

Lower Extremity Stress Fractures in the National Basketball Association, 2013-2014 Through 2018-2019

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Background: Players in the National Basketball Association (NBA) are at risk for lower extremity stress fractures, partly because of the sport's high-intensity demand on the lower body.

Purpose: To provide insight on the identification and management of potential risk factors associated with lower extremity stress fractures in NBA athletes.

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

Methods: A retrospective study was conducted using the NBA electronic medical record database for all players who were on an NBA roster for ≥ 1 game from the 2013-2014 through 2018-2019 seasons. Player characteristics, games missed, and treatment methodology were independently analyzed. Results were presented as incidence per 1000 player-games.

Results: There were 22 stress fractures identified in 20 NBA players over the course of 6 years, with an average of 3.67 stress fractures per year and an incidence of 0.12 stress fractures per 1000 player-games. Most stress fractures occurred in the foot (17/22), and 45% (10/22) of stress fractures were treated surgically, with the most common site of operation being the navicular. On average, approximately 37 games and 243 days were missed per stress fracture injury. There was no significant difference in time to return to play between high-risk stress fractures treated operatively versus nonoperatively (269.2 vs 243.8 days; $P = .82$).

Conclusion: The overall incidence of stress fractures in NBA players was 0.12 per 1000 player-games, and a high percentage of players returned to NBA activity after the injury. There was a relatively even distribution between high-risk stress fractures treated operatively and nonoperatively. When comparing high-risk stress fractures treated operatively to ones treated nonoperatively, no significant difference in average time to return to play in the NBA was found.

Keywords: stress fracture; National Basketball Association (NBA); EMR

Stress fractures are common overuse injuries in athletes¹⁵ and commonly occur within areas of exerted repetitive sub-maximal stress. Basketball players are susceptible to stress fractures given the high-velocity and high-energy

repetitive forces applied on the body throughout the course of their career.^{2,4,5,14,19} The most common sites of stress fractures in basketball players are the tibial shaft, medial malleolus, tarsal bones, and the metatarsal bones of the foot.⁸

The ideal management strategy for these high-risk stress fractures and stress fractures in general is not known, as there have been few investigations into the effect of stress fractures on National Basketball Association (NBA) players. Small-scale studies have shown that rest (in some cases combined with low-intensity pulsed ultrasound) helped to improve healing and time to return to sport.¹⁶ However, other studies have shown that rest and time away from physical activity were inadequate, and ultimately, surgical intervention was required to eliminate pain and allow the patient to return to play.¹

The purpose of this study was to provide insight on the identification and management of potential risk factors associated with lower extremity stress fractures in NBA athletes. Our primary objectives were to identify the incidence and to describe player characteristics associated with

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these injuries. Secondary objectives included describing outcomes and various treatment methodologies of stress fracture management in NBA players.

METHODS

We conducted a retrospective study of all NBA players during the 2013-2014 through 2018-2019 seasons. Approval for the study protocol was obtained from our institutional review board, the NBA, the National Basketball Players Association, and the Research Committee of the NBA Physicians Association.

Data Source

Data were obtained from the electronic medical record (EMR) database used by the NBA. The NBA EMR database is a centralized data collection system that is integrated with the clinical management of NBA players. All NBA teams adopted the NBA EMR at the start of the 2012-2013 NBA season.¹² Records for each player are maintained through a standardized, audited system customized for the NBA and deployed uniformly across all 30 teams in the league. Injury data, including onset, mechanism, setting, type, and time lost due to injury, for all NBA players on a team roster are entered into the EMR system by team medical staff prospectively as events occur. Team medical staff are trained annually, and data are subject to regular auditing to ensure injury and illness data completeness and accuracy. If a player changes teams, the new team medical staff is granted access to the health record, allowing for continuity in the management of an injury record and the player's medical history. Team medical staff are also required to enter player-game participation data, including associating each missed game with a particular diagnosis if the player was unable to participate in the game due to injury. Before 2016-2017, entry of practice participation information in the EMR was not required, and practice participation entry was not audited across the study period. Thus, injury effect on non-game participation was not analyzed. Player-minute (individual player-minutes of participation in NBA games) was used to assess playing time exposure.

Player Characteristics

We examined age, body mass index (BMI), position, and average minutes played per game in the year before and in the year of injury associated with players sustaining a stress fracture of the lower extremity. Age was determined on the date of the player-game. BMI was calculated using the most recent height and weight before the player-game, as recorded in the EMR. Players who were in their rookie season were excluded from total and average minutes played per game in the year before injury.

Playing Time Missed

Time missed due to stress fracture was calculated in 2 ways: (1) the average number of NBA games missed after

the injury occurred and (2) the average number of days between the date of injury and the date of the first NBA game in which the player returned. Preseason, regular season, and playoff games missed because of injury were all included to more accurately describe the effect of these injuries. The database does not account for adjusted times missed for players who were eligible to return during the off-season.

