

Epidemiology of Tibial Fractures in Professional American Football Athletes From 2013 to 2019

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Background: Lower extremity injuries occur with high frequency in National Football League (NFL) athletes and cause high burden to players and teams. Tibial fractures are among the most severe lower extremity injuries sustained in athletes and are associated with prolonged time loss from sport.

Purpose: To determine the number of tibial fractures in NFL athletes from the 2013 to 2019 NFL seasons and describe athlete demographics, fracture characteristics, and details of injury onset.

Study Design: Case series; Level of evidence, 4.

Methods: A retrospective review of the NFL injury database was performed to identify all NFL athletes sustaining tibial fractures over the 2013 to 2019 NFL seasons. Athlete characteristics, injury characteristics, days missed, and treatment (operative vs nonoperative) were examined. Descriptive statistics were used to calculate means, standard deviations, ranges, and percentages.

Results: A total of 64 tibial fractures were identified in 60 athletes, resulting in a median loss of 74 days. Defensive secondary athletes had the highest number of injuries (n = 10; 16%), followed by running backs (n = 9; 14%), while 61% of these injuries occurred during NFL regular-season games, primarily between weeks 13 and 17. The most commonly reported activity during injury was athletes being tackled, with a direct impact to the tibia being the most common mechanism of injury. Lateral tibial plateau fractures were the most frequently reported, while distal tibial fractures resulted in the greatest number of days lost. The median time lost for injuries requiring surgery was 232 days compared with 56 days for injuries treated using conservative management.

Conclusion: The highest proportion of tibial fractures were injuries to defensive secondary athletes and athletes being tackled while sustaining a direct impact to the leg, primarily to the lateral tibial plateau. Tibial fracture injuries were commonly sustained during NFL regular-season games, primarily during the final 4 weeks of the NFL regular season. Further investigations examining performance and career longevity in athletes sustaining tibial fractures are warranted to help improve the health and safety of NFL athletes.

Keywords: American football; athlete; tibia; fracture; plateau

The risk of injury to National Football League (NFL) athletes is greater when compared with other popular sports due to the increasing size, speed, and strength of NFL athletes.⁷ Feeley et al¹⁴ reported an injury rate of 65 injuries per 1000 athlete-exposures during NFL preseason games from 1998 to 2007, while Lawrence et al¹⁹ reported an all-cause injury rate of 395.8 injuries per 1000 athletes at risk over the course of the 2012 to 2014 NFL seasons. In particular, lower extremity injuries comprise up to 62% of

all reported injuries in NFL athletes,¹⁹ representing a substantial source of time lost, in addition to compromising future performance and potentially shortening career length.^{3,22,32}

While injuries to the knee and ankle represent the most common lower extremity injuries in NFL athletes,¹⁹ tibial fractures remain one of the most severe injuries in American football athletes.^{28,29} Tibial fractures have been reported to result in extended time lost from play when analyzing multiple sports, ranging from 12 to 54 weeks for tibial fractures treated surgically compared with 28 to 182 weeks for those managed conservatively with immobilization, manipulation, and rest.²⁷ While the impact of lower

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extremity injuries on return to play and performance has been examined in prior studies in NFL athletes,^{1,12,26} the incidence and impact of tibial fractures in NFL athletes remains largely unknown.

As such, gaining a better understanding of the true incidence and management of tibial fractures in NFL athletes is critical to aid in injury prevention while optimizing recovery programs after injury. The purpose of this study was to describe the incidence of tibial fractures in NFL athletes over the course of the 2013 to 2019 NFL seasons. Based on prior studies,^{14,19} we hypothesized that tibial fracture occurred primarily during NFL games as a result of a direct impact to the leg, with the majority of fractures being managed nonoperatively.

METHODS

Tibial fractures from the 2013 to 2019 NFL seasons were identified through a retrospective review of the NFL injury database. Injuries from the 2013 to 2014 seasons were collected through the NFL Injury Surveillance System (ISS). Injuries from the 2015 to 2019 seasons were reported through a centrally hosted electronic health record (EHR) system that is reviewed for completeness and quality, which is reviewed and audited on a weekly basis, while medical staff are trained throughout the year on standardized reporting practices.¹¹ Before study initiation, institutional review board approval was obtained from our institution and the NFL through its medical research application process.

