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Arthrodesis of the First Metatarsophalangeal Joint: A Retrospective Analysis of Plate versus Screw Fixation

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ABSTRACT

Arthrodesis of the first metatarsophalangeal joint is a commonly accepted technique to treat various afflictions of the hallux. Many techniques have been described to fixate the arthrodesis. However, no superior fixation technique has been identified in regard to nonunion. We performed a retrospective analysis of first metatarsophalangeal joint arthrodeses in our clinic from January 2000 to April 2010, focusing on plate and screw fixation. Our aim was to identify the best fixation construct in regard to fusion rates and radiologic nonunion. We identified 72 arthrodeses performed using 1 oblique (n = 24) or 2 crossed (n = 21) lag screws or a plate (n = 13) or a plate augmented with plantar lag screw fixation (n = 14). Our analysis showed that plate fixation alone results in significantly fewer nonunions than single screw fixation. A comparison of the other fixation types showed no significant differences with regard to nonunion. Although our analysis showed that plate fixation alone is superior to single screw fixation, no definitive conclusion can be drawn owing to methodologic shortcomings. We believe a randomized controlled trial with larger sample sizes is necessary to find the clinically superior fixation technique.

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Arthrodesis of the first metatarsophalangeal joint (MTPJ-1) is a commonly accepted technique for the treatment of several afflictions of the hallux. This procedure most commonly results in pain reduction, deformity correction, and the resumption of daily activities. Common indications are hallux rigidus (osteoarthritis of the MTPJ-1), rheumatoid arthritis, primary or revision hallux valgus correction, and post-traumatic arthritis (1–5).

Since the first description of MTPJ-1 arthrodesis by Clutton (6) in 1894, various different methods of fixation have been described. These methods include Kirschner wires (7–9), memory staples (7–10), plates (10–15), 1 or 2 interfragmentary screws crossed or in parallel (8,14,16,17). The essence of all these methods is to achieve sturdy and stable fixation.

The most commonly used methods of fixation for MTPJ-1 arthrodesis are plate or screw fixation. The current data suggest that the average success rate when using a plate or screw as the fixation method is about 90% (7,9–15,17–19). However, after assessing the clinical data concerning MTPJ-1 arthrodesis, it became apparent that no fixation method can be identified as superior in terms of the fusion rate. After reviewing biomechanical research aimed at assessing the strength of several different fixation methods for MTPJ-1 arthrodesis, it became apparent that plate and lag screw constructs have the greatest mechanical strength (20–24).

We performed a retrospective analysis of the MTPJ-1 arthrodeses performed using screw or plate fixation in our clinic to identify whether a screw or plate construct is superior in the interval required for fusion and the rate of radiologic union.

Patients and Methods

We performed a retrospective review of all MTPJ-1 arthrodeses performed at the Deventer Hospital (Deventer, The Netherlands) to identify the fixation method, whether screw or dorsal plate, to determine which is clinically superior.

Study Population

The study population consisted of all patients who had undergone primary or revision arthrodesis of their MTPJ-1 from January 1, 2000 to April 1, 2010 at the Department of Orthopaedic Surgery, Deventer Hospital (Deventer, The Netherlands).

The patients were included if they had undergone MTPJ-1 arthrodesis using 1 of 4 fixation methods: a single oblique lag screw, a crossed lag screw, a low contoured dorsal plate alone, or a low contoured dorsal plate augmented with a plantar lag screw. The patients were excluded if they had undergone arthrodesis using a fixation method other than these 4.

After exclusion, 72 primary and revision arthrodesis cases remained for chart review. The review was conducted without review board permission, which was not indicated for the present retrospective study. Seventy-two procedures were performed in 69 patients: 48 females and 21 males. Their median age was 62 (range 36 to 84)

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years. These patients had undergone surgery on 41 right and 31 left feet; 3 patients had received bilateral procedures. The preoperative diagnosis included hallux rigidus in 51, revision of hallux valgus correction in 5, rheumatoid arthritis in 10, and revision arthrodesis in 6. Because different fixation techniques were used, these patients were divided into 4 subgroups: single 2.7-mm cannulated, self-tapping lag screw fixation (Bold Screw®, Integra Life Sciences, Plainsburo, NJ; n = 24), crossed 2.7-mm, cannulated, self-tapping lag screw fixation (n = 21), precontoured titanium alloy, low-profile, nonlocking plate (Hallufix® S-Plate System, Integra Life Sciences) fixation (n = 13), and precontoured, titanium alloy, low-profile, nonlocking plate (Hallufix® S-Plate System, Integra Life Sciences) combined with plantar, 2.7-mm, cannulated, self-tapping lag screw fixation (n = 14). The plates were fixed using the standard 2.7-mm snap off screws supplied with the plate.

Surgical Procedure

A direct medial incision was used to expose the MTPJ-1. The remaining cartilage was abraded and the joint capsule released. The joint surfaces were prepared for fixation using planar cuts. The joint was fixed using 1 of the following: an oblique 2.7-mm, cannulated, self-tapping lag screw, positioned from medially to laterally; 2 crossed 2.7-mm, cannulated, self-tapping lag screws, with the first positioned medially to laterally in a proximal to distal orientation and the second positioned medially to laterally in a distal to proximal orientation; a precontoured dorsal plate; or a precontoured dorsal plate augmented with a plantar 2.7-mm, cannulated, self-tapping lag screw. The plate size and lag screw length was determined intraoperatively. A compression bandage was applied after surgery, and the patients were allowed full weight bearing the first day after surgery in a special forefoot-relieving postoperative shoe. The compression bandage was removed 2 weeks after surgery.