Injury Characterization and Treatment

Stress fracture location and laterality were recorded. Stress fractures were diagnosed based on team physician history, physical examination, and imaging findings (radiograph and magnetic resonance imaging scan) confirming partial or complete fracture. Fractures were stratified by treatment methods that included either a trial of activity modification and protected weightbearing or surgical intervention via open reduction internal fixation. Bone stimulation utilization was also recorded; however, whether this was used in nonoperative management, preoperative management, or postoperative management is not addressed within the database. High-risk stress fractures were defined as those of the fifth metatarsal, navicular, and tibia. Traditionally, the anterior cortex of the tibial shaft is considered a high-risk location²; however, because of the nature of the database, cortical location was not defined. As such, all tibial shaft fractures were included in the "high-risk" category.

Data Analysis

Continuous variables are presented as means with standard deviations, and binomial variables are presented as proportions. Incidence rates were calculated per 1000 athlete-exposures and included all games in which the player participated, irrespective of duration of participation. Statistical analysis was performed with SPSS Version 25 (Chicago, IL). Alpha was set at 0.05. T-tests were run for continuous variables.

RESULTS

After review of the EMR, fractures sustained during the study period included those of the tibia and foot, which included the navicular and metatarsals. There were no identified stress fractures to the femur. The total number of stress fractures that occurred throughout the study period was 22, among 20 unique players (Table 1).

There were 2 players who sustained 2 stress fractures each; 1 player sustained a stress fracture of the third metatarsal during the 2016 off-season and the fourth metatarsal during the 2016 regular season, while the other sustained repeat stress fractures of the right navicular in the same foot during the 2014 and 2015 off-seasons. An average of 3.67 stress fractures occurred yearly. Half of the fractures sustained (11/22) occurred during the regular season, with an average annual incidence of 0.12 fractures per 1000 player-games (Table 2).

TABLE 1

Lower Extremity Stress Fractures, Injured Players, Teams, and Players in the NBA by Year, 2013-2014 Through 2018-2019^a

	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	6-Season Average
Stress fractures	6	4	3	4	2	3	3.67
Stress fractures resulting in ≥1 game missed	6	2	2	2	2	2	2.67
Injured players	6	4	3	2	2	3	3.50
Injured players with ≥1 game missed	6	2	2	1	2	2	2.50
Games	1434	1429	1425	1411	1390	1391	1413.3
Players	552	557	582	572	606	601	578.3
Player-games	30,320	30,465	30,708	30,517	29,878	29,889	30,296.1
Player-minutes	692,148	688,848	686,705	681,062	668,908	669,216	681,147.8

^aData are reported as absolute values.

TABLE 2

Incidence of Lower Extremity Stress Fractures in the NBA by Year, 2013-2014 Through 2018-2019^a

	Stress Fractures, n	Player-Games, n	Incidence per 1000 Player-Games
Overall	22	181,777	0.12
By year			
2013-2014	6	30,320	0.20
2014-2015	4	30,465	0.13
2015-2016	3	30,708	0.10
2016-2017	4	30,517	0.13
2017-2018	2	29,878	0.07
2018-2019	3	29,889	0.10
Time of season			
Off-season	6	—	—
Preseason	4	15,066	0.27
Regular season	11	156,025	0.07
Playoffs	1	10,686	0.09

^aDashes indicate not applicable.

TABLE 3

Player Characteristics at Time of Stress Fracture by Anatomic Location, 2013-2014 Through 2018-2019^a

	All Stress Fractures (N = 22)	Tibia (n = 5)	Foot (n = 17)
Age at injury, y	25.4 ± 4.8	23.6 ± 2.3	25.9 ± 8.0
BMI	25.1 ± 1.5	23.9 ± 2.3	25.5 ± 6.1
Height, cm (inches)	195.1 (76.8)	200.7 (79.0)	205.5 (80.9)
Position, n			
Guard	6	2	4
Forward	7	0	7
Center	6	2	4
Center-forward	2	0	2
Guard-forward	1	1	0
Time played per game, min			
Year before injury	17.5 ± 8.2	22.5 ± 8.6	15.8 ± 8.2
Year of injury	19.5 ± 7.8	21.7 ± 7.9	18.3 ± 7.8

^aData are reported as mean ± SD unless otherwise indicated. BMI, body mass index.

At the time of injury, the mean age of players was 25.4 years and their mean BMI was 25.1 (Table 3). There was a relatively even distribution of injuries among player position. The average time played per game in the year before injury was 17.5 minutes as compared with 19.5 minutes during the year of injury.

