Article

AMERICAN ORTHOPAEDIC FOOT & ANKLE SOCIETY

Foot & Ankle Orthopaedics
2024, Vol. 9(4) 1–8
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DOI: 10.1177/24730114241281452
journals.sagepub.com/home/fao

Comparison of Clinical and Radiographic Outcomes Between Solid Headless and Headed Screws in the Treatment of Zone II and III Fifth Metatarsal Fractures in Elite Athletes

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Abstract

Background: Zone II and III fifth metatarsal (5-MT) fractures among athletes are typically managed with percutaneous fixation following anatomic reduction. However, screw head discomfort and refracture after bone union can occur because of the loads placed on the foot during play. Several hardware systems that use a smaller screw head compared to traditional hardware systems have been developed to minimize the rate of postoperative hardware complications. This study compares clinical and radiographic outcomes of 5-MT fractures in elite athletes treated with a solid headless screw vs a solid headed screw. We hypothesized that the headless screw would be associated with faster union rates, faster clearance times, and lower incidence of symptomatic hardware compared to the headed screw.
Methods: Athletes competing at a collegiate level or higher treated for a zone II or III 5-MT fracture between 2016 and 2022 by 2 surgeons fellowship-trained in foot and ankle orthopaedics were screened. Operative notes were reviewed to determine the hardware system used. Subjects were divided based on the hardware system used during operation: headed screw and headless screw. Time to radiographic union, time to full clearance, and return to competition were determined. Postoperative complications, including nonunions, need for revision, need for hardware removal, and refractures were also noted.
Results: Forty eligible patients (44 feet) were identified. The solid headed screw group included 20 patients (21 fractures), and the solid headless screw group included 20 patients (23 fractures). Average time to union for the headed screw group was 11.78 (range, 5.86-19.00) weeks; average time to union for the headless screw group was 11.65 (range, 6.00-22.57) weeks ($P = .93$). Nineteen out of twenty (95%) patients were able to return to competition in both groups. Average time to return to competition for the headed screw group was 26.9 (range, 10.00-47.86) weeks, while average time for the headless screw group was 21.2 (range, 6.86-55.00) weeks ($P = .55$). The overall complication rate for the headed screw was 23.8%, which was not statistically different from the overall complication rate for the headless screw of 13.0% ($P = .35$).
Conclusion: In this relatively small sample of elite athletes undergoing operative fixation of a 5-MT fracture, fixation using either a headless or headed screw system had similar good outcomes in regard to times to union, return to competition, and complication rate regardless of solid screw head type used.

Level of Evidence: Level III, retrospective cohort study.

Keywords: stress fractures, 5th metatarsal, Jones fracture, headless screw fixation

Introduction

Proximal fifth metatarsal fractures are traditionally classified into 3 anatomic zones: zone I, the tuberosity; zone II, the metaphyseal-diaphyseal junction; and zone III, the diaphyseal area within 1.5 cm of the tuberosity.[3,9] Although zone I fractures are typically managed conservatively, zone II and III fractures, which are traditionally referred to as Jones fractures, are usually managed surgically because of their tendency to develop delayed union, nonunion, or refracture after initial healing.[5]

Surgical intervention via percutaneous internal fixation with an intramedullary screw is often indicated for Jones fractures among athletes seeking to return to sport as quickly as possible and minimize potential nonunion. Although screw fixations have proven to have successful operations with good long-term outcomes, complications such as painful hardware and screw head discomfort still occur and have been observed at a much higher rate among athletes compared with the standard population, likely because of the intensity of their physical activity.[4,6] The etiology of these complications is unknown, but it has been suggested that hardware pain is typically localized to the base of the metatarsal and the cuboid because of the prominence of the screw head. In addition, ideal placement for the screw may also impinge on the fifth tarsometatarsal joint. The literature has suggested that low-profile designs that decrease the size of the screw head may minimize the need for hardware removal.[2,12,14] In this study, we test the importance of screw head size in the treatment for fifth metatarsal (5-MT) fractures by comparing postoperative outcomes between a headed screw and a headless screw. The screw of interest in this study is a solid titanium-alloy, partially threaded headless screw featuring a differential thread pitch on each end to provide compression across the fracture site (Jones Union System; Extremity Medical, Parsippany, NJ). The headed screw was represented by a standard noncannulated, semi-threaded Charlotte Carolina screw designed with a uniform pitch thread (Charlotte Carolina Jones Fracture System; Wright Medical Technology, Arlington, TN).[15,17]

The purpose of this study was to compare the outcomes following fixation of proximal 5-MT fractures between the headed and headless screw systems within an elite athlete population, defined as a collegiate athlete or higher level of play. Specific outcomes of interest included the time to union, return to play, and complication rates in each group to quantitatively assess the viability of the headless screw. We hypothesized that the headless screw system would produce similar outcomes and lower incidence of painful hardware compared with the headed screw system.