Variables of interest in this study included athlete characteristics (age, position at time of injury, activity at time of injury), injury timing (date, setting [offseason, preseason, regular season], timing of game injuries by week in season and quarter of game), injury characteristics (nature of injury [new injury vs ongoing/chronic vs recurrent], mechanism of injury, fracture type [medial plateau, lateral plateau, tibial tubercle, tibial shaft, distal tibia], fracture characteristics [open vs closed, extra-articular vs intra-articular]), associated injuries, fracture management (operative vs conservative) and days missed. Injuries classified as purely ligamentous or those recorded as demonstrating evidence of bony contusion/impaction without definite fracture were not included in the analysis. Fractures undergoing surgical management were identified using Current Procedural Terminology codes, which were reviewed with an analytics team at IQVIA Inc to ensure accuracy, proper categorization, and levels of specificity for each injury. No

TABLE 1
Injury Incidence Based on Athlete Position

Position	n (% of total) ^a
Defensive lineman	5 (7)
Defensive secondary	10 (16)
Linebacker	6 (9)
Offensive lineman	8 (13)
Quarterback	4 (6)
Running back	9 (14)
Special teams	8 (13)
Tight end	7 (11)
Wide receiver	7 (11)

^aBased on total number of injuries recorded during NFL regular-season games (n = 64).

injuries were reported as being treated surgically from data using the NFL ISS (2013-2014 seasons). As such, all analyses related to management by fracture type were limited to the 2015 to 2019 seasons.

Descriptive statistics were utilized to calculate and express variables as mean, standard deviation, range, and percentages. All analyses were performed using SPSS V 23 (IBM).

RESULTS

A total of 64 fractures in 60 NFL athletes were identified during the 2013 to 2019 seasons, with 28% (n = 18/64) of injuries recorded using the NFL ISS (2013-2014 seasons) and 72% (n = 46/64) from the NFL EHR (2015-2019 seasons). Most injuries were “new onset” (94%; n = 60/64), followed by ongoing/chronic (3%; n = 2/64) and recurrent (3%; n = 2/64). Mean age at the time of injury was 26 ± 3 (range, 21-35 years). The median number of days lost due to injury was 74 days (interquartile range, 34-153 days; mean, 112.3 ± 101.1 days; range, 10-346 days), while time lost was not recorded in 36% (n = 23/64) of injuries. Of the 64 tibial fractures, 16% (n = 10/64) were to defensive secondary players and 14% (n = 9/64) were to running backs (Table 1). The greatest number of injuries were recorded during the 2018 NFL season (22%; n = 14/64) (Table 2).

Injuries were most frequently reported as occurring during NFL regular-season games (61%; n = 39) (Table 3), with the majority of these game injuries recorded between weeks 13 and 17 (51%; n = 20/39) (Table 4). Injuries were most commonly reported as occurring during the second quarter

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Ethical approval for this study was obtained from University Hospitals Cleveland Medical Center (study No. 20191144).

TABLE 2
Injury Incidence Based on NFL Season^a

Injury Season	n (% of total) ^b
2013	7 (11)
2014	11 (17)
2015	9 (14)
2016	8 (13)
2017	6 (9)
2018	14 (22)
2019	9 (14)

^aNFL, National Football League.

^bBased on total number of injuries recorded during NFL regular-season games (n = 64).

TABLE 3
Setting of Injuries in NFL Athletes^a

Injury Setting	n (% of total) ^b
Preseason practice	11 (17)
Preseason game	8 (13)
Regular-season game	39 (61)
Regular-season practice	1 (1)
Offseason conditioning	2 (3)
Offseason practice	3 (5)
Postseason	0 (0)

^aNFL, National Football League.

^bBased on total number of injuries recorded during NFL regular-season games (n = 64).

TABLE 4
Injury Incidence During NFL Regular Season^a

Regular-Season Week	n (% of total) ^b
Weeks 1-4	4 (10)
Weeks 5-8	8 (21)
Weeks 9-12	7 (18)
Weeks 13-17	20 (51)

^aNFL, National Football League.

^bBased on total number of injuries recorded during NFL regular-season games (n = 39).

(28%; n = 11/39) of NFL games (Table 5). The most frequently reported activity during injury was being tackled (27%; n = 17/64), followed by blocking (17%; n = 11/64); while a direct impact to the leg was reported as the most common mechanism of injury (58%; n = 37/64) (Table 6).

