

ACL Tears in the National Football League From 2013 to 2020

Analysis of the 2020 Season After Delays and Schedule Changes From the Early COVID-19 Pandemic Relative to Prior Seasons

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Background: The impact of fatigue and preseason preparation on anterior cruciate ligament (ACL) tears in the National Football League (NFL) are not well described. The 2020 NFL season did not include the standard preseason in response to changes secondary to the coronavirus disease-2019 (COVID-19) pandemic.

Purpose: To evaluate the association of game play on ACL tears in NFL athletes and to determine if differences in ACL tear epidemiology were present based on season of play from 2013 to 2020.

Study Design: Descriptive epidemiology study.

Methods: ACL tears in NFL athletes were identified using publicly available data. Games played and snap counts at the time of injury were recorded for each athlete sustaining game-related injuries. Tear rates were determined, and injuries were also calculated per 1000 athlete-exposures. Incidence rate ratios (IRRs) with 95% confidence intervals (CIs) were calculated.

Results: Overall, 379 ACL tears were identified, including 256 (67.6%) during game play and 118 (31.1%) during practice. Practice-based injuries were significantly higher in the preseason versus the remainder of the season. Games and snaps at the time of injury did not differ by year. The incidence rate of preseason injuries was significantly greater relative to in-season injuries (IRR = 2.68; 95% CI, 2.18-3.29; $P < .00001$). There was an elevated incidence rate of in-season injuries in 2020 relative to 2014-2019 combined (IRR = 1.49; 95% CI, 0.98-2.19; $P = .048$). In 2013 to 2019, the most frequent month of injury was the first month of the preseason in August (119/334 tears; 35.6%), whereas in 2020, the most frequent month was September (13/41 tears, 31.7%). The proportion of tears in September 2020 was not different from the proportion of tears in August 2013 to 2019.

Conclusion: There was an increased proportion of in-season ACL tears in the 2020 NFL season relative to 2014 to 2019; this is attributable to a frameshift in the consistent trend of injuries in the 1st month to return of competitive play, with 2020 being in the regular season in September as opposed to the preseason in August.

Keywords: ACL; fatigue; football (American); National Football League; preparation; professional sports

In the National Football League (NFL), knee injuries have been shown to represent approximately 20% to 30% of all injuries,^{6,20} and 24% of literature on orthopaedic injuries in NFL athletes focuses on the knee.¹⁹ While NFL athletes are subject to numerous types of knee injuries, there has been much interest in the evaluation of players after anterior cruciate ligament (ACL) tears. ACL tears represent 2% of injuries in the NFL.⁶ Players seeking to return to play undergo ACL reconstruction, with bone-patellar

tendon-bone autograft being the most popular graft choice.^{6,13,21,30} Many studies have evaluated return-to-play statistics and performance outcomes after ACL reconstruction as well as the impact of variables such as player position, concomitant injuries, timing in draft selection, and experience, among others.^{7-9,12,14,27,29,32,33}

Additional work has also focused on the epidemiology of ACL tears in these high-level athletes,^{5,6,11,18,31} as prediction and understanding of risk factors may help target interventions to limit injury. Limited hip internal rotation and dynamic valgus during pivoting/cutting,^{5,18} experience,²⁸ game play,^{6,31} practice injuries during preseason,⁶ and particular positions,^{11,28} among others, have been cited as risks.

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TABLE 1
Games Played by Season and Estimated AEs, 2013-2020^a

Season	Games Played				Total AEs		
	Preseason	Regular Season	Postseason	Total	Preseason	In-Season	Total
2013-2015; 2018-2019	65	256	11	332	179,520	452,832	632,352
2016-2017	64	256	11	331	176,640	452,832	629,472
2020	0 ^b	256	13	269	0	456,224	456,224

^aAE, athlete-exposure.

^bThere were no preseason games played in 2020.

While some studies comment on timing in the year and within games,^{6,11} there are still limited data on the impacts of adequate preparation/training and fatigue on the impact on ACL tears.

