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# First Metatarsophalangeal Joint Arthrodesis Using an Intraosseous Post and Lag Screw With Immediate Bearing of Weight

Shelain Patel, FRCS (Tr&Orth)<sup>1</sup>, Parag Garg, MBBS<sup>2</sup>, M. Ali Fazal, FRCS (Tr&Orth)<sup>3</sup>,  
Pinak S. Ray, FRCS (Tr&Orth)<sup>3</sup>

<sup>1</sup> Consultant Orthopaedic Surgeon, Royal National Orthopaedic Hospital, Stanmore, United Kingdom

<sup>2</sup> Clinical Fellow, Barnet General Hospital, Barnet, United Kingdom

<sup>3</sup> Consultant Orthopaedic Surgeon, Barnet General Hospital, Barnet, United Kingdom



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## ABSTRACT

Arthrodesis is the gold standard procedure for advanced arthrosis of the first metatarsophalangeal joint. Having a strong construct is preferable for allowing immediate bearing of weight, which facilitates patient rehabilitation. Plate and screw fixation is currently in favor but can lead to prominent metalware necessitating removal. The aim of this study is to report the results of a series of 54 first metatarsophalangeal joint arthrodeses performed in 52 patients treated with an implant composed of an intraosseous post and lag screw. All of the patients had a minimum follow-up of 1 year, and the indication for the surgery was end-stage hallux rigidus in 44 (81.5%) feet, severe hallux valgus in 8 (14.8%) feet, and rheumatoid arthritis in 2 (3.7%) feet. Arthrodesis was achieved in 52 (96.3%) feet at a mean of  $61 \pm 16$  (range 39 to 201) days with nonunion observed in 2 (3.7%) feet; neither of the 2 patients had known risk factors. Metalware impinging on soft tissues necessitating removal was observed in 3 (5.6%) feet, and there were no cases of loss of position or implant breakage. The mean Manchester-Oxford Foot Questionnaire score improved from  $46.4 \pm 13.3$  to  $18.4 \pm 9.4$  ( $p < .001$ ) at latest follow-up. In conclusion, our results suggest the intraosseous post and lag screw device was safe and effective, and it can be considered an alternative method of stabilizing the first metatarsophalangeal joint when undertaking arthrodesis surgery.

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Arthrodesis is the gold standard procedure for advanced arthrosis of the first metatarsophalangeal joint (MTPJ) and is an excellent salvage or revision option for failed first MTPJ procedures. The outcome of surgery depends on meticulous joint preparation and stable fixation. Various methods of fixation have been described to facilitate union, but the most common are the use of screws, plates, and staples. The main advantage of screws over other devices is they can be buried within the bone to lessen soft tissue irritation, but compression staples are the easiest to insert (1). Screws and staples offer less stability than plate fixation however plates have been known to lead to soft tissue impingement because of their dorsal placement and the thin soft tissue envelope around the joint (2). The ideal implant, therefore, must be easy to use, provide reproducible and high-quality results, and enable early rehabilitation so that patients can return to function

quickly in addition to lessening soft tissue irritation so as to avoid secondary operations and dissatisfaction.

The purpose of this study was to observe the outcomes of first MTPJ arthrodesis by using an intraosseous post and lag screw fixation device for first MTPJ arthrodesis, coupled with immediate postoperative weightbearing. We hypothesized that the fixation device would provide a high incidence of union and facilitate early functional rehabilitation and that the successful fusion would be associated with improvements in functional outcome. Our primary aim was to measure functional outcomes, and our secondary aim was to measure radiographic outcomes and complications.

## Patients and Methods

We reviewed operations performed during the 30 months between January 2014 and July 2016. We included consecutive patients older than 18 years who had painful arthrosis of the first MTPJ (*International Classification of Diseases, Tenth Revision, Clinical Modification 20.2*) or severe hallux valgus (*International Classification of Diseases, Tenth Revision, Clinical Modification 20.1*) with consequent functional deficits who were refractory to nonsurgical treatments and underwent arthrodesis of the first MTPJ with the use of an intraosseous post and lag screw fixation device, specifically the IO FiX™ (Extremity Medical LLC, Parsippany-Troy Hills, NJ), followed by immediate postoperative weightbearing. This device features a metal post buried in the bone through which a compression screw is introduced and passed across the arthrodesis site. The post effectively acts as a stable

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Address correspondence to: Shelain Patel, FRCS (Tr&Orth), Foot and Ankle Unit, Royal National Orthopaedic Hospital, Brockley Hill, Stanmore HA7 4LP, UK.

