Second Metatarsal Osteotomy Shortening with Tarsometatarsal Arthrodesis: Comparison of Outcomes Between MSP™ Metatarsal Shortening System and Plates and Screws

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Abstract

Background: Metatarsalgia is a common cause of pain which results from several mechanisms. Care of metatarsalgia includes operative management with metatarsal osteotomy when initial conservative management fails. Multiple osteotomy techniques with varying success have been developed and described, including open reduction and internal fixation and a newer MSP™ metatarsal shortening system. Methods: A historical group composed of 95 patients compromising 126 osteotomies was compared to a MSP™ group composed of 42 patients and 60 osteotomies. Patient records were reviewed retrospectively to determine the union rate and complications experienced. Results: 125 of 126 osteotomies in the historical group and 60 of 60 osteotomies in the MSP™ group were successfully united. Complications included non-union (historical group: 1 patient) and delayed union (MSP™ group: 3 patients), superficial wound infections (historical group: 2, MSP™ group: 5), and additional recommended surgical intervention (historical group: 1, MSP™ group: 2). Conclusions: Although further investigation into clinical markers of progress and role of concomitant procedures needs to be completed, the MSP™ system resulted in comparable union rate to traditional osteotomy with open reduction and internal fixation.

Introduction

Metatarsalgia is characterized by pain localized to the plantar surface of the forefoot underlying the metatarsal heads. The causative mechanisms of metatarsalgia can be external forces, biomechanical variables including bone and soft tissue abnormalities, overuse, or any combination of these factors. Differential diagnoses responsible for metatarsalgia include long metatarsals, hypermobility of the first ray, arthritic changes, dermatologic lesions on the plantar surface of the forefoot, atrophy of the plantar fat pad, subluxation or dislocation of the metatarsophalangeal joint, or complications from previous surgery. Standard of care typically involves initial attempts at conservative management including rest, elevation, stretching, activity alterations, shoewear modification, custom orthotics designed to unload the metatarsal head, corticosteroid injections, and anti-inflammatory medications. However, if conservative
management fails, the next treatment option is often surgical correction with a shortening osteotomy.

Several osteotomy techniques have been designed to reduce the length of the metatarsal shaft and reduce the pressure exerted on the metatarsal heads including the Weil osteotomy, transverse diaphyseal shortening, the Hoke procedure, the Helal technique, diaphyseal and distal dorsal wedge closing osteotomy, chevron osteotomy with dorsal displacement, and a step-cut shortening diaphyseal osteotomy as described by Giannestras. Midshaft segmental osteotomy with open reduction and internal fixation has been previously shown by the senior authors to be a useful technique with a high fusion rate. Recently, the MSP Metatarsal Shortening System has been developed and marketed as both an osteotomy guide and implant which reduces the likelihood of plantar displacement of the metatarsal head following osteotomy and allows for controlled shortening. The purpose of this paper is to compare the rate of successful metatarsal fusion following historically utilized plate and screws versus the MSP Metatarsal Shortening System.

Materials and Methods

The patients enrolled in the study were divided into two groups based on the type of osteotomy performed. The historical group was comprised of ninety-five patients that underwent midshaft metatarsal osteotomy with open reduction and internal fixation from June 1999 to October 2001 representing 102 feet and 126 osteotomies. The MSP group was comprised of forty-four patients who had metatarsal osteotomies with the MSP Metatarsal Shortening System from January 2014 to January 2016 representing 42 feet and 60 osteotomies (second and third metatarsal). The patient population consisted of 73 women and 22 men in the historical group, and 34 women and 8 men in the MSP group with an average age of 56.8 (women) and 56.1 (men) in the historical group and 56.9 (women) and 53.4 (men) in the MSP group, respectively. The patient records were identified and reviewed for age at the time of surgery, gender, comorbidities, indications for osteotomy, procedures performed, postoperative course, osteotomy union, as well as any associated complications. Radiography obtained included anteroposterior and lateral views of the foot preoperatively, two weeks postoperatively, six to eight weeks postoperatively, four to six months postoperatively, and as needed if complications arose. Comorbid conditions commonly encountered (reported as: condition (historical, MSP)) included smoking (28 of 95 (29.5%), 16 of 42 (38.1%)), diabetes (4 of 95 (4.2%), 4 of 42 (9.5%), and rheumatoid arthritis (3 of 95 (3.2%), 3 of 42 (7.1%). 94 patients in the historical group and 42 patients in the MSP group had multiple concomitant procedures on the affected foot, as described below (Table 1). In the historical group, a single metatarsal osteotomy was done in 82 feet (80.4%) while multiple osteotomies were done in 20 feet (19.6%). In the MSP group, a single metatarsal osteotomy was done in 25 feet (59.5%) and multiple osteotomies were done in 17 feet (40.4%), totaling 60 MSP Metatarsal Shortening System implants utilized.
### Tables 1 & 2: Indications and Procedures performed

