reported in a retrospective review of immediate weight bearing after first MTPJ fusion.[27]

The Staple fixation is a recommended technique.[31,32] It is technically less challenging as compared to other fixation methods of first MTPJ. Other advantages include smaller exposure, low profile, less soft tissue irritation.

There was one incidence of metal failure leading to non-union and subsequently requiring revision arthrodesis. A detailed review of the case suggested that perhaps the patient started unprotected full weight bearing before the clinical or radiological evidence union, resulting in metal fracture. This patient was treated with revision arthrodesis using plate fixation and bone graft.

There was one case of asymptomatic non-union in this study. The patient had complete non-union, confirmed on the CT scan at six months. The patient was managing well in comfortable footwear. This patient decided against any revision surgery.

One patient had an infection that did not respond to antibiotics. This case had debridement, removal of the staples and revision arthrodesis with plate fixation and bone graft.

Two patients with non-union were heavy smokers. It is well established in the literature that smokers have twice the risk of developing a non-union afterarthrodesis or treatment of non-union. (25) Smokers also have longer union time following a fracture or arthrodesis. Smokers should be encouraged to quit or abstain from smoking to avoid non-union or delayed union.

The reoperation rate (3 cases) in this studywas 8.1% which is comparable to 4% to 18.7% reported in the literature.[13, 24, 29]

Limitations of this study include retrospective review, small cohort and a single surgeon series with patients being followed up in his clinic and as such intra-observer errors or bias cannot be ignored.

CONCLUSION

Hallux rigidus is a common condition seen by orthopaedic foot and ankle surgeons. Arthrodesis of the first MTP joint remains the gold standard option for advanced arthritis. This study concludes that first metatarsophalangeal joint arthrodesis using flat on flat cut technique and using two staples for fixation is a simple technique with good outcome results and is recommended for the treatment of advanced osteoarthritis of the joint.

Author's Contribution:

Concept & Design of Study:	Muhammed Ahmed Mansoor
Drafting:	Muhammad Ehtesham Siddiqui
Data Analysis:	Muhammad Ehtesham Siddiqui
Revisiting Critically:	Muhammed Ahmed Mansoor, Muhammad Ehtesham Siddiqui
Final Approval of version:	Muhammed Ahmed Mansoor

Conflict of Interest: The study has no conflict of interest to declare by any author.

REFERENCES

1. Laky B, Koelblinger R, Brandl G, Anderl W, Schwameis E. Metatarsophalangeal joint hemiarthroplasty for advanced hallux rigidus: a mid-term follow-up. Orthopaedic Proceedings 2016; 98-B(SUPP_8): 114-114.
2. Keiserman LS, Sammarco VJ, Sammarco GJ. Surgical treatment of the hallux rigidus. Foot Ankle Clin 2005;10(1):75-96.
3. Beertema W, Draijer WF, van Os JJ, Pilot P. A retrospective analysis of surgical treatment in patients with symptomatic hallux rigidus: long-term follow-up. J Foot Ankle Surg 2006;45(4): 244-251.
4. Chana GS, Andrew TA, Cotterill CP. A simple method of arthrodesis of the first metatarso-phalangeal joint. J Bone Joint Surg Br 1984; 66(5):703-705.
5. Coughlin MJ, Abdo RV. Arthrodesis of the first metatarsophalangeal joint with Vitallium plate fixation. Foot Ankle Int 1994;15(1):18-28.

