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First metatarsophalangeal joint arthrodesis – Do joint configuration and preparation technique matter?

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ABSTRACT

Background: The purpose of this study was to investigate the influence of joint configuration and preparation on first metatarsophalangeal (MTPJ) union rates.
Methods: We performed a retrospective analysis of first MTPJ arthrodeses undertaken in our institution. Clinical notes, radiographs and postal questionnaires were used to determine outcome.
Results: Two hundred first MTPJ arthrodeses (172 patients) were included in the analysis (34 male: 138 female; mean age 62 yr). The overall union rate was 93.5%. Union was achieved in 109/118 MTPJs (92.4%) prepared in the flat-on-flat configuration and in 78/82 (95%) prepared in the ball-and-socket configuration ($p = 0.438$). Higher union rates favoured low-velocity joint preparation [using rongeur only 21/21 (100%), rongeur and burr 26/27 (96.3%) and conical reamer 31/34 (91.2%)] but this did not reach statistical significance ($p = 0.317$). There was a 95% satisfaction rate with surgery but male patients were less satisfied ($p = 0.031$).
Conclusion: Union rates were not influenced by joint configuration or preparation techniques.

1. Introduction

Arthrodesis of the first metatarsophalangeal joint (MTPJ) is commonly used and is considered the gold-standard procedure for managing advance stages of hallux rigidus, degenerate hallux valgus and inflammatory arthropathy. The efficacy and predictability of the procedure is well established in the literature, with high patient satisfaction [1–4].

There have been various descriptions of this procedure since it was first described by Clutton [5] in 1894. The joint surfaces are generally prepared for arthrodesis using two configurations, the flat-on-flat and ball-and-socket type preparation [6]. Flat cuts are made using a power saw whereas the ball-and-socket preparation can be done using conical reamers, burrs or rongeurs. Osteosynthesis is achieved using wires, staples, one or two screws (cross or parallel configuration), low-profile plates and combinations thereof [4,7–9]. The most reliable technique however, is yet to be established and this is reflected in a large number of published studies with equivocal results. A recent systematic review of over 2800 first MTPJ arthrodesis showed an overall incidence of non-union of only 5.4 percent [6]. However, non-union rates do vary from study to study [3,9–13]. The combination of using spherical reamers followed by interfragmentary screw and dorsal plate osteosynthesis produced a non-union rate of only two percent in one series [3]. On the other hand, Grimes and Coughlin [12] demonstrated a twelve percent non-union rate in their series when either a Steinman pin or plate fixation was used to achieve arthrodesis. Were the varying rates of union a reflection of the technique utilised to achieve first MTPJ arthrodesis?

Published literature had mainly focused on osteosynthesis techniques in first MTPJ arthrodesis. The purpose of this study was to investigate the influence of joint configuration and preparation on first MTPJ union rates among foot and ankle surgeons.

2. Patients and methods

We performed a retrospective review of medical and radiographic records of patients who had undergone first MTPJ arthrodesis in our institution from May 2003 to April 2013. The demographics and pathologies were recorded. Post-operative patient reported outcome measures and satisfaction with surgery were obtained through postal questionnaires. Approval was obtained from the institutional review board.

The inclusion criteria included first MTPJ arthrodesis performed by fellowship trained foot and ankle surgeons and osteosynthesis

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constructs of crossed-compression screws or dorsal plate and oblique compression screw only. We included pathologies of hallux rigidus, hallux valgus and inflammatory arthropathy (gout and rheumatoid arthritis). Cases with previous first metatarsal surgery including cheilectomy, bunionectomy and hallux valgus correction were also entered.

The exclusion criteria included: (1) revision arthrodesis; (2) concomitant midfoot or hindfoot surgery; (3) procedure performed by non-foot and ankle surgeons; and (4) alternative osteosynthesis methods including staples and intramedullary fixation.

2.1. Surgical technique

A medial approach was used by all foot and ankle surgeons to expose the first MTPJ. The joints were prepared using either a flat-on-flat or ball-and-socket type configuration, depending on the surgeons preferred technique. Each surgeon performed only one type of joint preparation. The techniques used to achieve the joint preparation were categorised as follows:

(1) Group 1: Flat-on-flat configuration
   - A power saw was used to create flat cuts on the corresponding surfaces of the MTPJ.

