

Risk Factors for Reoperation and Performance-Based Outcomes After Operative Fixation of Foot Fractures in the Professional Athlete: A Cross-Sport Analysis

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Background: Professional athletes are predisposed to fractures of the foot due to large stresses placed on the lower extremity. These players are concerned with efficiently returning to play at a high level. Return-to-play rates after operative treatment have been previously reported, yet performance outcomes after such treatment are generally unknown in this population.

Hypothesis: Overall, professional athletes sustaining a foot fracture would return to play at high rates with little impact on postoperative performance or league participation. However, National Football League (NFL) athletes would have a significantly greater decline in performance due to the high-impact nature of the sport.

Study Design: Case series.

Level of Evidence: Level 4.

Methods: Athletes in the National Basketball League (NBA), NFL, Major League Baseball (MLB), and National Hockey League (NHL) undergoing operative fixation of a foot fracture were identified through a well-established protocol confirmed by multiple sources of the public record. Return-to-play rate and time to return were collected for each sport. League participation and game performance data were collected before and after surgery. Statistical analysis was performed, with significance accepted as $P \leq 0.05$.

Results: A total of 77 players undergoing 84 procedures met the inclusion criteria. Overall, 98.7% (76/77) of players were able to return to play, with a median time to return across all sports of 137 days. Players returned to preoperative performance levels within 1 season of surgery. Six players (7.8%) sustained refracture requiring reoperation, all of whom were in the NBA. Percentage of games started during the season after primary operative treatment was a predictive factor for reinjury (99% vs 40%, $P = 0.001$).

Conclusion: Athletes returned to play at a high rate after foot fracture fixation, with excellent postoperative performance levels, regardless of sport and fracture location. NBA athletes sustaining fifth metatarsal and navicular fractures are at greater risk of reinjury compared with other athletes. Returning to high levels of athletic participation soon after surgery may predispose athletes to refracture and subsequent reoperation.

Clinical Relevance: Players, coaches, and team physicians should be aware of the impact of foot fractures on career performance and longevity to best guide therapy.

Keywords: foot fracture; fifth metatarsal; NBA; sports

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The physical demands required of professional athletes predispose them to a variety of orthopaedic injuries. Fractures of the foot are common in this population due to sudden change of direction and the impact from such activities.^{1,4,6,9,12} Because of the excessive stress placed on these joints, operative fixation is often recommended as treatment.^{4,23} However, outcomes after foot surgery are affected by a number of factors unique to the elite athlete, as evidence-based literature in the general population may not be applicable. Unfortunately, data elucidating the impact of such injuries on career performance and longevity after operative intervention are currently lacking.

While some clinical studies have reported return-to-play rates after operative treatment of Jones fractures in professional athletes,^{2,5,14} performance-based outcomes in this population are generally unknown. Furthermore, less is known about the fate of other foot fractures, such as the navicular fracture, despite their high incidence. The particular position of the navicular bone in the midfoot along with its relative hypovascularity make it vulnerable to stress injury.¹⁸ These fractures generally are able to heal without surgery using nonweightbearing management.^{8,26} However, some patients, particularly elite athletes, are managed with operative fixation to minimize recovery time and risk of reinjury. Furthermore, expectations of recovery time and career length after other foot fractures are unknown in this population.

Despite the high incidence of foot fractures in the professional athlete population,^{16,21} little is known regarding postoperative athletic performance and the effect of sport played. This information may be helpful for players, coaches, and team physicians assessing the potential impact of this injury on an athlete's career. We hypothesized that professional athletes sustaining a foot fracture would return to play at high rates with little impact on postoperative performance or league participation, with National Football League (NFL) athletes having a significantly greater decline in performance due to the high-impact nature of the sport.

METHODS

Using a well-established, multistep protocol involving review of archives of the public record,^{11,13,16,20,21} we identified professional players who underwent operative fixation of fractures of the foot in the National Basketball Association (NBA), NFL, Major League Baseball (MLB), and National Hockey League (NHL) between 1986 and 2016. Players were first identified using either the ProSports Transaction or NewsBank databases using the search terms *foot fracture*, *foot surgery*, *Jones fracture*, *metatarsal fracture*, and *navicular fracture*. Once players were identified, injury details were confirmed using a second source derived from player profiles, newspaper archives, press releases, or team injury reports. Injures were only included if specific anatomic location could be confirmed, which included first metatarsal, third metatarsal, fifth metatarsal,

navicular, sesamoid, calcaneus, and great toe. Athletes who were injured and underwent procedures prior to participating in their first professional regular-season game were excluded. Other exclusion criteria included athletes undergoing concomitant procedures, with an unspecified fracture location, and those treated only with nonoperative treatment.