6. Coughlin MJ, Shurnas PS. Hallux rigidus: grading and long-term results of operative treatment. J Bone Joint Surg Am 2003;85-A(11):2072-2088.
7. Ettl V, Radke S, Gaertner M, Walther M. Arthrodesis in the treatment of hallux rigidus. Int Orthop 2003;27(6):382-385.
8. Fitzgerald JA, Wilkinson JM.Arthrodesis of the metatarsophalangeal joint of the great toe. Clin Orthop Relat Res 1981;(157):70-77.
9. Fitzgerald JA. A review of long-term results of arthrodesis of the first metatarso-phalangeal joint. J Bone Joint Surg Br 1969;51(3):488-493.
10. Lombardi CM, Silhanek AD, Connolly FG, Dennis LN, Keslonsky AJ. First metatarsophalangeal arthrodesis for treatment of hallux rigidus: a retrospective study. J Foot Ankle Surg 2001;40(3): 137-143.
11. Riggs SA, Johnson EW. McKeever arthrodesis for the painful hallux. Foot Ankle 1983;3(5):248-253.
12. Turan I, Lindgren U. Compression-screw arthrodesis of the first metatarsophalangeal joint of the foot. Clin OrthopRelat Res 1987;(221): 292-295.
13. Ellington JK, Jones CP, Cohen BE, Davis WH, Nickisch F, Anderson RB. Review of 107 hallux MTP joint arthrodesis using dome-shaped reamers and a stainless steel dorsal plate. Foot Ankle Int 2010;31(5):385-390.
14. Korim MT, Allen PE. Effect of pathology on union of first metatarsophalangeal joint arthrodesis. Foot Ankle Int 2015;36(1):51-54.
15. Shurnas PS. Hallux rigidus: etiology, biomechanics, and nonoperative treatment. Foot Ankle Clin 2009;14(1):1-8.
16. Grady JF, Axe TM, Zager EJ, Sheldon LA. A retrospective analysis of 772 patients with hallux limitus. J Am Podiatr Med Assoc 2002;92(2): 102-108.
17. Storts EC, Camasta CA. Immediate weight bearing of first metatarsophalangeal joint fusion comparing buried crossed Kirschner wires versus crossing screws: does incorporating the sesamoids into the fusion contribute to higher incidence of bony union. J Foot Ankle Surg 2016;55(3):562–566
18. Mohammed R, Gadgil A. Molded arthrodesis of the hallux metatarsophalangeal joint using the crossed-screw technique: surgical technique, results and functional outcomes. Foot Ankle Surg 2012;18(2):132–135.
19. Dening J, van Erve RH. Arthrodesis of the first metatarsophalangeal joint: a retrospective analysis of plate versus screw fixation. J Foot Ankle Surg 2012;51(2):172–175.
20. Kumar S, Pradhan R, Rosenfeld PF. First metatarsophalangeal arthrodesis using a dorsal plate and a compression screw. Foot Ankle Int 2010;31(9):797–801.
21. Hyer CF, Scott RT, Swiatek M. A retrospective comparison of four plate constructs for first metatarsophalangeal joint fusion: static plate, static plate with lag screw, locked plate, and locked plate with lag screw. J Foot Ankle Surg 2012;51(3): 285–287.
22. Besse JL, Chouteau J, Laptoiu D. Arthrodesis of the first metatarsophalangeal joint with ball and cup reamers and osteosynthesis with pure titanium staples radiological evaluation of a continuous series of 54 cases. Foot Ankle Surg 2010;16(1): 32–37.
23. Ho B, Baumhauer J. Hallux rigidus. EFORT Open Rev 2017; 2(1):13-20.
24. Roukis TS, Meusnier T, Augoyard M. Incidence of non-union of first metatarsophalangeal joint arthrodesis for severe hallux valgus using crossed, flexible titanium intramedullary nails and a dorsal static staple with immediate weightbearing in female patients. J Foot Ankle Surg 2012;51(4): 433-436.
25. Pearson RG, Clement RGE, Edwards KL, et al. Do smokers have greater risk of delayed and non-union after fracture, osteotomy and arthrodesis? A systematic review with meta-analysis BMJ Open 2016;6:e010303.
26. Bennett GL, Kay DB, Sabatta J. First metatarsophalangeal joint arthrodesis: an evaluation of hardware failure. Foot Ankle Int 2005;26(8):593-596.
27. Berlet GC, Hyer CF, Glover JP. A retrospective review of immediate weightbearing after first metatarsophalangeal joint arthrodesis. Foot Ankle Spec 2008;1(1):24-28.
28. Coughlin MJ, Grebing BR, Jones CP. Arthrodesis of the first metatarsophalangeal joint for idiopathic hallux valgus: intermediate results. Foot Ankle Int 2005;26(10):783-792.
29. Goucher NR, Coughlin MJ. Hallux metatarsophalangeal joint arthrodesis using dome-shaped reamers and dorsal plate fixation: a prospective study. Foot Ankle Int 2006;27(11): 869-876.
30. Jarde O, Chabaille E, Ganry O, Havet E, Vives P. Recurrent hallux valgus treated with metatarsophalangeal arthrodesis. A series of 32 patients. Rev ChirOrthop 2001;87(3):257-262.
31. Gaheer RS, Bell S, J Dillon J, Ferdinand RD. Memory compression staples for fusion of small joints of the foot. Orthopaedic Proceedings 2011; 93-B:SUPP_I, 64-64
32. Choudhary R, Theruvil B, Taylor G. First metatarsophalangeal joint arthrodesis: A new technique of internal fixation by using memory compression staples. J foot and ankle surg 43(5): 312-317.