Of the 22 total stress fractures, 10 (45%) were treated operatively. One navicular stress fracture sustained during the 2014 off-season was initially treated nonoperatively; however, the player refractured it the following off-season and was then treated surgically. The breakdown of surgically treated stress fractures by body location is shown in Table 4.

Overall, 36.9 games and 243 days were missed due to each stress fracture injury (Table 5). The average time to return to NBA gameplay after operative fixation was 269.2 days, with an average of 59 games missed, while the average time to return to play after nonoperative management of high-risk stress fractures (navicular, tibia, and base of the fifth metatarsal) was 243.8 days, with 18.1 games missed. We found no significant difference in time to return to play between high-risk stress fractures treated operatively and nonoperatively ($P = .82$); however, the average number of games missed was significantly lower in the non-operative group ($P = .01$). Two players with navicular stress fractures did not return to play in the NBA; 1 was treated operatively, and the other was treated nonoperatively. Of the high-risk stress fractures treated nonoperatively, 1 occurred during the preseason, 3 during the regular season, 1 during the playoffs, and 2 during the off-season. For the ones treated operatively, 3 occurred during the preseason, 5 during the regular season, and 3 during the off-season. Because of the small numbers in each group (between low-risk and high-risk stress fractures), conclusions could not be drawn regarding comparison between the 2 groups.

Bone stimulation was utilized for 6 fractures (27%) including 2 navicular, 2 at the base of the fifth metatarsal, 1 tibial, and 1 second metatarsal. Four of the 6 players (67%) treated with bone stimulation underwent operative fixation of their fractures; these included 2 navicular, 1 at the base of the fifth metatarsal, and 1 tibial. It is important to note, however, that it is not indicated if bone stimulation

was used as an adjunct to surgery or if preoperative failure of bone stimulation led to surgery.

DISCUSSION

The most important finding of the current study was that the game incidence rate of stress fracture was low in NBA players (0.12 stress fractures per 1000 player-games) compared with previously published incidence rates of stress fractures in the general athlete (approximately 1%).^{3,6,7} As expected, high-risk stress fractures (navicular, tibia, base of the fifth metatarsal) were the only fractures treated operatively. There was a relatively even distribution between high-risk stress fractures treated operatively (10/18; 56%) and nonoperatively (8/18; 44%). When comparing high-risk stress fractures treated operatively with ones treated nonoperatively, we found no significant difference in average time to return to play in the NBA. However, we did note a statistically significant difference in NBA games missed between players with high-risk stress fractures treated operatively and nonoperatively, favoring nonoperative treatment. We speculate that the timing of injury influenced this finding given that 2 players in the nonoperative cohort were injured in the playoffs and off-season and missed 3 and 0 games, respectively.

Two players in the current study did not return to play in the NBA, both of whom sustained navicular stress fractures. One fracture was treated with internal fixation, while the other was managed nonoperatively. Overall, 91% (20/22) of the athletes included in this study returned

to play in the NBA. This small case series of stress fractures in NBA athletes suggests similar and successful outcomes of both operative and nonoperative treatment of high-risk stress fractures. However, given the small sample size of NBA players included, further studies on stress fractures in NBA players are warranted.

Treatment bias likely played a role in the management of some of the high-risk stress fractures included in this study. The utilization of bone stimulation highlights this potential area of bias, as the majority of the stress fractures that were treated with bone stimulation were high-risk fracture patterns (5/6; 83%). Further, of the 5 high-risk stress fractures treated with bone stimulation, 4 (80%) ultimately underwent operative fixation. The utilization of both bone stimulation and operative fixation in the management of high-risk lower extremity stress fracture suggests an increased severity of fracture pattern. Our study results should be interpreted in the context of potential treatment bias.

To our knowledge, this is the first study to investigate stress fractures in NBA athletes utilizing audited NBA EMR data. Khan et al¹⁰ previously investigated the effect of lower extremity stress fractures on NBA player performance between 2005 and 2015, although the database utilized in that study is based on publicly available information. Injury reports may have several limitations, including potential for selection bias as described by Maak et al.¹¹ In their search of publicly available data, Khan et al reported a slightly higher incidence rate of bony stress fractures in NBA players: 5.2 stress fractures per season versus 3.7 in the current study.¹⁰ Unfortunately, Khan et al did not report an incidence rate of stress fracture per 1000 player-games, so we cannot directly compare these data. Contrary to our hypothesis, the rate of stress fracture in the current study was lower (0.006% of NBA athletes) than the previously reported estimated incidence of stress fractures in the general athlete.⁶

The findings in the current study are similar to those of Khan et al¹⁰ in that the majority of the stress fractures identified involved the foot 77% (17/22) and occurred during the regular season 50% (11/22); however, the most common stress fracture in the study of Khan et al was the fifth metatarsal, compared with the navicular in the current study. The 45% rate of operative fixation in the current study was also similar to the rate in the study of Khan et al, who reported 38% (29/76). Fifth metatarsal,