E-mail address: [shelain.patel@doctors.org.uk](mailto:shelain.patel@doctors.org.uk) (S. Patel).

washer for the compression screw to act on rather than relying on a patient's cortical bone. Exclusion criteria included active local and systemic infection, revision arthrodesis, concomitant first ray procedures (eg, realignment osteotomy), and severe vascular deficiency of the affected limb.

Sixty-seven feet in 65 potentially eligible patients were identified; although 3 (4.5%) feet were lost to follow-up, 5 (7.5%) feet were revision surgery, 1 (1.5%) foot had concomitant basal osteotomy, and complete outcome data were not collected for 4 (5.97%) feet, leaving 54 feet in 52 patients for final evaluation. There were 14 (26.9%) males and 38 (73.1%) females, with an overall mean age of  $64.4 \pm 8.3$  (range 36 to 78) years. The indication for the surgery was end-stage hallux rigidus in 44 (81.5%) feet, severe hallux valgus in 8 (14.8%) feet, and rheumatoid arthritis in 2 (3.7%) feet.

All of the patients were seen by a chartered physiotherapist preoperatively and fitted with a rigid-soled shoe and given crutches. The patients were advised to maintain ankle and lesser toe range of motion exercises unless contraindicated due to concurrent procedures and to keep the foot elevated when resting, during the postoperative period.

All of the operations were performed by the senior authors (M.A.F., P.S.R.) or under their direct supervision. All operations were performed with the patient under general anesthesia with a thigh tourniquet inflated after a single parenteral dose of prophylactic antibiotics was administered and before the skin incision. Six (11.1%) procedures were combined with concomitant lesser toe operations. A dorsal or medial incision was used based on surgeon preference. After capsulotomy and joint exposure, a similar surgical technique was used that involved removing the medial eminence, denuding the existing joint cartilage to cancellous bone, and then using cannulated concentric reamers over an intramedullary guide wire to create a conforming ball and socket articulation. The first MTPJ was properly aligned and held in place with a temporary 0.062-inch Kirschner wire before placement of the lag screw. We have found the compression provided by the lag screw in the IO FIX™ device results in slight varus and elevatus of the proximal phalanx and therefore we take consideration of this. We have also come to understand that the optimal position of the x-post is approximately 10 mm from the joint, in the midpoint between the dorsal and plantar metatarsal surfaces and parallel to the metatarsal joint surface. To facilitate accurate placement, a 0.062-inch guidewire was inserted under fluoroscopy where the x-post should be. The bone was then drilled and reamed over the wire. A 6.6-mm x-post was inserted until flush with the cortex and aligned toward the central sagittal plane of the proximal phalanx. The guidewire was removed and soft tissue was cleared from the eyelet. A 0.062-inch guidewire was then inserted through the eyelet of the x-post and driven distally across the MTPJ to provide a guide for the trajectory of the lag screw at  $60^\circ$  to it. The proximal cortex was drilled, and a 4.0-mm lag screw of an appropriate length screw was inserted until compression was achieved across the arthrodesis interface. Remaining osteophytes were then removed, and the wound was closed and dressed as per surgeon preference. Patients were allowed to fully bear weight in a rigid-soled shoe, and 2 crutches were dispensed to assist walking.

Patients were initially reviewed at 2 weeks after their surgery for assessment of the incision and removal of sutures. Patients were seen again at 6 weeks for clinical and radiographic assessments when they were allowed to transition back to normal footwear. Clinical assessment was undertaken using the Manchester-Oxford Foot Questionnaire (MOXFQ) (3,4), the results for which were entered into a database by one of the authors (P.G.). All complications were recorded during early and late follow-up and diagnosed by the operating surgeon. Radiographs were reviewed by 2 surgeons (S.P., P.G.) who were involved in some, but not all, of the operations, assessing for osseous union of the fusion site (defined as trabeculation across 3 cortices), intermetatarsal angle, hallux abductus angle, and MTPJ dorsiflexion angle using weightbearing anteroposterior and lateral views of the foot (Figs. 1 and 2, respectively).

