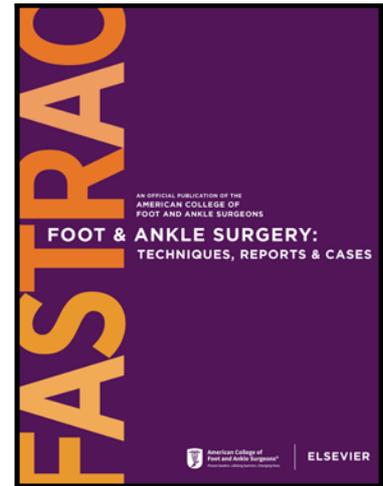


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Arthrodesis of the First Metatarsophalangeal Joint Utilizing a Chamfered Compression Screw and Low-Profile Dorsal Locking Plate

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Abstract

Background: First Metatarsophalangeal Joint (MTPJ) fusion is a reliable treatment for end stage arthritis of the 1st MTPJ and is still considered the gold standard. Historically non-union and hardware removal rates are in the 5-10% range which can lead to need for revision surgery. We describe a technique utilizing a chamfered headless compression screw and low profile dorsal locking plate to evaluate hardware removal rates and time to osseous union.

Methods: Retrospective radiographic review performed on 43 1st MTPJ fusions utilizing a chamfered headless compression screw and low profile dorsal locking plate. Patients were evaluated for time to union (days), complications, need for hardware removal, and non-union rates.

Results: We demonstrated that the fusion rate at a mean time of 76.3 days was 93.1 percent. Three patients underwent revision surgery for non-union while no patients required revision surgery for painful hardware. Complications included 4 superficial infections that cleared with oral antibiotics, 1 contact dermatitis, 1 asymptomatic hardware lucency and 3 non-unions

Conclusion: We found our technique utilizing a chamfered compression screw and low profile dorsal locking plate provides satisfactory union rates and low rates of hardware pain which may decrease the necessity for additional surgical procedures.

Introduction:

End stage arthritis of the first metatarsophalangeal joint (MTPJ) is a debilitating condition that occurs in approximately 2.5% of patients over the age of 50.¹ Treatment options of end stage arthritis are limited and arthrodesis has long been considered the gold standard. Fixation methods for MTPJ fusion have varied over the years ranging from screws or plates alone to plate and screw constructs. Two main concerns when looking at 1st MTPJ arthrodesis should always be non-union rates and Hardware removal rates as both of these can lead to need for subsequent surgery. Historically rates of non-union have been reported to be around 10% however newer techniques and fixation constructs have allowed these rates to improve to ~5%. Symptomatic hardware necessitating removal have been reported to range from 8-10% dependent on the construct. The optimal construct for MTPJ arthrodesis provides excellent stability and union rates while also limiting the need for hardware removal.¹⁻¹⁴

We present a fixation construct utilizing a chamfered compression screw (PECA-C, Novastep) with a low-profile dorsal locking plate (Airlock, NovaStep) that provides excellent compression and stability while limiting the need for subsequent surgery and hardware removal.

Methods:

Surgical Technique:

Two primary surgeons (AN, KL) performed 1st MTPJ arthrodesis for end stage arthritis. Standard dorsal linear incision was carried out, linear capsulotomy was performed, joints were prepped utilizing the appropriately sized cup and cone reamers. After joint prep subchondral fenestration and fish scaling were utilized to stimulate arthrodesis. Reduction of any deformity was then performed to place the patient in the optimal position for ambulation. Temporary fixation was utilized as necessary, guide wire for the PECA-C screw was thrown from distal medial to proximal lateral ensuring that this did catch the far cortex, screw size was measured, and drill was utilized to go through all 4 cortices. PECA-C screw was then inserted so that the chamfered surface was flush with the proximal phalanx.

After insertion of the PECA-C screw, the dorsal locking plate was sized and contoured as needed to fit patient anatomy. Fluoroscopic images were taken to confirm positioning and the plate was secured with combination of locking and non-locking screws. All patients were placed into a posterior splint post-operatively, they were then transitioned into a CAM walking boot at 1-week post-op and kept NWB a minimum of 4 weeks. When the arthrodesis site began to demonstrate evidence of osseous bridging protected weightbearing in the CAM boot was initiated. Typical return to tennis shoes was around the 8-week post-op mark as swelling allowed. Radiographs demonstrating optimal hardware placement for this construct are seen in figures 1 and 2 below.

Radiographic evaluation was performed by 2 surgeons (TT, KL) osseous union was defined as evidence of cortical bridging across arthrodesis site with absence of radiographic lucency. Data was gathered regarding patient demographics such as age, sex, smoking status as well as time to osseous union, complications (defined as superficial infection, deep infection, mal-union, delayed union or non-union), and need for hardware removal.

Hardware irritation was defined as palpable prominent hardware (plate or screws), continued irritation due to the hardware, or inability to wear shoe gear because of prominent hardware. Delayed union was defined as no evidence of complete osseous union at the 3 month (90 day) mark, non-union was defined as no evidence of osseous bridging at the 9 month (270 day) mark.

Results:

A total of n=37 patient charts with 43 operative 1st MPJs were retrospectively reviewed that had undergone 1st MTPJ arthrodesis utilizing a chamfered compression screw and low-profile dorsal locking plate. Mean age at the time of surgery was 58.9 years. There were 18 males and 19 females, and 19 left and 24 right sided fusions. A total of 3 patients underwent fusion on bilateral sides at different times after demonstrating healing on the contralateral limb.

