

## Variable Angle Locking Compression Plate as Alternative Fixation for Jones Fractures: A Case Series

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### ABSTRACT

**Introduction.** Jones fractures pose many challenges for the treating surgeon and can cause significant disability for some patients. The aim of this study was to review the results of using a variable angle locking compression plate as an alternative fixation method in the treatment of Jones fractures.

**Methods.** A retrospective chart review was conducted of patients who had undergone fixation of Jones fracture with a variable angle locking compression plate from September 2012 through February 2016. Radiographs of the preoperative and six-week postoperative and postoperative follow-up outcomes, including complication and hardware removal, were collected.

**Results.** Twenty-three cases met the inclusion/exclusion criteria. The overall bony union rate was 96% at six-week postoperative and 100% at 20-week postoperative. Mean age was  $30 \pm 16$  years, and mean BMI was  $30.7 \pm 5.2$  kg/m<sup>2</sup>. Three patients (13%) had plate removal: two (9%) were due to irritation caused by shoe wearing and one patient (4%) had a skin infection (cellulitis) which was treated with intravenous antibiotics. One patient (4%) had developed deep vein thrombosis (DVT) that was resolved with anticoagulant without implant removal. No fixation loss and no associated complications developed from implant removal.

**Conclusions.** Based on our limited experience, this study provided evidence that the variable angle locking compression plate may be an alternative form of fixation for Jones fractures with a low complication rate. This procedure seemed to provide a safe, reliable method that can achieve an anatomic reduction, stable fixation, rapid healing, and good results in the treatment of Jones fractures.

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### INTRODUCTION

A Jones fracture, a fracture in the proximal end of the meta-diaphyseal junction of the fifth metatarsal of the foot, was first described by Sir Robert Jones in 1902.<sup>1</sup> It is a relatively common injury in athletes.<sup>2-4</sup> The mechanism for this injury occurs with ankle plantar flexion and adduction to the forefoot, usually the result of landing on the lateral border of the foot.<sup>1,5</sup> Jones fractures pose many challenges for the treating surgeon and can cause significant disability for some patients.<sup>2</sup>

Plate fixation has been introduced as one of the surgical treatment options for this type of injury.<sup>6-8</sup> The conventional fixed angle locking plate fixation was first introduced, which provides stable fixation of the fragments, regardless of the bone quality, and lower risk of loss of reduction. With fixed angle of the locking screws, however, some compromises may be necessary in either plate positioning or quality of subchondral support to facilitate fixed-angle fixation. These difficulties have led to the development of variable angle locking compression plates that permit an inclination of the screw insertion angle within a 30° cone. The apparent design goal is to yield screw placement flexibility while providing equivocal fixation versus fixed angle screw designs. There are, however, few studies evaluating or discussing the early outcomes of this variable angle locking compression plate fixation in this patient population. The specific aims of this study were to review the results of using a variable angle locking compression plate as an alternative fixation method in the treatment of Jones fractures.

### METHODS

**Subjects.** Institutional review board approval was obtained for this study. This retrospective case series study reviewed the clinical charts and radiographic studies of consecutive Jones fracture patients utilizing variable angle locking compression plate fixation. Inclusion criteria consisted of ambulatory subject age between 18 and 70, diagnosis of a Jones fracture (Type I Stewart fracture) with no other injury involved, acute fractures, either non-union or mal-union fracture, and treatment with variable angle locking compression plate fixation by the same surgeon from September 2012 through February 2016 from numerous hospitals within a selected community. Subjects who were non-ambulatory, had other combined foot and ankle fractures, Charcot arthropathy, dislocation, or deformity that disrupted the normal relationship of the fifth metatarsal with the foot, or had no follow-up radiographs were excluded from the study.

**Surgical Treatment.** Each surgery was performed through a traditional longitudinal incision approach under tourniquet control. The patient was placed in the supine position on a radiolucent operating table with elevation of the hip on the affected side, with the knee flexed, and the legs and hips padded appropriately, and with the affected extremity placed in neutral rotation. The procedure was performed under regional anesthesia with C-arm fluoroscopic guidance. A 3.5 to 4.0 cm skin incision was made just lateral to the fifth metatarsal.