Statistical analyses was performed with the use of Medcalc software (Version 11.3; Ostend, Belgium) by one of the authors (S.P.). All radiographic indices and outcomes scores were assessed for normality by using the Kolmogorov-Smirnov test and found to observe a Gaussian distribution, so Student's *t*-tests were used for comparisons. Statistical significance was defined at the 5% ( $p \leq .05$ ) level.

## Results

The mean follow-up was  $14.2 \pm 1.7$  (range 12 to 23) months. The mean MOXFQ score improved from  $46.4 \pm 13.3$  (range 18 to 64) before surgery to  $30.2 \pm 8.7$  (range 0 to 54) at 6 months after surgery ( $p = .02$ ) and to  $18.4 \pm 9.4$  (range 0 to 36) ( $p < 0.001$ ) at the latest follow-up. Arthrodesis across the MTPJ was achieved in 52 (96.3%) of the 54 feet, at a mean of  $61 \pm 16.0$  (range 39 to 201) days. Nonunion was observed in 2 (3.7%) feet that underwent the procedure for end-stage arthrosis; neither of the patients had known risk factors. One (1.9%) patient remained asymptomatic and declined further intervention, and the other (1.9%) patient underwent revision with removal of the intraosseous post and lag screw fixation device, repeat preparation of the joint surfaces, bone grafting, and fixation using a dorsal precountered locking plate at 11 months after the index procedure. There were 5 (9.3%) other



**Fig. 1.** Standing anteroposterior radiographs taken at 4 months postoperatively in a 67-year-old female treated with the intraosseous post and lag screw fixation device in whom immediate bearing of weight was allowed, demonstrating union (same patient as shown in Fig. 2).



**Fig. 2.** Standing lateral radiographs taken at 4 months postoperatively in a 67-year-old female treated with the intraosseous post and lag screw fixation device in whom immediate bearing of weight was allowed, demonstrating union (same patient as shown in Fig. 1).

complications noted, including 2 (3.7%) superficial wound infections that responded to an oral course of antibiotics without further sequelae. In 3 (5.6%) feet, the metalware impinged on the soft tissues, necessitating removal after union had occurred. There were no cases of loss of position or implant breakage. The mean radiographic indices at the latest follow-up were hallux valgus angle of  $14.2^\circ \pm 2.8^\circ$  (range  $12^\circ$  to  $18^\circ$ ) reduced from a preoperative value of  $15.8^\circ \pm 3.7^\circ$  (range  $12^\circ$  to  $23^\circ$ ) ( $p = .58$ ), intermetatarsal angle  $10.1^\circ \pm 1.7^\circ$  (range  $8^\circ$  to  $15^\circ$ ) reduced from a preoperative value of  $12.9^\circ \pm 2.6^\circ$  (range  $8^\circ$  to  $17^\circ$ ) ( $p = .21$ ), and dorsal angulation of the first MTPJ was  $21.6^\circ \pm 3.7^\circ$  (range  $12^\circ$  to  $35^\circ$ ) changed from a preoperative value of  $18.5^\circ \pm 4.1^\circ$  (range  $11^\circ$  to  $35^\circ$ ) ( $p = .38$ ).

## Discussion

The incidence of radiographic union of the first MTPJ observed in this study was 96%, the MOXFQ improved statistically significantly, and the metalware impinged on the soft tissues, necessitating removal after fusion had occurred in 5.6% of the feet.

The interest in immediate weightbearing after first MTPJ arthrodesis has been long-standing since a randomized trial in the early 1980s showed comparable union rates of 87% between patients who were allowed full weightbearing in a below knee walking cast from 2 to 4 postoperative days and full weightbearing starting 4 weeks after surgery (5). Since that study was published, however, modern implants have been designed that obviate the need for plaster due to superior stabilization of the fusion interface.