The most commonly reported tibial fractures in the NFL EHR from 2015 to 2019 were to the lateral tibial plateau (46%; n = 21/46) and the tibial shaft (31%; n = 14/46) (Table 7). Associated injuries were most frequently reported in athletes with lateral plateau fractures, occurring in 29% (n = 6/21) of injuries. Distal tibial fractures resulted in the greatest amount of time lost (mean, 175.3 ± 88.3 days; range, 60-253 days). Open fractures were reported in 4% (n = 2/46) of fractures, while 43% (n = 3/7) of distal tibial

TABLE 5
Injury Timing During NFL Regular Season^a

Timing During Game	n (% of total) ^b
1st quarter	6 (15)
2nd quarter	11 (28)
3rd quarter	9 (23)
4th quarter	10 (26)
Unknown	2 (5)
Pregame	1 (3)

^aNFL, National Football League.

^bBased on total number of injuries recorded during NFL regular-season games (n = 39).

TABLE 6
Reported Activity and Mechanism of Injury at Time of Fracture

Activity	n (% of total)	Mechanism of Injury	n (% of total) ^a
Blocked	9 (14)	Anterior translation	1 (2)
Blocking	11 (17)	Direct impact	37 (58)
Catching	1 (2)	Hyperextension	3 (5)
Cutting	2 (3)	Indirect force	5 (8)
Jumping	1 (2)	Insidious/Overuse	5 (8)
Landing	1 (2)	Shearing	1 (2)
Other	5 (8)	Spontaneous	2 (3)
Sprinting/running	4 (6)	Stretch	1 (2)
Tackled	17 (27)	Torsion	3 (5)
Tackling	6 (9)	Unknown/Inconclusive	4 (6)
Unknown	7 (11)	Valgus force	1 (2)

^aBased on total number of injuries recorded during NFL regular-season games (n = 64).

fractures were noted to have intra-articular involvement. Overall, surgery was performed in 34% (n = 22/64) of injuries recorded in the NFL ISS (2013-2014 seasons) and NFL EHR (2015-2019 seasons). For injuries recorded in the NFL EHR (2015-2019 seasons) alone, surgery was performed in 48% (n = 22/46) of injuries, being most commonly performed for injuries to the distal tibia (71%; n = 5/7). Injuries requiring surgery led to a loss of a median of 232 days (mean, 220.9 ± 97.2 days; range, 75-346 days) compared with a median of 56 days (mean, 78.1 ± 79.3 days; range, 10-253 days) for injuries treated without surgery.

DISCUSSION

The primary findings from this investigation were that over 7 NFL seasons, 64 tibial fractures were reported in 60 athletes, resulting in a median loss of 74 days. Of the injuries, 61% occurred during NFL regular-season games, predominately between weeks 13 and 17. The most commonly reported activity at the time of injury was athletes being tackled, with a direct impact to the leg being the most frequently reported mechanism of injury. Lateral tibial plateau fractures were the most commonly reported fracture

TABLE 7
Injury Characteristics and Treatment Based on Fracture Classification^a

Fracture Classification	No. of Injuries	Activity at Time of Injury (n)	Associated Injuries (n)	Days Missed	Surgery
Lateral tibial plateau	21 (46)	Blocking (6) Blocked (5) Tackled (4) Cutting (2) Tackling (2) Unknown (2)	· Knee dislocation + LCL rupture + PCL rupture (1) · ACL rupture + LCL sprain (1) · Patellar subluxation + MCL sprain (1) · LMT (1) · MCL sprain (2)	58.5 ± 45.7 (10-282); NR, 8	5 (24) · Arthroscopic MMR (1) · Fasciotomy, arterial bypass (1) · ACL recon, LCL repair (1) · Arthroscopic PLM (1) · MCL repair (1)
Medial tibial plateau	2 (4)	Landing (1) Sprinting/running (1)	PCL rupture + MMT (1)	208 (70-346); NR, 3	1 (50) · PCL recon, MCL repair, tibial plateau ORIF (1)
Proximal tibial fracture	1 (2)	Unknown (1)	None	NR	1 (100) · IM nail (1)
Tibial shaft fracture	14 ^b (31)	Tackled (4) Unknown (4) Tackling (2) Sprinting/Running (2) Blocking (1) Catching (1)	Fibular fracture (3)	229.7 ± 106 (91-345); NR, 7	9 (64) · IM nail (7) · IM nail + I&D (1) · Tibial ORIF (1)
Distal tibial fracture	7 ^{bc} (15)	Tackled (3) Tackling (1) Blocked (1) Sprinting/Running (1) Unknown (1)	Fibular fracture (3)	175.3 ± 88.3 (60-253); NR, 3	5 (71) · IM nail (1) · IM nail + ORIF fibula ^d (2) · Ankle ligament repair (1) · Ankle arthroscopy, ORIF posterior malleolus, syndesmotom fixation (1)
Tibial tubercle avulsion	1 (2)	Tackling (1)	None	22	None