Methods

Approval was obtained from the institutional review board steering committee that oversees our foot and ankle registry. The registry was retrospectively reviewed to identify patients treated for a zone II or zone III 5-MT fracture by 2 surgeons fellowship-trained in foot and ankle orthopaedics between 2016 and 2023 (Figure 1). Clinical charts for each patient were reviewed to identify elite athletes. A person competing at or above collegiate-level athletics was considered an elite athlete. Acute and nonacute fractures were included. Nonacute fractures were defined as chronic and acute on chronic fractures as well as previous refractures and nonunions. Patients with concomitant injuries were excluded. Patients who did not participate in at least collegiate-level athletics were excluded.

Operative notes were reviewed to ensure that subjects were treated with either hardware system of interest. Intraoperative bone marrow aspirate concentrate (BMAC) and bone graft were used in several patients in the cohort. BMAC and bone graft use were based on physician recommendation and patient choice.

Clinical charts and radiographic records were reviewed for each patient, and demographic information was documented. All patients received standard anteroposterior, lateral, and 30-degree oblique postoperative radiographs preoperatively and postoperatively until the fracture was 100% united in all 3 radiographs (Figure 2). Follow-up time, time to union, time to full clearance, and refracture time, if applicable, were recorded. The number of postoperative visits and radiographs varied per patient and was often based on player availability. However, the attempt was made to collect 2-week, 6-week, 12-week, and 6-month postoperative radiographs. Time to union was considered the amount of time from the initial surgery to the day complete cortical remodeling across the fracture site was identifiable on all 3 views of the foot radiographs. Return to competition was considered the amount of time from the initial surgery to the day the patient was able to compete at the equivalent level of physical competition as prior to their injury. Postoperative complications, including nonunions, delayed unions, refractures, symptomatic hardware, and need for revision were also documented.[2]

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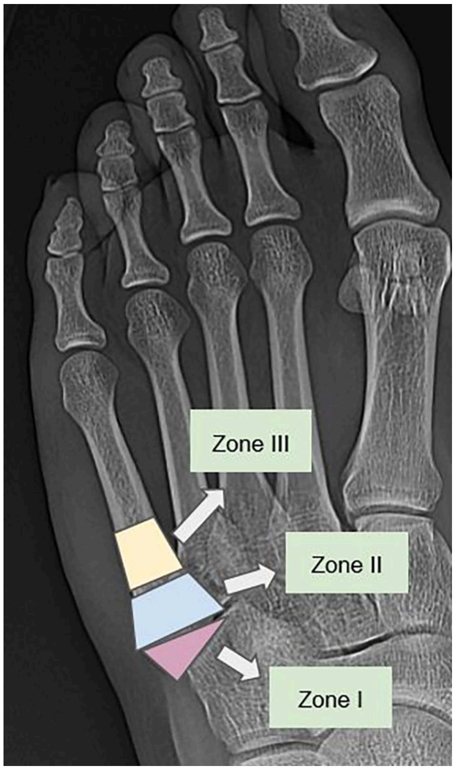

Figure 1. Classification of Zone I, II, and III fifth metatarsal fractures.

Surgical Procedure and Postoperative Protocol

The surgical procedure for both groups was performed with the patient under ankle block or spinal anesthesia. A thigh tourniquet was routinely used. A 1-cm incision was made 2 cm proximal to the 5-MT base in line with the dorsal cortex. Dissection was carried out to the level of the metatarsal. A guidewire was then introduced down the metatarsal shaft on the central position.[21] Using the wire, a cannulated drill was advanced down the medullary canal and past the fracture line with fluoroscopic guidance. Sequential reaming was carried out. In some cases, to ensure the ideal entry point, a minor osteoplasty of the cuboid was performed. Intramedullary taps were performed to determine the optimal screw size. Taps sizes were increased until the maximal-diameter screw size that could be accommodated in the canal was attained. Screw diameter and length were recorded for each fracture. Screws in both groups were available in various diameters (4.5, 5.5, and 6.5 mm) and lengths (35-60 mm) to allow for individualization based on specific patient anatomy. Forty-millimeter screws are most often needed to cross the fracture site and avoid the apex of curvature.[18] The technique requires 15 mm of threads distal to the fracture, and the fracture line is commonly 20 mm distal to the metatarsal tuberosity. The appropriately sized screw was placed down the canal so that the distal threads were distal to the fracture site. In cases where bone graft was used, the bone graft