After careful soft tissue dissection with the periosteum left intact, the fracture fragments were exposed. The variable angle locking compression plate (Cloverleaf fusion plate, Synthes, West Chester, PA) was placed onto the lateral aspect of the fifth metatarsal (Figure 1). The Cloverleaf end was placed proximal to the fracture line and

straight aspect was placed distally. The threaded compression wires were inserted through the compression wire hole (or compression slot) and through the bone. Screws were placed proximally followed by application of the reduction instrument.



Figure 1. Photograph of the variable angle locking compression plate (Clover-leaf fusion plate, Synthes, West Chester, PA).

Reduction of the fracture fragment was performed using the compression forceps with the tips around the compression wire spheres. Once radiographic verification of the fracture compression was obtained, 2.7 mm locking screws were inserted for final fixation. After stable fixation was achieved, the compression wires were removed.

Adequate visualization was imperative to achieve good reduction and confirm proper alignment, screw placement, and screw length with multiple views under radiographic imaging. Bony approximation of all fractures was confirmed with three views radiograph images (dorsal-plantar view, oblique view, and lateral view) intra-operatively (Figure 2).



Figure 2. Radiographic images of a Jones fracture case from initial preoperative to postoperative. Preoperatively: (a) Dorsal-Plantar view, (b) Oblique view, and (c) Lateral view; Postoperatively: (d) Dorsal-Plantar view, (e) Oblique view, and (f) Lateral view.

Postoperatively, the foot was immobilized and kept non-weight bearing for two weeks, then with progressive weight bearing in a cam boot for four weeks. This non-weight bearing protocol was based on previous studies.<sup>9-11</sup> After healing was confirmed radiographically four to six weeks post-operatively, a functional brace or foot orthoses often were worn if the patient was returning to strenuous competitive activity at the surgeon's discretion.<sup>11-12</sup>

**Variables.** A retrospective chart review was performed including documentation of age, gender, body mass index (BMI), feet injury site, and mechanism of injury. Surgical date, participation in sports, radiographs of the preoperative and six-week postoperative, post-operative follow-up outcomes including complication, and hardware removal were collected.

**Statistical Analysis.** Descriptive statistics of the mean, standard deviation, and range were determined using the continuous variables of subject's demographics (age and BMI) and postoperative follow-up weeks. The percentage of athlete subjects, complication rate, and hardware removal incidence also were calculated. Data entry was accomplished using Microsoft Excel 2013 (Microsoft, Redmond, WA).

## RESULTS

A total of 25 consecutive cases were identified and reviewed. Twenty-three cases (16 male, 7 female) met the inclusion criteria, and two cases were excluded due to loss to follow-up. The mean age was  $30 \pm 16$  years (range, 17 - 65 years) and the mean BMI was  $30.7 \pm 5.2$  kg/m<sup>2</sup> (range, 23.2 - 43.2 kg/m<sup>2</sup>). The mean follow-up time was  $6.6 \pm 3.4$  weeks (range, 3.4 - 20.2 weeks). Radiography assessment revealed the bony union rate at four to eight weeks was 96% (Table 1) with only one case (4%) of delayed union. This case was a 56-year-old male with high varus heel deformity. This patient eventually achieved union at 14.7 weeks after the diagnosis of delayed union (20.2 weeks postoperatively; Figure 3).

No fixation loss, such as plate migration or implant failure, was reported. One patient (4%) developed deep vein thrombosis (DVT), but it resolved with anticoagulant (enoxaparin) without implant removal. Three patients (13%) had plate removal: two (9%) were at the patients' request after 33.4 and 34.6 weeks due to irritation caused by shoes, and one (4%) had a skin infection (cellulitis) where it was treated with intravenous antibiotics. No associated complications developed from implant removal. The skin-infected patient, subsequently, had achieved union after 15.9 weeks postoperatively.