TABLE 4
Stress Fractures That Required Operative Intervention by Location

Location	Stress Fractures Requiring Surgery, n (%)
Tibia	3/5 (60)
Foot	
Second metatarsal	0/1 (0)
Third metatarsal	0/1 (0)
Fourth metatarsal	0/2 (0)
Fifth metatarsal	2/5 (40)
Navicular	5/8 (63)

TABLE 5
Outcomes After Stress Fracture by Anatomic Location, 2013-2014 Through 2018-2019^a

	All Stress Fractures (N = 22)	Tibia (n = 5)	Foot (n = 17)
Days to return to NBA gameplay	243.0 ± 226.7	272.0 ± 88.6	234.5 ± 253.7
NBA games missed	36.9 ± 35.2	48.8 ± 37.5	33.4 ± 34.8
Injury treated with surgery	10	3	7 (5 navicular)
Bone stimulation used	6	1	5
Injury treated with surgery and bone stimulation	4	1	3

^aData are reported as mean ± SD or absolute values. NBA, National Basketball Association.

navicular, and tibial stress fractures were the most common stress fractures treated operatively in both studies, which was expected given the high risk of these fracture patterns developing a nonunion.⁶

Despite the low volume and quality of evidence on non-operative versus operative treatment of lower extremity stress fractures, several reviews have provided treatment recommendations.^{9,17,18} To the best of our knowledge, there are no randomized controlled trials or direct comparison studies evaluating outcomes between operatively and non-operatively treated lower extremity stress fractures. In their systematic review and meta-analysis, Mallee et al¹³ found no significant difference in operative versus nonoperative treatment of navicular and proximal fifth metatarsal stress fractures. However, patients with operatively treated navicular and proximal fifth metatarsal stress fractures returned to sport earlier (16.4 vs 21.7 and 13.8 vs 19.2 weeks, respectively).¹³ Contrary to these findings, we found no significant difference in time to return to play in the NBA between high-risk stress fractures treated operatively compared with nonoperatively.

Mallee et al¹³ also noted a lower rate of nonunion and refracture in proximal fifth metatarsal fractures treated surgically. Unfortunately, because of a lack of evidence for initial surgery on stress fractures of the anterior tibial cortex, they were unable to compare operative versus nonoperative treatment of this high-risk fracture pattern. The included studies did report a high rate of nonunion in nonoperatively treated stress fractures of the anterior tibial cortex, with most patients being unable to return to their previous level of sport.¹³ The findings of Mallee et al, though, were limited by the low quality of evidence and high risk of bias of the included studies. Further, they highlighted that there is a lack of focus on fracture severity within the available literature on stress fractures. Mallee et al argued that omission of fracture severity is a significant confounder when attempting to compare surgical versus nonsurgical treatment.

The current study utilized the NBA EMR database, which contains detailed information on player health and participation. The consistent reporting guidelines of the NBA EMR database, across the study period, likely improved the accuracy and completeness of the data presented. However, reporting changes in data entry over time may affect comparisons across seasons of the study. It is also important to note that several players are released from an NBA team roster at the start of the regular season, and the number of minutes a player participates per game can vary drastically. Thus, not all players on an NBA team roster have the same amount of athletic exposure to NBA gameplay. Importantly, player injury history outside of the NBA is limited, potentially resulting in some underascertainment of stress fractures that occurred outside of the player's NBA career. However, all injuries that occurred while a player is on an active NBA roster are required to be included in the EMR database.

Limitations

This study has several limitations. Player outcomes including return-to-play statistics, time to return to play, and

minutes played upon return are influenced by many factors that are not related to injury. Confounding factors including timing of injury in the season, particularly late-season injuries as players will miss fewer games, and coaching decisions can influence the above outcomes and are not necessarily injury related. Further, there may be a different threshold for return to play at different stages throughout the season (ie, players are more likely to return for a playoff game rather than a preseason game) that may influence return-to-play outcomes. We were unable to assess practice or conditioning time missed due to injury. Within the database there is also no assessment of several known risk factors for stress fractures, including vitamin D levels, foot morphology (particularly the cavovarus foot), or history of stress fracture occurrence before NBA gameplay. The database also does not allow for a comparison with noninjured players as a control population. Finally, given that this study investigated a unique population of NBA athletes, the results likely lack direct applicability to other populations.

CONCLUSION

The overall incidence of stress fractures in NBA players was 0.12 per 1000 player-games, and there was a high percentage of players who returned to NBA activity after injury. There was a relatively even distribution between high-risk stress fractures treated operatively and those treated nonoperatively. When comparing high-risk stress fractures treated operatively with ones treated nonoperatively, we found no significant difference in average time to return to play in the NBA. Further investigation into the optimal treatment of stress fractures in NBA players is needed.

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