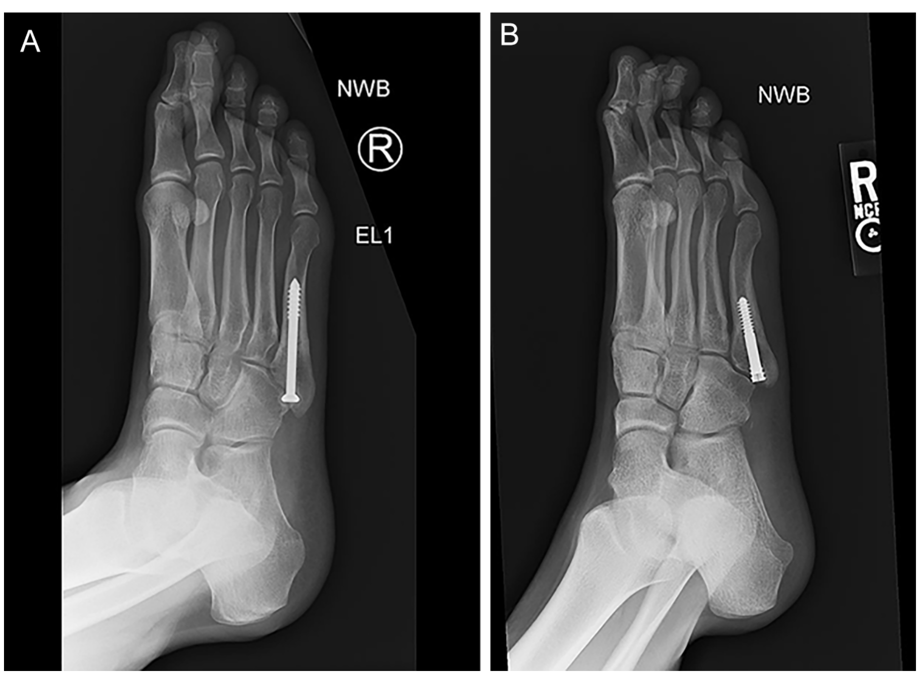

Figure 2. Postoperative radiograph comparison between (A) headed and (B) headless screws.

Table 1. Demographic Comparison Between Groups.

Characteristic	Headed Screw	Headless Screw	*P* Value
Age, y, mean	22.0	21.5	.69
Sex, male/female, n	20/0	18/2	.15
BMI, mean	25.95	25.02	.23
Height, in., mean	76.3	74.9	.34
Weight, lb, mean	215.9	201.5	.18
Injury type, n			
Acute	13	10	.63
Acute on Chronic	3	5	.77
Chronic	3	4	.56
Refractures	2	4	.62
Nonunions	1	1	.81

was placed at the level of the fracture after compression was achieved with screw fixation. The incision was irrigated and closed. In patients who received a BMAC injection, BMAC was subcutaneously injected medially, dorsally, and plantarly around the fracture site once the area was closed. Patients were placed in a splint and remained nonweightbearing for 2 weeks. Patients were transitioned into a controlled ankle motion (CAM) walker boot and began partial weightbearing at 2 weeks postoperatively. Physical therapy was initiated at 2 weeks. Patients transitioned out of the boot when they were able to walk without a limp.

Statistical Analysis

All continuous variables were expressed in terms of the mean and SD. Statistical significance was accepted for *P* values of $<.05$ for descriptive analysis. Differences in clinical features between athletes treated with the headed and headless screw were assessed with independent sample *t* tests. Differences in complications were assessed with χ^2 tests.

Results

Demographics

In total, 40 patients (44 fractures) were eligible for inclusion. Twenty patients (21 fractures) received the headed screw, whereas 20 patients (23 fractures) received the headless screw. Average time to clinical follow-up was 19.9 (range, 10.2-31.4) months. Demographic comparisons are shown in Table 1. No significant differences were observed in patient age, sex, BMI, height, or weight. Of the 44 fractures presented, there were 39 zone II fractures and 5 zone III fractures. In addition, 23 acute fractures, 8 acute on chronic fractures, 7 chronic fractures, 4 refractures, and 2 nonunions were represented in our subject cohort.