To date, the most widely accepted perception is that a dorsal plate and oblique lag screw provide the most stable construct to secure the first MTPJ, which is supported by biomechanical studies (6,7). Plate and screw fixation is a stiff construct that acts as a composite beam with the bone sandwiched between the plate and screw, although this has not always clinically translated into success (8,9). Interestingly, rates of union have broadly been reported as similar between patients treated with locked and unlocked plates, with the exception of nonunion observed in patients with rheumatoid arthritis who were stabilized with the use of a locked plate (10). Another disadvantage of plates is soft tissue irritation, which may necessitate secondary operations. Ellington et al. (2) reported that in a series of 107 patients treated with plate fixation, 5 (4.7%) had metalware that was sufficiently symptomatic to merit removal. With this in mind, there has been a refocus on improving intramedullary fixation. In our series of patients, we observed metalware that impinged on the soft tissues, necessitating removal after union, in 3 (5.6%) feet.

When traditional screws are used, compression across an arthrodesis site can be limited by the amount of bone that is engaged with the threads and the integrity of the cortex against which the screw head will sit. In osteopenic bone, this can be of particular concern. The intraosseous post and lag screw fixation device used in our series of patients eliminates this potential deficiency, because the lag screw engages the x-post's Morse taper as it is tightened, thereby reinforcing the cortical bone bridge (11). In a biomechanical study evaluating this device across the tibiotalar joint, it was shown to create significantly higher median forces within the arthrodesis compared with the single cancellous lag screw and washer and a more uniform pressure across the arthrodesis, and a higher median contact area was exhibited. The question of how the intraosseous post and lag screw fixation device compares biomechanically across the MTPJ with other constructs cannot be answered at this time, because there are no data available.

Two case series using the IO FiX™ for first MTPJ arthrodesis have been published, although both have smaller cohorts than ours. Drampalos et al. (12) followed 23 patients to a mean 19 months noting a union rate of 91%. Postsurgical rehabilitation consisted of protecting the foot in a cast-slab with immediate heel weightbearing in a surgical shoe and

unrestricted activity was allowed as long as bone union was evident on radiographs after 6 to 12 weeks. Singhal et al. (13) followed 21 patients to a mean of 29 months, noting a union rate of 95%. They did not use a cast-slab and similarly allowed immediate heel weightbearing in a firm-soled sandal with the aid of crutches and mobilization as tolerated at 6 weeks if satisfactory fusion was achieved at this stage. This mimics our union rate of 96%, which in itself compares favorably with the general literature on primary first MTPJ arthrodesis where rates vary from 87% to 100% (14,15). We experienced a learning curve using the intraosseous post and lag screw fixation device, which can be demonstrated in 2 patients. In the first example, insufficient tissue clearance from the eyelet of the x-post led to lag screw prominence along the medial cortex of the first metatarsal (Figs. 1 and 2). In another patient in whom bilateral procedures were performed, the x-post was positioned too deep in the left foot, which resulted in the use of a shorter lag screw with less bone for purchase in the proximal phalanx than was achieved in the right foot, although this did not reduce the ability to achieve union (Fig. 3). One additional learning point that has not been emphasized in other reports of the implant is that compression promotes hallux varus and elevatus. This is because the entry point of the lag screw is on the superomedial aspect of the distal metatarsal and, therefore, provisional fixation should take this into account to achieve a functional position. This is a classic compression fixation effect that can occur whenever the lag effect is asymmetrically loaded across an arthrodesis interface.

The study has 3 major limitations. First, we did not have another fixation construct against which to compare our results. However, the majority of similar studies report the results of a single technique for first MTPJ arthrodesis. Moreover, the sample size may be considered small and duration of follow-up considered short. Nonetheless, this study represents the largest series of the device studied, and the duration of follow-up was sufficient to identify union and complications. Despite these limitations, we believe that the results of this study could be useful in the future development of prospective randomized controlled trials that focus on identifying the optimal method of fixation in first MTPJ arthrodesis. We also believe that the results of this investigation could be used in the development of future studies that focus on fixation of first MTPJ fusion.

In conclusion, the intraosseous post and lag screw fixation device used in our series of patients appears to be a safe and effective device to achieve arthrodesis across the first MTPJ when immediate weightbearing is desired, providing an alternative to other methods of fixation.



Fig. 3. Anteroposterior radiographs taken at 9 months after left foot surgery and 5 months after right foot surgery.

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