(2) Group 2: Ball-and-socket configuration
   - techniques were used to achieve this configuration:
     i. A rongeur was used to prepare both metatarsal head and proximal phalanx surfaces
     ii. A rongeur and burr were used for metatarsal head and proximal phalanx preparation, respectively
     iii. Conical reamer system for surface preparation (HALLU®-ream, Integra Neurosciences Ltd., Hampshire, UK)

Joint preparation was completed with multiple K-wire fenestrations into the subchondral bone. The joint was then stabilised with K-wires in the desired position. The hallux was positioned to sit just off a flat tray, which was applied to the plantar side of the foot to simulate weight bearing. The valgus alignment was matched to the contralateral foot if normal or set at neutral (15 degrees valgus alignment). Osteosynthesis was performed using either crossed-compression screws (4.0 mm cannulated or 3.5 mm non-cannulated screws) or a combined dorsal plate and oblique compression screw (4.0 mm cannulated screw). The choice of osteosynthesis was dependent on the surgeon's preferred technique but occasionally, the plate construct was used when bone quality was poor. All patients were reviewed at varying time-points post-operatively in outpatients by their respective surgeons (minimum of 3 months follow-up). Patients were discharged when they achieved radiological union, or were asymptomatic with non-unions beyond 12 months of surgery.

2.2. Outcome measures

The primary outcome of this study was radiological union. This was defined as the visualisation of bone bridging in at least 3 out of 4 cortices in 2 orthogonal radiographic views. All the radiographs were assessed by radiologists and confirmed by 3 independent orthopaedic surgeons. The clinical notes were also reviewed. If radiological union was not conclusive, an independent surgeon other than the operating surgeon assessed the radiographs. The secondary outcomes included patients' satisfaction with the outcome of surgery as derived from Johnson et al. [14] (Table 1). The Manchester-Oxford Foot Questionnaire (MOxFQ) [15] and EQ-5D-3L™ [16] questionnaire were used to assess foot function after surgery.

Table 1
Satisfaction with outcome of surgery.

Satisfaction score	
1	Completely satisfied – essentially pain free, no restrictions in activity, and only minor restriction in footwear
2	Satisfied with minor reservation – occasional mild pain, minor restrictions in activity and minor restrictions in footwear
3	Satisfied with major reservation – mild or moderate pain, moderate restrictions in activity and major restrictions in footwear, but overall improvement
4	Dissatisfied – no improvement in pain or worse pain, major restrictions in activity and footwear, no improvement or worse symptoms

2.3. Statistical analysis

Data was analysed using IBM Statistics 19 (IBM Inc.). Non-parametric data was expressed as median (interquartile range) and parametric data as mean (standard deviation). Categorical data was analysed using the Chi-Square test and numerical data was analysed using the Mann–Whitney *U* test or Student's *t*-test depending on the normality of distribution. Significance was determined at $p < 0.05$. The MOxFQ summed domain scores were expressed in metric form (0–64; 64 being most severe). The EQ Health today scale was expressed in metric form (0–100; 100 being the best possible score).

3. Results

A total of 172 patients (200 MTPJs); 34 males and 138 females were included in the analysis. The mean age of the study population at the time of their surgery was 62 (SD 12) years. There were 103 right-sided procedures. No patient was lost to follow-up. Radiological studies and clinical notes were available for all patients. The median follow-up for the postal questionnaire was 43 months (IQR 25–76) from the time of surgery.

Table 2 summarises the diagnoses and osteosynthesis technique of the flat-on-flat and ball-and-socket groups. The two groups were matched for age and gender. However, there were higher numbers of inflammatory arthropathies in the flat-on-flat joint preparation group (Chi-Square test, $p = 0.005$). The distribution of osteosynthesis technique between the two groups was not statistically different (Chi-square test, $p = 0.06$).

3.1. Union rates

The overall union rate in our study was 93.5% (187 out of 200 MTPJs). Radiological union rates were not statistically different between the two joint configurations (Fig. 1). Union was seen in 109/118 (92.4%) MTPJs in the flat-on-flat configuration and 78/82 (95%) MTPJs in the ball-and-socket configuration (Chi-Square test, $p = 0.438$).

Subgroup analysis within the ball-and-socket group showed that union rates were not statistically different between the

Table 2
Distribution of diagnoses and osteosynthesis techniques between the two groups.

Group	Diagnosis	Osteosynthesis technique
Flat-on-flat configuration ($n = 118$)	Hallux valgus (40%)	Compression screws (94%)
	Hallux rigidus (31%)	Plate and screw (6%)
	Inflammatory (29%)	
Ball-and-socket configuration ($n = 82$)	Hallux valgus (54%)	
Rongeur ($n = 21$)	Hallux rigidus (37%)	Compressions screws (82%)
Rongeur & burr ($n = 27$)	Inflammatory (8%)	Plate and screw (18%)
Conical reamer ($n = 34$)	Hallux varus (1%)	