The sports represented in the patient cohort were also recorded in Table 2. Overall, 24 professional athletes and 16 collegiate athletes were presented in our cohort; 24 patients played basketball, 8 patients played American football, 4 patients played soccer, 2 patients played lacrosse, 1 patient played baseball, and 1 patient boxed. Additionally, 32 of 44 fractures (72.7%) underwent BMAC injection and 28 out 44 (63.6%) received bone graft along with BMAC injection at the time of fixation. In the headed screw group, 19 patients received BMAC and bone graft, 2 patients received BMAC alone, and no patient received any biological augmentation. In the headless screw group, 9 patients received BMAC and bone graft, 4 patients received BMAC alone, and 11 patients did not receive any biological augmentation.

Time to Union and Return to Competition

Statistical comparisons of time to union and return to competition between each screw group and injury type are shown in Table 3. In the acute injury group, the average time to union was 12.2 (range, 5.9-19.0) weeks for the headed screw group and 9.7 (range, 6-14.9) weeks for the headless screw group ($P = .11$). Twelve of 13 patients (92.3%) in the headed screw group were able to return to competition at an average of 25.0 weeks (range, 10.0-47.9), whereas 9 of 10 patients (90.0%) in the headless screw group were able to return to competition at an average of 23.0 weeks (range, 12.4-55.0) for the headless screw group ($P = .76$). The 2 patients who were unable to return to competition were medically cleared to return to physical activities but were unable to receive contracts to continue playing after their injury.

In the nonacute injury group, the average time to union was 11.8 (range, 5.9-17.1) weeks for the headed screw group and 9.4 (range, 6.0-18.7) weeks for the headless screw group ($P = .22$). Eight out of eight patients (100%) in the headed screw group were able to return to competition at an average of 21.5 (range, 12.3-35.1) weeks, while thirteen out of thirteen patients (100%) in the headless screw group were able to return at an average of 19.8 (range, 6.9-29.1) weeks ($P = .63$).

Outcomes for patients in the headed screw and headless screw groups who received either BMAC, BMAC and bone graft, or did not receive BMAC were compared as well (Supplemental Table 1). No significant differences in time to osseous union, return to competition, and complications were demonstrated between the headed and headless screw groups concerning the use and absence of biologics.

Complications

The overall complication rates of the headed screw and headless screw groups is represented in Table 4. Among

Table 2. Return to Sport Characteristics.

Patient No.	Screw Type	Laterality	Sport	Level of Competition	RTP	Time to Clearance, wk
1	Headed	R	Basketball	Professional	Yes	19
2	Headed	L	Basketball	Professional	Yes	12
3	Headed	L	Football	Professional	Yes	35
4	Headed	L	Basketball	Professional	Yes	21
5	Headed	L	Basketball	Professional	Yes	13
6	Headed	R	Basketball	Professional	Yes	14
7	Headed	R	Football	Professional	Yes	35
8	Headed	L	Football	Professional	No	N/A
9	Headed	R	Basketball	Professional	Yes	44
10	Headed	R	Football	Professional	Yes	48
11[a]	Headed	R	Basketball	Professional	Yes	14
11[a]	Headed	L	Basketball	Professional	Yes	14
12	Headed	R	Football	Professional	Yes	17
13	Headed	L	Basketball	Collegiate	Yes	27
14	Headed	L	Basketball	Collegiate	Yes	18
15	Headed	R	Lacrosse	Collegiate	Yes	19
16	Headed	L	Football	Collegiate	Yes	10
17	Headed	L	Basketball	Collegiate	Yes	13
18	Headed	L	Basketball	Collegiate	Yes	48
19	Headed	R	Basketball	Professional	Yes	25
20	Headed	R	Basketball	Professional	Yes	23
21	Headless	L	Basketball	Collegiate	Yes	29
22[b]	Headless	L	Basketball	Professional	Yes	N/A
22[b]	Headless	R	Basketball	Professional	Yes	55
23	Headless	R	Lacrosse	Collegiate	Yes	31
24	Headless	L	Basketball	Collegiate	Yes	20
25	Headless	L	Basketball	Professional	Yes	29
26	Headless	R	Basketball	Professional	Yes	12
27	Headless	L	Basketball	Collegiate	Yes	20
28	Headless	L	Soccer	Collegiate	Yes	19
29	Headless	R	Soccer	Professional	Yes	12
30[b]	Headless	R	Football	Professional	No	N/A
30[b]	Headless	L	Football	Professional	No	N/A
31[b]	Headless	R	Soccer	Collegiate	Yes	15
31[b]	Headless	L	Soccer	Collegiate	Yes	22
32	Headless	L	Soccer	Professional	Yes	17
33	Headless	L	Boxing	Professional	Yes	24
34	Headless	L	Basketball	Collegiate	Yes	15
35	Headless	R	Baseball	Professional	Yes	13
36	Headless	L	Basketball	Collegiate	Yes	7
37	Headless	R	Basketball	Professional	Yes	29
38	Headless	R	Basketball	Professional	Yes	15
39	Headless	L	Football	Collegiate	Yes	16
40	Headless	R	Basketball	Professional	Yes	22