<table>
<thead>
<tr>
<th>Indications</th>
<th>Historical Group</th>
<th>MSP™ Group</th>
<th>Concurrent Procedures</th>
<th>Historical Group</th>
<th>MSP™ Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hammertoe</td>
<td>75</td>
<td>15</td>
<td>Third Metatarsal Osteotomy</td>
<td>23</td>
<td>17</td>
</tr>
<tr>
<td>Hallux Valgus</td>
<td>45</td>
<td>22</td>
<td>Fourth Metatarsal Osteotomy</td>
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<td>Hypermobile First Ray</td>
<td>31</td>
<td>27</td>
<td>Hammertoe Correction</td>
<td>75</td>
<td>20</td>
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<tr>
<td>Metatarsalphalangeal Joint Arthrosis</td>
<td>7</td>
<td>3</td>
<td>First Tarsometatarsal Joint Fusion</td>
<td>20</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gastrocnemius recession</td>
<td>4</td>
<td>39</td>
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</table>

**Operative Technique**

The patient was brought to the operating suite and positioned supine. A tourniquet was applied and the foot was prepped and draped in a sterile fashion. A dorsal longitudinal incision was made over the metatarsal diaphysis. The metatarsal diaphysis was exposed by blunt dissection leaving the periosteum intact. A subperiosteal area slightly larger than the plating system to be used was exposed.

For patients in the historical group, the desired segment of resection was marked on the diaphysis with an oscillating saw. Screw holes were drilled (2.0mm drill) and measured prior to completion of the osteotomy. The distal cut was made prior to the proximal cut and saline irrigation was performed. A four-hole quarter tubular plate, pre-bent to 5 degrees to facilitate plantar cortex compression, was centered over the osteotomy site. The plate was first secured distally using 2.7mm cortical screws, followed by placement of 2.7mm cortical screws proximally while compression of the distal and proximal segments was applied by an assistant. Autogenous bone graft, obtained from drill reaming harvesting and the resected portion of the metatarsal, was packed around the osteotomy.

For patients in the MSP™ group, the distal edge of the plate was positioned approximately 5mm proximal to the metatarsal head. Screw holes were drilled and measured and locking screws were placed distally while applying dorsal and medial pressure to the plate to ensure contact. The proximal screw hole was drilled and measured, and a compression screw was applied in the proximal end of the dog-leg slot without fully tightening. The osteotomy was obliquely made using the guide in the MSP™ plate and saline irrigation was performed. The metatarsal was then shortened by compressing the osteotomy and the dog-leg screw was fully tightened. During this compression, the final screw hole was drilled and measured and the compression screw was placed.
Postoperative Course

A short leg posterior splint was applied and worn for the first two weeks postoperatively. At the two-week postoperative appointment, the splint was removed, incision was inspected, sutures/staples were removed if indicated, plain radiographs were obtained, and a heel touch or non-weight bearing boot or cast (with a toe guard if K-wires were used for hammertoe correction) was applied. At the six to eight-week postoperative appointment, the cast was removed, the wound was rechecked, repeat plain radiographs were obtained, and the patient was fitted in a fixed ankle support to begin a protected return to weight bearing protocol. Formal physical therapy, if the patient elected, and a standard home exercise regimen were also initiated at this time. A final postoperative evaluation with plain radiographs was completed at four to six months.

Results

In the historical group, 125 of 126 osteotomies were united (99.2%). In the MSP™ group, 60 of 60 osteotomies were united (100%) which was not significantly different (p= 1.0) when compared to the historical group. Complications encountered included non-union (historical group: 1 patient) and delayed union (MSP™ group: 3 patients) and superficial wound infections which cleared with oral antibiotic therapy (historical group: 2 patients, MSP™ group: 5 patients). Additional procedures necessitated in the post-operative period included one hardware removal due to pain for one patient in the historical group and one patient in the MSP™ group. A revision procedure to address complications associated with a concomitant procedure (first tarsometatarsal joint fusion) was recommended for a patient with in the MSP™ group, but had not been completed at the time of data analysis.

Discussion

Appropriate management of metatarsalgia presents a challenge to the surgeon. When conservative treatment fails, a variety of operative techniques with their own benefits and complications have been described and utilized with varying success. Non-union rates as high as 76% for proximal osteotomy without internal fixation⁹ and 22.7% for the Helal osteotomy with internal fixation¹⁰ have been described. Vandeputte et al. noted a non-union rate as low as 0.8% for the Weil osteotomy, which was comparable to that of the historical group in this study, although the described procedure’s success was complicated by recurrent dislocations which occurred in 15% of patients¹¹.

In this study, radiographic outcomes and complications of metatarsal osteotomy with open reduction and internal fixation versus osteotomy with the MSP™ Metatarsal Shortening System were compared. Both groups consisted of patient populations with multiple comorbid conditions complicating their recovery and underwent procedures and post-operative care facilitated by the same clinicians. The MSP™ group experienced higher union rates, although this was not statistically significant, but more complications than the historical group. However, despite delayed union time complications in some
patients of the MSP™ group, the fusion rate was 100% and the revision procedures necessitated was comparable between groups. Further investigation examining larger patient populations, markers of clinical progress including AOFAS Scores and patient satisfaction, and the role of concomitant procedures performed should be completed to better understand the impact of operative fixation technique in the management of metatarsalgia.

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