In the 2020 NFL season, the preseason was canceled in its entirety due to the coronavirus disease 2019 (COVID-19) pandemic, making training challenging due to distancing guidelines, limited training camp roster sizes down to 80 players from the typical 90,²⁶ and less formalized training. The offseason programming differed from typical years with not only preseason game cancellations but also substantial practice schedule changes, including more strength and conditioning sessions, more walk throughs, and delayed live contact and padded practices.²⁵ Limited training increases injury risk, and it has been demonstrated that overall injuries increased in the NFL during early season play in the 2020 season after organizational changes including the lack of preseason due to the COVID-19 pandemic.⁴ However, the influences of the COVID-19 pandemic and midseason delays on ACL tear risk specifically during the 2020 NFL season (September 10, 2020-January 3, 2021) have not been characterized.

The purpose of this study was to evaluate the association of game play on ACL tears in NFL athletes and to determine if differences in ACL tear epidemiology were present based on season of play from 2013 to 2020. We hypothesized that there would be a higher proportion of ACL tears in-season in 2020 compared with prior years, that there would be a greater proportion of ACL tears in 2020 in the 1st month of regular season play, and that there would be no associations between snaps and games played on ACL tear rates by year.

METHODS

This was a descriptive epidemiology study that was performed retrospectively based on publicly available data,

as has been performed previously.^{2,11,18} The websites and databases searched included the official NFL website (<https://www.nfl.com>), Pro Football Reference (<https://www.pro-football-reference.com>), the Football Database (<https://www.footballdb.com/players/index.html>), and additional news sources. Due to the public nature of the search, no institutional review board approval was obtained.

ACL tears in active-roster NFL athletes were searched from 2013 to 2020. We selected 2013 as the initial season due to more reliable lists of ACL tears in NFL players from 2013 onward. The year noted for each season refers to the year in which the season began; for example, “2016” refers to the season beginning in 2016 and ending in early 2017 (ie, including both the normal season and postseason/play-offs). For preseason injuries, preseason games played for that season was noted, while for in-season injuries, season games, season snaps, and game snaps were recorded.

The injury setting was classified as practice or game. For the 2020 NFL season, it was noted if the injury occurred after a COVID-19-associated midseason interruption. Mid-season interruptions were defined as any facility shutdowns or change in team game schedule secondary to the COVID-19 pandemic. NFL teams typically have 1 bye week each season; bye weeks that were performed as scheduled were not counted as midseason interruptions and were not accounted for in analyses, but bye weeks that moved or were contiguous with interruptions were counted as mid-season interruptions. One example interruption that affected each team was the league-wide shutdown on November 30 and December 1, 2020.²⁴

The total number of games by season is noted in Table 1. In 2016, the Hall of Fame Game between the Green Bay Packers and Indianapolis Colts was canceled due to concerns about field safety.¹⁶ In 2017, the Dallas Cowboys versus Houston Texans preseason game was likewise canceled due to Hurricane Harvey.¹⁰ In 2020, all preseason games were canceled,²⁶ and in the 2020 to 2021 season, postseason games were expanded.²³

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Ethical approval was not sought for the present study.

Demographic data on players collected included player team, position, age, height, and weight. The date of ACL tear was noted. Each player with an ACL tear had career data collected for career regular season games, career regular season snaps, career postseason games, career postseason snaps, total career NFL games (regular season plus postseason), and total career NFL snaps (regular season plus postseason) at the time of ACL tear. Numbers for career regular season snaps and career postseason snaps were limited to 2012 and later based on online data availability; therefore, only career snap counts in the final year (2020) were reported, as opposed to aggregate data for this variable.

Tear rates were calculated by games played during the preseason, in-season, and total season. Injuries were also calculated per 1000 athlete-exposures (AEs), in which 1 AE was defined as 1 game per athlete. Only active-roster players (not practice squad players) were included in injury recordings and injury-rate calculations, even though there was an expansion of practice squads in the 2020 season.¹⁷ For preseason games, AEs were estimated for each season, using 90 players on the roster for the first 3 weeks of preseason games (including the Hall of Fame Game) and 75 players for the 4th week of preseason games.⁴ For in-season games, total AEs were calculated using the regular season plus postseason games, 53-man active roster, and 32 NFL teams (Table 1). While the 2020 season allowed for teams to add up to 1 to 2 additional players from the practice squad to the active roster (to a 54- or 55-man roster),¹⁷ this was not used in calculations due to the variability in usage by teams throughout the season and because these players reverted to the practice squad after games for up to maximal 2 games for the season per player.