Abbreviations: L, Left; R, Right; RTP, return to play.
[a]Patient received bilateral repair of 5-MT fractures simultaneously.
[b]Patient received a repair on the contralateral foot at a later date.

acute injuries, 3 of 13 patients (23.1%) in the headed screw group and 1 of 10 patients (10%) in the headless screw group required a return to the operating room ($P = .41$). In the headed screw group, 2 patients presented with a refracture, and 1 presented with painful hardware that required removal. In the headless screw group, 1 patient returned for the removal of painful hardware. All patients who returned to the operating room were able to return to

Table 3. Time to Union and Return to Sport Comparison between Headed and Headless Screw.

	Outcome	Headed Screw	Headless Screw	*P* Value
Acute	Time to union, wk	12.2	9.7	.11
	Return to sport, wk	25.0	23.0	.76
Nonacute	Time to union, wk	11.8	9.4	.22
	Return to sport, wk	21.5	19.8	.63

Table 4. Complication Rate Between Groups.

	Headed Screw, n/n (%)	Headless Screw, n/n (%)	*P* Value
Acute			
Complication rate	3/13 (23.1)	1/10 (10.0)	.41
Nonunions	2/13 (15.4)	0/10 (0.0)	.19
Painful hardware removed	1/13 (7.7)	1/10 (10.0)	.85
Nonacute			
Complication rate	2/8 (25.0)	1/13 (7.7)	.27
Nonunions	1/8 (12.5)	1/13 (7.7)	.13
Painful hardware removed	1/8 (12.5)	0/13 (0)	.19

competition at an average of 3.0 (range, 1.8-3.8) months after their subsequent procedure. Among nonacute injuries, 2 of 8 patients (25.0%) in the headed screw group and 1 of 13 patients (7.7%) in the headless screw group required a return to the operating room ($P=.27$). In the headed screw group, one patient presented with a refracture and the other returned for the removal of painful hardware. In the headless screw group, 1 patient presented with a refracture. All patients who required a return to the operating room were able to return to competition at an average of 3.4 (range, 1.6-5.8) months after their subsequent procedure.

Discussion

In this study, we compared outcomes of fifth metatarsal fracture fixations among elite athletes with a headed screw and a headless screw designed to prevent screw head discomfort. Both groups demonstrated osseous union before 12 postoperative weeks and required less than 6 months before returning to preinjury levels of physical activity. In addition, complication rates between each group were statistically similar, suggesting that either surgical implant can result in good outcomes. Our results suggest that this headless screw compression system may provide equivalent outcomes compared to the headed screw.

The headed screw examined in this study was a partially threaded screw used in the Charlotte Carolina Jones Fracture System. Murawski and Kennedy observed outcomes for this particular screw and reported 2 of 26 cases (7.7%) resulting in painful hardware that required subsequent hardware removal.[13] One of these patients developed pain 6 months postoperatively (4 months after return to play), and imaging showed loosening of the screw as well as peroneus brevis irritation, likely attributable to the screw head. The second patient's imaging showed impingement on the tarsal cuboid joint. In both cases, removal of the screw resolved the pain, and both patients were reported to be doing well subsequently. Metzl et al[12] investigated the impact of using the same 5-MT-specific screw and reported no adverse events among the 26 patients examined. Interestingly, despite the potential for cuboid and fifth tarsometatarsal impingement, there were low rates for hardware removal in our study as well.