**Table I. Patient demographic and clinical data.**

Gender	Side	Age (years)	BMI (kg/m <sup>2</sup> )	F/U (weeks)	Athlete	Implant removal	Bony union at 6-week post-operatively	Complication	Other
F	R	21	30.2	5.7	Yes	No	Yes		
F	L	18	26.7	5.1	Yes	No	Yes		
F	R	23	43.2	5.9	No	No	Yes		
F	R	21	25.7	5.7	Yes	No	Yes		
F	R	53	26.5	6.3	No	No	Yes		
F	R	59	39.2	5.4	No	No	Yes		
F	L	36	28.9	4.0	No	Yes	Yes		Irritation (shoe wear)
M	R	65	30.3	5.4	No	No	Yes		
M	R	22	23.2	5.9	Yes	Yes	Yes		Irritation (shoe wear)
M	R	59	26.3	6.1	No	No	Yes		
M	R	56	30.7	6.0	No	No	No	Delayed Union	
M	R	27	37.9	13.3	No	No	Yes		
M	L	18	28.6	5.9	Yes	No	Yes		
M	L	20	25.4	3.4	Yes	Yes	Yes	Cellulitis	
M	L	20	31.4	6.1	No	No	Yes		
M	L	21	34.5	6.0	Yes	No	Yes		
M	L	21	37.3	6.1	Yes	No	Yes	DVT	
M	L	20	27.5	5.1	Yes	No	Yes		
M	R	20	27.5	6.4	Yes	No	Yes		
M	L	20	31.1	6.9	Yes	No	Yes		
M	R	34	35.0	5.7	No	No	Yes		
M	L	24	34.0	5.6	No	No	Yes		
M	L	17	25.9	5.7	Yes	No	Yes		
<b>Average ± SD</b>		<b>30 ± 16</b>	<b>30.7 ± 5.2</b>	<b>6.0 ± 2.1</b>	<b>52% (Yes)</b>	<b>13% (Yes)</b>	<b>96% (Yes)</b>	<b>13%</b>	<b>9%</b>
<b>Range</b>		<b>17 - 65</b>	<b>23.2 - 43.2</b>	<b>3.4 - 13.3</b>					



Figure 3. A 56-year-old patient with delayed union: (a) Preoperative; (b) six-week postoperatively; and (c) 20-week postoperatively.

## DISCUSSION

The most important finding of this study was that utilizing a variable angle locking compression plate for Jones fracture demonstrated good clinical outcomes. This treatment was comparable to those with other operative management reported in the literature (complete radiographic union at six weeks: 96%).<sup>9,12-17</sup> To our knowledge, this is the first published follow-up study of this technique used in Jones fracture treatment. Rosenberg et al.<sup>13</sup> reported that the mean time to union in Jones fracture operated on acutely to be as short as 7.4 weeks. Similar results have been reported by several other studies.<sup>9,12,14-17</sup> In high-demand patients or athletes, shortened healing time allowing more rapid return to sports activities and a lower rate of complications are the most dominant reasons these patients seek surgical treatment for this type of fracture. The results of this study demonstrated that a variable angle locking compression plate could be an alternative fixation method to treat Jones fractures with low complication rates and re-fracture rates that would predispose the athlete to sustain this type of fracture.

These acute Jones fracture injuries have a prevalence of delayed union, nonunion, and re-fracture rates ranging from 7% to 67% with a long period of rehabilitation if treated non-operatively.<sup>13,18-22</sup> Operative management has been advocated, and there are many modalities for operative management, including percutaneous fixation with an intramedullary screw, differential pitch screw, bi-cortical screw, corticocancellous bone graft, closed reduction, and cross-pinning with Kirschner-wires (K-wire) fixation, or open reduction and internal fixation with tension band wiring, mini-fragment plate and screws.<sup>2,3,6-9,13-15,20,21,23-32</sup> Intramedullary screw fixation has been the most common surgical technique to treat Jones fracture because, as several studies have found, it provides optimal union and reduces re-fracture rates.<sup>9,14,15,20,23,24,27,29,31,32</sup> Screw application, however, has had several problems, including technically demanding, screw breakage, screw penetration of the cortex, screw head prominence, metatarsalgia, rupture of the peroneus brevis tendon, irritation of the sural nerve, and it may not achieve accurate reduction.<sup>21,33-35</sup>

Wright et al.<sup>21</sup> reported six re-fractures after cannulated screw fixation in athletes. Many of these operative managements are not perfect; they have been associated with significant complications, such as loss of reduction, pin migration, implant breakage, screw penetration of the cortex, hardware prominence, nerve neurapraxia, sural neuroma, deep infection, re-fracture, and cubometatarsal joint arthritis.<sup>21,25,28,33,34</sup>