Overall, the radiographic union at a mean of 10.9 weeks (76.3 days) was found to be 93.1 percent. There were a total of 5 delayed unions and 3 non-unions. A total of 3 patients required revision surgery. There were 0 hardware removals performed in the study period for painful, prominent hardware. One patient did have mild irritation from the plate that has been tolerated with shoe gear modification. 6 minor complications were noted including 4 with superficial infection that cleared with oral antibiotics, 1 with allergic contact dermatitis and one with non-painful radiolucency around the hardware (table 1). Three major complications requiring reoperation and revision surgery were also noted. Of the three patients who underwent revision for non-union 1 was a former smoker, 1 had secondhand smoke exposure and the other was a non-smoker (table 2). Of the 3 revisions performed 2 demonstrated osseous healing at a mean of 10.5 weeks while the other is just over one month out of the revision surgery.

Discussion:

Arthrodesis of the 1st MTPJ has been shown to be a reliable procedure for the treatment of end stage arthritis as well as a number of other conditions of the 1st MTPJ. Roukis performed a systematic review of n=2818 1st MTPJ fusions that evaluated non-union and hardware removal rates after 1st MTPJ fusion and found an overall non-union rate of 5.4% and hardware removal rate of 8.5%.² A mean of 64.3 days to radiographic union was noted across all studies examined including multiple different fixation types and noted that the old adage of 10% non-

union rates are not true with modern fixation techniques.² This falls in line with our study where we demonstrated a 6.9% rate of non-union and 0% rate of hardware removal with a mean time to arthrodesis of 73.8 days.

In a comparison of different fixation techniques including plate with screw vs. crossed screw fixation, Maleki et.al. found that their low-profile non-locking plate with crossing screw resulted in no failures in their study period. They did not evaluate the use of anatomic locking plates in the comparative study.¹³ In a Biomechanical evaluation of fixation types Harris et.al. found that use of a dorsal plate and screw construct provided the greatest stiffness regardless of joint preparation technique.⁷ Another study by West et.al from 2022 looked at crossed screw vs. plate + screw fixation which demonstrated similar fusion rates (95.3% and 93.5%) but did note that more aggressive weightbearing protocols were utilized in the plate + screw fixation group.⁹

Sorenson et. al. evaluated immediate weightbearing of 1st MPJ fusion construct utilizing a dorsal locking plate with interfragmentary screw and found an overall union rate of 96%. These results are similar to those seen by Berlet et.al where they evaluated the effect of early weightbearing and found it did not significantly compromise clinical results or union rates.⁸ While immediate weightbearing is not a part of the primary surgeons (A.N. or K.L.) post-operative protocols the construct presented does provide excellent stability. The Authors have found that immediate weightbearing has increased post-operative pain and swelling and do elect for a longer period of non-weightbearing to help limit this.

In a retrospective analysis of 60 patients treated with 1st MTPJ fusion with dorsal locking plate and screws, Chraim et.al. found an overall union rate of 93.3% however none of the non-unions required revision surgery due to the stability of the construct. They also demonstrated more normal physiological foot pressures and first ray function on pedobarographic measurements after 1st MTPJ arthrodesis.¹² Curran et. Al. looked at functional outcomes following 1st MTPJ fusion utilizing a dorsal plate and compression screw in 103 patients. They noted only 1 non-union and 2 delayed unions in the study and saw significant improvements in all four aspects of AOFAS score as well as 97% of patients being very satisfied with the procedure.¹⁰

Of note in our study we have had a 0% rate of hardware removal which we believe is related to this lower profile locking plate design as well as the chamfered screw which allows the head to sit flush with the cortex. The main advantage of this is avoiding the need for hardware removal which is an additional surgery and cost to the patient. A cost analysis performed in 2019 looking specifically at syndesmotic hardware noted that the average operative cost of hardware removal was \$3579.¹⁵ This doesn't even take into the inherent morbidity of additional surgery or any complications that could arise from a second surgery as well.

Inherent limitations to this study are the retrospective nature in which it is conducted as well as the non-comparative nature. A larger study size as well as direct comparison of fixation techniques would aid in increasing the power of this study.

In conclusion, 1st MTPJ fusion utilizing this low-profile construct demonstrates excellent union rates and minimal post-operative hardware irritation while providing excellent stability and good radiographic outcomes. The authors believe that this low profile plate and chamfered screw are beneficial for limiting the need for hardware removal while maintaining excellent stability. Longer follow up and sample sizes are still needed however this construct appears to be a viable option for use in 1st MTPJ fusion.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Tyler Tewilliager declares no conflict of interest
Alan Ng and Kevin Lutta are paid consultants of NovaStep

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Complications	N (%)
Superficial Infection	4(9.3%)
Hardware Lucency	1(2.3%)
Dermatitis	1(2.3%)
Non-Union	3(6.9%)

Table 1: Summary of postoperative complications (N=43)

Demographics				

	Male	Female	Left	Right
N (%)	18	19	19	24
Smoke Exposure	2	0		
Former Smoker	4	7		
Never Smoker	12	12		

Table 2: Summary of patient demographics

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Figure 1: Pre-operative (left) and post-operative (right) AP radiographs demonstrating optimal hardware placement of low profile dorsal locking plate with chamfered compression screw



Figure 2: Pre-operative (bottom) and post-operative (top) radiographs demonstrating optimal fusion construct