Demographic variables including player age, height, weight, body mass index (BMI), and position were collected. Statistical metrics such as games played, games started, and game performance were collected in the preoperative and 3 postoperative seasons. Athletes excluded from performance analysis included those who did not return ($n = 1$), were offensive linemen in the NFL ($n = 1$), or did not play a full season before surgery ($n = 20$). To assess and compare the impact of injury on performance, the athlete's performance 1 season prior to surgery was used as a baseline from which postoperative performance could be compared as a percent change. To account for a difference in number of games per season depending on sport, the number of games played was calculated as a fraction of the total possible number of games played in 1 season. This proportion was then standardized to the length of the MLB season (162 games) so that sports with different season lengths could be compared. A similar calculation was utilized for career length, using the reported mean career length in the NBA, NFL, NHL, and MLB (4.8, 3.5, 5.5, and 5.6 years, respectively).²² Return-to-play (RTP) rates, defined as returning to play at least 1 game postoperatively, were recorded. Finally, time to return (TTR) was defined as the number of days between surgery and the first postoperative game played. For season-ending injuries, certain sports with a longer offseason inevitably have longer times to return until the first postoperative game. As such, TTR was primarily used to compare athletes of the same sport with different types of fractures as a measure of how quickly athletes could return to professional levels of play after surgery.

Statistical metrics used to gauge game performance were derived based on the evidence-based literature for each sport.^{10,24} For the NBA, player efficiency rating (PER) was used,^{13,20,21} and for the MLB, on-base plus slugging (OPS) and walks plus hits per inning pitched (WHIP) were used for hitters and pitchers, respectively.^{7,17,19,25} Previously published and validated "performance scores" were also used for the NFL and NHL, varying by position played.^{10,24}

Statistical analysis was performed using SPSS (version 24; IBM Corp). Age, height, weight, BMI, years of experience, all-star appearances, and games played before injury were compared between players who did and did not RTP using independent-samples t tests. A bivariate correlation was used to assess which factors were correlated with TTR. Each player's preoperative season served as his own control, and a 2-tailed paired t test with Levene test of equality was used to evaluate postoperative participation and performance changes. Analysis of variance was used to compare demographic data as well as performance outcomes across the 4 leagues. A P value ≤ 0.05 was deemed statistically significant.

Table 1. Player demographics by fracture location

	Total (N = 84)	Fifth MT (n = 63)	Navicular (n = 13)	Sesamoid (n = 2)	Calcaneus (n = 2)	Toe (n = 1)	Third MT (n = 1)	First MT (n = 2)
Age, y, mean ± SD	25.7 ± 3.6	24.8 ± 3.1	28.3 ± 3.1	27.5 ± 3.3	26 ± 3.6	29.6	21	33.5 ± 3.8
BMI, kg/m ² , mean ± SD	26.7 ± 3.2	26.7 ± 3.4	26.1 ± 1.7	29.6 ± 3.6	26.1 ± 0.4	26.0	31.8	26.4 ± 1.5
League, n (%)								
NBA	51 (61)	42 (67)	7 (54)	0 (0)	2 (100)	0 (0)	0 (0)	0 (0)
NFL	21 (25)	17 (27)	2 (15)	1 (50)	0 (0)	0 (0)	1 (100)	0 (0)
MLB	9 (11)	4 (6)	3 (23)	1 (50)	0 (0)	1 (100)	0 (0)	0 (0)
NHL	3 (4)	0 (0)	1 (8)	0 (0)	0 (0)	0 (0)	0 (0)	2 (100)

BMI, body mass index; MLB, Major League Baseball; MT, metatarsal; NBA, National Basketball Association; NFL, National Football League; NHL, National Hockey League.

RESULTS

A total of 77 players undergoing a total of 84 operative procedures met the inclusion criteria (NBA, n = 51; NFL, n = 21; MLB, n = 9; and NHL, n = 3). A total of 6 players underwent primary operative fixation for a foot fracture, returned to play at least 1 game, and then experienced refracture requiring revision surgery. One player sustained a foot fracture, returned to play, and then sustained a fracture in a different location on the same foot requiring operative treatment (Table 1).