Descriptive statistics were used to characterize the data. Chi-square tests were utilized to compare frequencies of categorical data. Analysis of variance (ANOVA) was used to compare continuous variables across seasons, and Tukey post hoc analysis was applied to identify differences. Incidence rate ratios (IRRs) with 95% confidence intervals (CIs) were calculated. All statistical tests were performed on STATA Version 16.1 (StataCorp). Statistical significance was set to 2-tailed $\alpha < 0.05$.

RESULTS

A total of 379 ACL tears were included in this study. The average age of NFL players sustaining ACL tears was 25.7 ± 2.8 years (range, 20.8-35.3 years). The mean player height was 186.8 ± 7.7 cm, and the mean weight was 108.0 ± 19.4 kg.

Athletes had played an average of 3.1 ± 2.9 NFL career seasons (median 3; range, 0-13 seasons) and 38.7 ± 41.2 NFL career games (median 25; range, 0-214 games), including 37.1 ± 39.3 career regular season games (median 24; range, 0-196 games) and 1.6 ± 2.8 career postseason games (median 0; range, 0-18 games) at the time of injury. For the year 2020, the average career snaps since 2012 recorded at the time of injury was 2049.0 ± 2323.2 (median 1100; range 0-8823 snaps) total career snaps.

The 5 most frequent positions of players sustaining tears were linebacker (63 tears, 16.6%), wide receiver (57 tears, 15.0%), offensive line (51 tears, 13.5%), cornerback (41 tears, 10.8%), and running back (29 tears, 7.7%). The proportion of tears by player position did not differ by season ($P = .28$).

A total of 256 tears (67.6%) were sustained during game play, while 118 (31.1%) were sustained during practice; this did not differ by year ($P = .92$); 1 (0.3%) player sustained an ACL rupture in a nonfootball setting, and 4 were in unidentified settings (1.1%). Practice-based injuries were significantly higher in the preseason (106 practice-based injuries and 74 game-related injuries) relative to the remainder of the season (12 practice-based injuries and 182 game-related injuries) ($P < .0001$).

The average preseason games played by players in the season in the NFL season in which they had an ACL rupture, excluding 2020 (no preseason games), was 1.9 ± 1.5 preseason games (median 2; range, 0-5 games). The average season games played in the season prior to injury was 3.3 ± 4.5 (median 1; range, 0-19 games).

Season snaps at the time of that season's ACL injury averaged 148.7 ± 241.5 (median 5; range, 0-1254 snaps), and the average game snaps, excluding preseason, during the game of injury was 25.7 ± 19.3 (median 21; range, 1-79 snaps). Season games ($P = .08$) and season snaps ($P = .20$) at the time of injury did not differ by year.

The distribution of tears in the preseason versus season are noted in Table 2; 182 (48.0%) of injuries occurred in the preseason and 197 (52.0%) occurred during the season plus postseason. In total, 2013 had the most tears in the years studied (63.6 tears, 16.6% of total). The proportion of in-season tears was significantly higher in 2020 relative to each year from 2013 to 2018 ($P < .01$ for all), with the exception of 2019.

Injuries per 1000 AEs by season are reported in Table 3. The incidence rate of preseason tears per 1000 AEs was greater in 2013 than 2019 (IRR = 2.38; 95% CI, 1.21-4.97; $P = .0066$), greater in 2017 than 2019 (IRR = 2.42; 95% CI, 1.23-5.05; $P = .0056$), and greater in 2018 than 2019 (IRR = 2.23; 95% CI, 1.12-4.67; $P = .014$). No other significant differences by season in IRR within preseason tears were identified. For in-season tears, no significant differences in IRR were identified by individual years.