Various fixed angle compression locking plates have been introduced recently.<sup>6-8</sup> Locking compression plate fixation achieves angular stable fixation of the fragments, regardless of the bone quality, and lower risk of primary and secondary loss of reduction. Lee et al.<sup>6</sup> and Choi et al.<sup>7</sup> introduced the locking compression plate, distal ulna hook plate (Synthes, Oberdorf, Switzerland), as a compatible fixation instrument for treating Jones fracture, as they believed that the fifth metatarsal base and its tuberosity have anatomic architecture similar to that of the distal ulna metaphysis and its styloid process. Lee et al.<sup>6</sup> performed it on 19 patients, and only four patients developed complications, including three patients who developed post-traumatic cubometatarsal arthrosis and one patient who developed sural nerve

neurapraxia. Whereas Choi et al.<sup>7</sup> performed this procedure on 17 patients, and only one patient developed hardware irritation complication due to inadequate bending of the plate and screw curving by pressure. This mini-hook fixed angle locking compression plate provides compression to the fracture site and obtains a positive tension-banding effect.<sup>6,7</sup>

Despite the advantages of fixed angle locking compression fixation, there are potential disadvantages.<sup>36-38</sup> For traditional locked plates, it is hard or impossible to lag a fracture fragment perfectly to the plate. The screw's trajectory of the fixed angle plate designs has not offered the ability to alter fixation to accommodate specific variations in fracture pattern to capture and stabilize fragments. The traditional locked constructs rely on the manufacturers' predetermined screw path that does not take into account for differences in patient's fifth metatarsal anatomy, fracture pattern, or variation in plate positioning. Regardless, some compromises may be necessary in either plate positioning or quality of bone support to facilitate fixed-angle fixation. Hardware irritation may occur due to screw fixation and inadequate bending of the plate, which may cause hardware prominence, because the plate is of a non-anatomical design.

The variable angle locking compression plate used in this study featured four columns of threads in the variable angle locking hole and provided four points of threaded locking between the plate and the variable angle locking screw to create a fixed-angle construct at the desired screw angle of 15° off-nominal-axis or variable angulation within a 30° cone of angulation.<sup>38,39</sup> This variable angle screw fixation frees the surgeon from placing screws strictly dictated by plate design and allows more adaptability in creating fracture fixation constructs. This could improve purchase in higher bone density areas, avoid joint penetration, and help to avoid missing or osteoporotic bony areas, potentially increasing overall construct stability.

This specific system used compression forceps to provide a streamlined method of compression across the fracture. The plate reduction wires with stop temporarily hold the plate to the bone.<sup>39</sup> The rounded plate profile reduces soft tissue irritation and recess for screw heads minimize screw prominence. Intraoperatively, caution should be taken with the number of times the locking screw interlocks into the plate, as there is a tendency of potential cross-threaded or stripping at the screw-plate junction that might later cause loss of reduction. This plate system consisted of a tactile compression feature designed within the plate to aid in reconstructive surgery. Proper alignment can be visualized before final screw insertion with the compression forceps and the locking ratchet mechanism.

One other possible concern with a variable angle locking compression plate is the implant cost. The high cost of this system will hinder its widespread acceptance. In some selected patients, especially osteoporotic patients with Jones fracture, this variable angle locking compression plate may offer substantial potential benefits, including increased stability of segment fixation and improved early functional recovery.

Our experimental design had certain limitations, including the small sample size, which prevented applying tests of significance due to a low power. The low number of procedures performed was unavoidable because Jones fractures are not a common occurrence. In addition, this study was not a comparative study of various fixation techniques and only used one selected locking compression plate system; these outcomes may not be applied to other plate fixations or draw a definitive conclusion.

The outcomes of this study were valuable because they contributed to the available literature on the outcome with one particular locking plate fixation system. This study, unfortunately, did not determine long-term functional outcome, as the degenerative changes might have become more significant than that reported. Despite these limitations, fixation using the variable angle locking compression plate achieved favorable results in the treatment of Jones fractures. Further evaluation in a larger patient population with a longer period of follow-up time is required to support our findings.

In conclusion, based on our limited experience, the variable angle locking compression plate fixation seemed to provide a safe and reliable method that can achieve an anatomic reduction, stable fixation, rapid healing, and good results in the treatment of Jones fractures.

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