^aData are reported as n (% of total) or mean ± SD (range) unless otherwise indicated. ACL, anterior cruciate ligament; I&D, irrigation and debridement; IM, intramedullary; LCL, lateral collateral ligament; LMT, lateral meniscal tear; MCL, medial collateral ligament; MMR, medial meniscal repair; MMT, medial meniscal tear; NR, not recorded; ORIF, open reduction and internal fixation; PCL, posterior cruciate ligament; PLM, partial lateral meniscectomy; recon, reconstruction.

^bIncludes open fracture (n = 1).

^cIncludes fractures with intra-articular extension (n = 3).

^dTreated with irrigation and debridement with staged split thickness skin grafting (n = 1).

type, while distal tibial fractures resulted in the greatest amount of time lost. Injuries requiring surgery missed a median of 232 days compared with a median of 56 days for injuries treated conservatively.

The 2 positions that comprised the greatest number of tibial fractures were defensive secondary and running backs. In their epidemiologic study utilizing the NFL EHR to determine the incidence of lower extremity injuries from the 2015 to 2018 NFL seasons, Mack et al²² reported that of the 5417 injured athletes identified over a 5-year study, defensive secondary (n = 1204; 22.2%) represented the greatest proportion of injured athletes with time-loss injuries to the lower extremities. Defensive secondary athletes generally experience higher velocity impacts, as their positional responsibilities dictate the need to cover and tackle opponents in the open field. Meanwhile, running backs generally encounter frequent direct contact at the knee level while being tackled, accounting for the high incidence of tibial fractures in this position group. Injury prevention measures should be tailored by position and aimed at

athletes required to stop opponents in both the open and the crowded field in order to minimize the risk of tibial fractures.

Of tibial fractures, 61% were recorded as occurring during NFL regular-season games, with 51% (n = 20/39) of fractures occurring during the final 4 games (weeks 13-17) of the NFL regular season. The higher frequency of injury during regular-season games when compared with practices or conditioning has been attributed to the increased intensity and greater degree of contact occurring during competition.^{10,14,30} Mack et al²² similarly reported that over the course of the 2015 to 2018 NFL seasons, a mean of 58.7% of athletes incurred time-loss lower extremity injuries during NFL games compared with 37.3% of athletes with injuries recorded during practices. The high incidence of tibial fractures recorded during the final 4 weeks of the NFL season may be due to the accumulation of athlete fatigue over the course of the season, contributing to alterations in dynamic balance and neuromuscular control during physical exertion.^{4,8,17} Specifically, physical

fatigue has been shown to result in the loss of proper tackling technique,⁹ increasing the risk of injury in the athlete being tackled, as well as the athlete performing the tackle.^{13,17}

The most commonly reported fracture type was to the lateral tibial plateau, with the most common activity at the time of fracture for the injured athlete was being tackled and sustaining a direct impact to the leg. Anatomically, the lateral tibial plateau possesses an inherently greater risk for fracture during trauma, as the medial tibial plateau has been shown to possess denser and stronger bone due to increased subchondral bone as a result of the eccentric load distribution within the knee, with the medial plateau bearing approximately 60% of force during loading.²⁵ As such, the high frequency of lateral tibial plateau fractures may be explained by the relative strength of the medial tibial plateau relative to the thinner and weaker lateral plateau, as well as the susceptibility of the leg to medially directed forces during competition.^{2,5} Specifically, when an excessive valgus force is placed on the knee, as commonly seen during tackling and blocking, the force transmitted across the joint places the knee at high risk for injury to the lateral tibial plateau, medial collateral ligament, anterior cruciate ligament, and meniscus.^{15,18,20,33} These findings are consistent with our results, in which 29% ($n = 6/21$) of athletes with lateral tibial plateau fractures sustained associated injuries within the knee. As such, surgeons must be aware of the potential for fractures to the lateral tibial plateau during tackling, with a high suspicion for concomitant injuries in athletes reporting knee pain following contact to the lateral aspect of the leg and knee.