The other screw evaluated in this study was a titanium-alloy headless screw. With differential threads on either side of the screw, the screw is designed to protect against the torsional stresses that a conventional partially threaded headed screw may not address.[1] Nagao et al[14] investigating the effects of headless compression screw fixation on Jones fractures in Japanese athletes demonstrated positive results. Fifty-seven of the 60 (95.0%) athletes achieved complete radiographic union with a mean time to union of 8.8 weeks (range, 4-20.1 weeks). There were 2 cases of treatment failure, including 1 delayed union and 1 nonunion. None of the athletes reported screw head irritation, and all athletes were able to return to full activity at an average of 11.2 weeks after surgery (range, 6-25 weeks). Biomechanical studies of this screw have also indicated that its bending resistance is similar to that of a normal screw.[19] The incidence of symptomatic hardware in our study for the headless screw was notable, given that decreasing symptomatic hardware was one of the proposed benefits of the headless screw.[2,12,14] In this case, the screw may not have been recessed enough and impinged on the cuboid. Care should be taken to ensure proper screw alignment and placement.

One discrepancy we noticed between our data and the literature was the elongated time required for osseous union and return to competition. The observed time to union rates for both screws were longer than the 6- to 8-week range that has been established in the existing literature evaluating other percutaneous internal fixation methods for 5-MT fractures in elite athletes. We attribute these differences to the assertion that clinical healing may precede radiographic healing, which may explain why the observed times to union are longer than previously reported.[7,10] Ultimately, a CT scan study would be useful to determine exact timelines as well as percentage healing at those timelines. In addition, our return to competition time frames were greater than previously described in the literature.[8,11,13] Stone et al[20] reported a return to sport at 11.1 weeks for 18 Major League Soccer athletes. O'Malley et al[16] reported a return to sport among 10 National Basketball Association athletes at 9.8 weeks. Hunt and Anderson[8] reported a return to previous level of athletic competition at an average of 12.3 weeks for 21 elite athletes. We attribute these longer time frames to 2 factors: the inclusion of data from patients who experienced a season-ending injury and did not return until the following season and the decision to define "return to competition" as the time from injury to the time of participation in preinjury levels of competition. For example, a professional athlete was only considered to have returned if they participated in a professional competition rather than being cleared for unrestricted physical activity. Although this may overestimate when some athletes are able to return to physical activity, we believe this data collection strategy contextualizes a realistic expectation for an athlete to expect to participate in preinjury levels of physical competition. We also intentionally did not say "return to sport" to avoid any confusion with the terminology.

There are several limitations of this study. First, the small sample size substantially limits the statistical power of the study and our precision to find equivalence. Larger study cohort might reveal significant differences between use of these 2 screws. Second, the grouping of acute on chronic, chronic, previous refractures, and previous nonunions into a "nonacute" group is a confounding factor. Because the number of nonacute injuries were too small to analyze by injury type, the decision was made to group them into a single nonacute category and allow for a more descriptive analytical comparison. This, however, allowed us to isolate acute fractures during our analysis while also representing other injuries. Third, there was a variance of subjects who received BMAC injections and bone graft at the time of fixation. Because 32 of 44 fractures received BMAC injection and 27 of 44 received bone graft, there was an inability to standardize the patient cohort based on intervention type. Future studies could observe how these biologic interventions affect outcomes for a particular screw. Although these factors introduce additional variables into the study, our results suggest that elite athletes undergoing 5-MT fixation regardless of fracture type, concurrent procedure, or screw type experience good outcomes and were able to return to competition.

Conclusion

In our cohort, we found that fixation of zones II and III 5-MT fractures using the headed screw and the headless screw produced excellent and comparable postoperative outcomes for elite athletes with regard to return to competition and time to union.

Ethical Approval

Ethical approval for this study was obtained from the Institutional Review Board (2013-038).

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Mark Drakos, MD, reports consulting fees from Extremity and Arthrex. Martin O'Malley, MD, reports consulting fees from Arthrex. Disclosure forms for all authors are available online.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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Supplemental Table 1. Summary of Patient Athletic Activity and Return to Sport Based on Biologic Use.

Outcome	Headed Screw	Headless Screw	*P* Value
BMAC			
Time to union, wk	14.9	8.8	.27
Return to sport, wk	20.2	29.2	.63
Complication rate, n/n (%)	0/2 (0)	0/4 (0)	N/A
BMAC + bone graft			
Time to union, wk	11.6	9.3	.19
Return to sport, wk	24.0	21.4	.58
Complication rate, n/n (%)	15.8	11.1	.74
Without BMAC			
Time to union, wk	N/A	8.0	N/A
Return to sport, wk	N/A	17.7	N/A
Complication rate, n/n	0/0	1/10	N/A

Abbreviation: BMAC, bone marrow aspirate concentrate.