All but 1 player (98.7%) were able to RTP after foot fracture fixation. Of the players who did return, the median time to postoperative play was 137 days (range, 14-492 days). Navicular fractures required longer TTR from surgery (median, 195 days; range, 14-462 days) compared with fifth metatarsal fractures (median, 125 days; range, 26-492 days), though this difference was not statistically significant ($P = 0.22$).

A total of 55 players met the inclusion criteria and were analyzed for pre- and postoperative performance. Compared with preoperative level of play, professional athletes demonstrated no discernable change in performance during postoperative season 1 ($P = 0.29$) and a significant decline in performance in seasons 2 and 3 after surgery (-6.8% , $P = 0.05$) (Figure 1). There were no differences in performance change across individual sports. However, compared with other athletes, NFL players sustained a notable drop in performance level.

A total of 63 fifth metatarsal fractures were included in the analysis. The mean age of players undergoing operative fixation was 24.8 ± 3.1 years with 3.6 ± 3.7 years of experience. There was no difference between pre- and postoperative performance and participation up to 3 seasons after surgery, with players returning to preoperative levels within 1 season of surgery. These players continued to play for a mean 5.1 ± 4.5 years after surgery (Table 2).

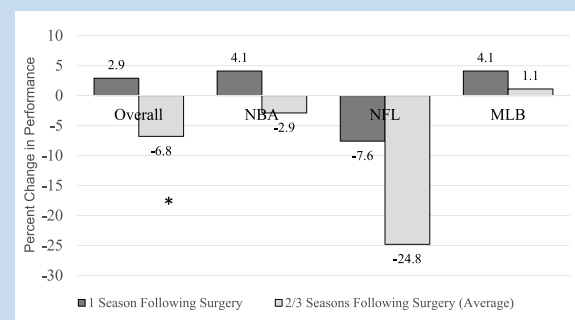


Figure 1. Change in performance after foot fracture fixation across sports. The National Hockey League cohort is omitted due to its small size (n = 3). *Significant difference ($P \leq 0.05$) compared with preoperative season for each athlete. MLB, Major League Baseball; NBA, National Basketball Association; NFL, National Football League.

This study included 13 navicular fractures. The mean age of players sustaining such injury was 28.3 ± 3.1 years, with 6.9 ± 4.6 years of experience prior to injury. Compared with athletes sustaining fifth metatarsal injuries, those with navicular fractures were significantly older ($P = 0.002$) and had longer careers prior to injury ($P = 0.04$). For athletes with navicular fracture, there was no discernable difference between pre- and postoperative performance and participation up to 3 seasons after surgery, which was no different than that from fifth metatarsal injuries. Athletes continued to play for a mean 6.0 ± 5.2 years after surgery.

Six players (7.8%) sustained refracture of the fifth metatarsal or navicular requiring a second operation, which only occurred in NBA athletes (6/41, 14.6%). In this population, 11% of fifth metatarsal fractures (4/38) and 40% of navicular fractures (2/5)

Table 2. League analysis among fifth metatarsal fractures^a

	Total (N = 63)	NBA (n = 42)	NFL (n = 17)	MLB (n = 4)	P Value
Age, y, mean ± SD	24.8 ± 3.1	24.8 ± 3.6	24.6 ± 2.1	25.2 ± 1.5	0.94
Experience, y, mean ± SD	3.6 ± 3.7	4.0 ± 4.0	3.2 ± 3.2	1.9 ± 1.9	0.50
Time to return, d, median	125	115	189	242.5	0.33
Change in performance, %, mean ± SD					
1 Season	1.0 ± 36.2	2.6 ± 30.0	-11.3 ± 57.6	13.8 ± 32.0	0.49
2-3 Season	-1.1 ± 38.4	2.0 ± 39.0	-29.4 ± 30.7	15.3 ± 27.3	0.18
Career after, y, mean ± SD	5.1 ± 4.5	5.4 ± 4.6	3.8 ± 3.7	6.0 ± 5.1	0.49

MLB, Major League Baseball; NBA, National Basketball Association; NFL, National Football League.