Athletes undergoing surgical fixation missed a median of 130 days compared with 22.5 days for athletes treated conservatively. This finding may be explained by the high degree of heterogeneity in the types of fractures recorded and the differences in treatment recommendations based on fracture location and severity. For the majority of athletes sustaining tibial shaft fractures, intramedullary (IM) nailing remains the standard of care for athletes. In their evaluation of 559 NFL athletes undergoing orthopaedic procedures due to injury, Mai et al²³ reported that in 55 athletes undergoing IM nailing, athletes had a significantly higher return to play rates (90.2%) when compared with all other procedures ($P = .03$). Moreover, athletes undergoing IM nailing experienced longer careers following surgery (2.8 years; $P = .02$), played in significantly more games following surgery (47 games; $P = .003$), and possessed the highest median survival time (2.2 years) compared with other procedures.²³ Athletes with tibial fractures undergoing IM nailing have also been reported to return to play faster when compared with tibial fractures treated with open reduction and internal fixation (ORIF), which requires extended immobilization and delayed weightbearing.²⁷ These limitations following ORIF likely explain the prolonged time missed in athletes sustaining distal tibial fractures not amenable to IM nailing. Specifically, distal tibial fractures with intra-articular extension into the joint, present in 43% ($n = 3/7$) athletes, require not only fixation to the tibial shaft, but anatomic restoration of the distal tibial articular surface, requiring further rehabilitation.³¹

In addition, the presence of a concomitant fibular fracture, present in 43% ($n = 3/7$) athletes with distal tibial fractures has similarly been shown to increase return to sport times.^{6,16,29} When managing expectations after injury, NFL athletes sustaining tibial fractures amenable to IM nailing can be expected to return to sport sooner when compared with athletes with distal tibial fractures.

Limitations

This study is not without limitations. Due to the retrospective nature of the study, the quality and accuracy of the data are dependent on the extent of information entered into the NFL ISS and EHR databases. Therefore, the ability of the authors to distinguish and categorize tibial fractures according to mechanism, type, and management options was purely dependent upon the extent of documentation within the database. Conversely, as the study data are assessed using a centralized, mandated EHR data collection system with standardized reporting procedures (including structured reporter training for NFL medical staff, and quality reviews¹¹), the completeness and reliability of the injury data are high, particularly compared with publicly reported data.^{21,24} Over the 6-year data collection period, the ascertainment of injuries and covariates was more accurately recorded in the latter part of the data collection period compared with the years before the EHR launch (2013-2014). Because of this, injuries in 2013 and 2014 were excluded from analyses around surgery and return to play, where these limitations are known; other differences in data collection may also exist over the full 6 years. However, days missed was unavailable in 36% ($n = 23/64$) of injuries recorded in the EHR database, potentially confounding the data reported in our investigation. Information on athletes who left the NFL after sustaining a tibial fracture (for any reason) was not collected. Moreover, the overall injury incidence based on the number of NFL athletes participating in the NFL over the course of the study period was not calculated, nor was injury incidence based on the total number of athletes participating in each position. Data regarding activity and mechanism of injury were entered by athletic trainers and not systematically validated by video review. Reports regarding complications after surgical management were infrequently provided and not included in this study. Images were not reviewed as part of this study; as such, the authors are unable to examine treatment decisions based on the presence or degree of fracture displacement, presence of additional concomitant injuries, or precise type of surgical fixation performed, as operative reports were not available. As all athletes were professional American football athletes, injury types and mechanisms of injury are not generalizable to athletes participating in other sporting activities or at lower levels of competition.

CONCLUSION

While tibial fractures remain an uncommon injury in NFL athletes, these fractures result in a substantial amount of

time lost from sport. Defensive secondary athletes were the most common position injured while athletes being tackled and sustaining a direct impact to the leg was the most common mechanism for fracture, primarily to the lateral tibial plateau. Tibial fracture injuries were commonly sustained during NFL regular-season games, primarily during the final 4 weeks of the NFL regular season. Further investigations examining performance and career longevity in athletes sustaining tibial fractures are warranted to help improve the health and safety of NFL athletes while also helping manage expectations following specific tibial fractures.

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