Postoperative Follow-up

The patients were reviewed clinically and radiologically (using anteroposterior and lateral radiographs) at 2 weeks, 6 weeks, and 3 months after surgery. All patients had a minimum follow-up of 3 months; however, if the arthrodesis site did not fuse after 3 months, the follow-up period was prolonged until fusion or nonunion occurred. One of us (J.D.) retrospectively reviewed all the radiographs to determine whether radiologic union had occurred. A joint was considered fused when three-fourths trabecular bridging was seen on both anteroposterior and lateral radiographs. Nonunion was defined as no sign of bone healing 6 months after surgery (i.e., no contical or trabecular bridging).

Statistical Analysis

All categorical data were analyzed using the chi-square test and, as needed (i.e., 1 variable in the equation less than 5) analyzed using the Fisher exact test. The alpha value for significance was set at $p \leq .05$. Statistical analysis was performed by 1 of our hospital epidemiologists. All statistical analyses were performed using the Statistical Package for Social Sciences, version 17.0 (SPSS, Chicago, IL).

Results

Subgroup Characteristics

The 24 patients with single screw fixation had a median age of 60 (range 38 to 84) years, and 15 were female and 9 male. They underwent surgery on 14 right and 10 left feet. The 21 patients with crossed screw fixation had a median age of 58 (range 43 to 78) years, and 15 were female and 6 male. They underwent surgery on 13 right and 8 left feet. Arthrodesis of MTPJ-1 using a low-contoured dorsal plate alone was performed in 10 female and 3 male patients. They underwent surgery on 6 right and 7 left feet. They had a median age of 74 (range 36 to 83) years. The 14 patients undergoing arthrodesis fixed with a low-contoured dorsal plate augmented with plantar screw fixation had a median age of 66 (range 37 to 80) years; 11 were female and 3 male. They underwent surgery on 8 right and 6 left feet.

Fusion Rate

The MTPJ-1 arthrodeses performed with single screw fixation had a fusion rate of 71%, with 17 of 24 fused. Those fixed using crossed screws had a fusion rate of 90%, with 19 of 21 fused. The MTPJ-1 arthrodeses performed with a low-contoured dorsal plate alone had a fusion rate of 100%, and those performed using a low-contoured dorsal plate augmented with plantar screw fixation had a fusion rate of 93%, with 13 of 14 fused.

The statistical analysis of the 4 different subgroups regarding fusion at 6 weeks and 3 months after surgery showed no statistically significant differences (Tables 1 and 2). An analysis of the nonunions showed that plate fixation alone resulted in a significantly lower rate of nonunion than did single screw fixation ($p = .038$). We found no significant difference in the results for the other fixation techniques regarding the rate of nonunion (Table 3).

Discussion

Arthrodesis of the MTPJ-1 is an effective and safe technique that can be used to treat a multitude of afflictions of the hallux (1–5). To date, no single fixation technique has been proved to be clinically superior.

The fixation techniques used in our analysis were shown to be effective and to have a fusion rate of 90% or greater, except for single screw fixation, which had a fusion rate of only 71%. This finding was contradicted by research performed by Wassink and van der Oever (17). Their retrospective analysis of 109 feet showed that single screw fixation is an effective technique and has an adequate fusion rate of 95.4%. This difference in the fusion rate might have resulted from the greater screw core diameter of 3.5 mm used in their study. A retrospective analysis of 34 feet by Sharma et al (18) also contradicts our finding that single screw fixation is a lesser technique for fixation of MTPJ-1 arthrodesis. They showed that both single compression screws and single compression screws augmented with a dorsal plate are effective methods of fixation for MTPJ-1 arthrodesis, with a fusion rate of 100% and 94%, respectively (18). Curtis et al (20) showed that single lag screw fixation is significantly stronger biomechanically than dorsal plate fixation.

Comparing plate and screw fixation, our analysis showed that dorsal plate fixation alone had a significantly lower rate of nonunion than single screw fixation. All other fixation methods had a rate of fusion that was not significantly different. These results are supported

Table 1
Results of statistical analysis of fusion rate after 6 weeks (N = 72 arthrodeses in 69 patients)

Fixation Method	Fusion at 6 wk		Total	*p* Value
	No	Yes		
Comparison 1				.259*
Single screw	12	12	24	
Crossed screw	7	14	21	
Total	19	26	45	
Comparison 2				.315†
Single screw	12	12	24	
Plate	4	9	13	
Total	16	21	37	
Comparison 3				.671*
Single screw	12	12	24	
Plate plus screw	8	6	14	
Total	20	18	38	
Comparison 4				1.0†
Crossed screw	7	14	21	
Plate	4	9	13	
Total	11	23	34	
Comparison 5				.163*
Crossed screw	7	14	21	
Plate plus screw	8	6	14	
Total	15	20	35	
Comparison 6				.252*
Plate	4	9	13	
Plate plus screw	8	6	14	
Total	12	15	27	

* Chi-square test.
† Fisher's exact test.

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