^aThe National Hockey League cohort is omitted due to its small size (n = 3).

required reoperation. Percentage of games started 1 season after primary operative treatment was a predictive factor for reinjury (99% vs 40%, $P = 0.001$). All 6 players who underwent reoperation were able to RTP after surgery. Time to RTP after surgery was significantly longer after reoperation compared with primary operative treatment (275 vs 130 days, respectively; $P = 0.04$). Furthermore, players started fewer games 1 season after reoperation compared with 1 season after primary operative treatment (56% vs 99%, respectively; $P = 0.03$). Notably, there was no difference in performance (17.3 vs 20.0 player efficiency rating [PER], $P = 0.53$) or games played (54 games vs 90 games, $P = 0.32$) the season after primary surgery or reoperation. Finally, players who did undergo reoperation had no difference in career lengths than players who did not (5.0 years vs 6.0 years, $P = 0.67$).

DISCUSSION

Clinical outcomes after foot fracture fixation in the general population are excellent in terms of radiographic union and return to activity.^{3,23} However, while the average patient is concerned with returning to the routines of daily life, the professional athlete may be concerned with returning to a much more demanding career in a quick yet safe manner. Furthermore, the professional athlete is exposed to far greater physical stress than the average patient, warranting separate outcome measures and assessment of injury impact. To best guide therapy, it is vital for players, coaches, and team physicians to be well aware of the potential impact of these injuries on career performance and longevity.

The data from this study suggest that regardless of sport, professional athletes have excellent outcomes after foot fracture fixation. Athletes RTP at a high rate (98.7%) with minimal change in postoperative performance levels. Compared with injuries in other anatomic areas, players with these injuries

enjoy the most successful outcomes after operative treatment,¹⁶ which are consistent with findings from other studies of foot fractures in elite athletes.^{5,14,21} Among players who did return, median time to return was 137 days, and athletes continued to play for an average of 5.0 years after surgery. Athletes were able to achieve preoperative performance and participation levels within 1 season of surgery.

Fifth metatarsal fractures, which have been previously reported in NBA² and NFL^{5,14} athletes, were the most common injury requiring operative fixation in this study, followed by navicular fractures. Compared with athletes who sustained fifth metatarsal fractures, those with navicular fractures were older and had a greater number of years of professional experience ($P < 0.04$). However, despite differences in age and experience, players performed similarly after injury, returning to preoperative performance and participation levels within 1 season of surgery and sustaining high levels of performance up to 3 seasons postoperatively.

Professional basketball athletes are at a greater risk of refracture when compared with players of other sports, which may be due to the greater stress placed on the foot from more frequent jumping and landing activities. These factors, along with others, could potentially make NBA players particularly susceptible to refracture of the foot. Reinjury of fifth metatarsal fractures after operative treatment has been previously associated with elite physical activity.¹⁵ However, data from the present study show that the number of games started 1 season after primary surgery is a predictor of reinjury. Players who started more games the season after initial surgery were more likely to experience refracture, which generally occurred within 1 year of returning to play. This may suggest that returning to demanding levels of participation immediately after surgery may increase the risk of reinjury. Minimizing such complications should be of particular importance to players, coaches, and team physicians, as players who underwent reoperation took

twice as long to return from reoperation than they did from initial surgery (275 vs 130 days). Furthermore, athletes started fewer games after reoperation than they did after primary operative treatment, suggesting that players were not able to participate to the same extent. However, all players undergoing reoperation were able to successfully return to play and to preoperative performance levels with no impact on overall career length, indicating that revision procedures may not affect long-term career performance.

This study has several limitations. Because public sources were used, it is possible that some injuries may have been missed. Additionally, public sources introduce potential confounders that were not controlled for, including playing style, team and league preferences, and concomitant injuries. Public sources may also introduce a bias toward more high-profile players. However, the mean preoperative PER of 14.8 for NBA players in this study correlates with the standardized league PER of 15.0, which suggests that the average player in this database corresponded to the average player's performance in the NBA. With the present methodology, information such as presenting symptoms, radiographic evidence, and specific operative details (eg, screw placement, allograft use) were not available through public sources. These factors may play a role in recovery after surgery. Finally, some reoperations in this cohort may not have been publicly reported, and as such, would not be included in this study.

CONCLUSION

Overall, elite athletes return to play after foot fracture fixation at a high rate with excellent postoperative performance levels regardless of sport and fracture location. NBA athletes sustaining fifth metatarsal and navicular fractures are at greater risk of reinjury compared with other athletes. Returning to high levels of athletic participation soon after surgery may predispose athletes to reinjury and subsequent reoperation.

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