For ACL tears per 1000 AEs, there was an increased incidence rate of injury in 2020 relative to 2019 (IRR = 1.76; 95% CI, 1.09-2.87; $P = .015$) but not relative to any other individual year. For total ACL tears, there was an elevated incidence rate in 2013 relative to 2019 (IRR = 1.91; 95% CI, 1.23-3.00; $P = .0022$), but not any other individual year. The 2020 season saw an elevated incidence rate for in-season injuries (IRR = 1.49; 95% CI, 0.98-2.19; $P = .048$) relative to 2014 to 2019 combined, and 2013 had an increased injury incidence (IRR = 1.38; 95% CI, 1.03-1.82; $P = .026$) for total season ACL injuries relative to 2014 to 2019 combined.

For each year between 2013 and 2018, there was a significantly greater incidence rate of ACL tears in the preseason relative to in-season (Table 3). For the 2013 to 2019 seasons, there was a significantly higher rate of preseason injuries relative to in-season (IRR = 2.67, 95% CI, 2.15-3.33;

TABLE 2
Preseason and In-Season ACL Tears, 2013-2020^a

Year	Total ACL Tears (n = 379)		Preseason ACL Tears (n = 182)		In-Season ACL Tears (n = 197)		Proportion of In-Season Tears, %	P-value (Proportion of In-Season Tears vs 2020)
	No. (% of Total ACL Tears)	Tears per Games Played, %	No.	Tears per Games Played, %	No.	Tears per Games Played, % ^b		
2013	63 (16.6)	19.0	31	47.7	32	12.0	50.8	.004
2014	44 (11.6)	13.3	22	33.8	22	8.2	50.0	.006
2015	48 (12.7)	14.5	25	38.5	23	8.6	47.9	.003
2016	45 (11.9)	13.6	22	34.4	23	8.6	51.1	.008
2017	51 (13.5)	15.4	31	48.4	20	7.5	39.2	<.0001
2018	53 (14.0)	16.0	29	44.6	24	9.0	45.3	.001
2019	33 (8.7)	9.9	13	20.0	20	7.5	60.6	.090
2020	42 (11.1)	15.6	9	— ^c	33	12.3	78.6	-

^aBoldface *P* values denote statistically significant difference relative to proportion of in-season tears in 2020 ($P < .05$). ACL, anterior cruciate ligament.

^bIncluded games played during both the regular season and postseason.

^cThere were no preseason games played in 2020.

TABLE 3
ACL Tears by 1000 AEs^a

Year	ACL Tears per 1000 AEs			IRR, Preseason vs In-Season (95% CI)	P-value
	Total	Preseason	In-Season		
2013	0.100	0.173	0.071	2.44 (1.44-4.14)	.0005
2014	0.070	0.123	0.049	2.52 (1.33-4.78)	.0027
2015	0.076	0.139	0.051	2.74 (1.49-5.06)	.0006
2016	0.071	0.125	0.051	2.45 (1.30-4.60)	.0033
2017	0.081	0.175	0.044	3.97 (2.19-7.36)	<.00001
2018	0.084	0.162	0.053	3.05 (1.71-5.47)	.0001
2019	0.052	0.072	0.044	1.64 (0.75-3.46)	.17
2020	0.092	— ^b	0.072	-	-

^aBoldface *P* values denote statistically significant difference between preseason and in-season incidence rate of tears ($P < .05$). ACL, anterior cruciate ligament; AE, athlete-exposure; CI, confidence interval; IRR: incidence rate ratio per 1000 AEs.

^bThere were no preseason games played in 2020.

$P < .00001$). Overall, between 2013 and 2020, the most frequent month in which tears were sustained overall was August (33.3%) and the most frequent in-season month for tears was October (17.6%) (Table 4).

In 2020, the most frequent month for ACL tears was September (13/41 tears with known month of injury, 31.7%), which was a significantly higher proportion than the other years for September combined ($P < .0001$). The proportion of tears in September 2020 was not significantly different from the proportion of tears in August in 2013-2019 (119/334 tears with known month of injury, 35.6%) ($P = .62$).

In 2013 to 2020, each of the 32 teams played a game following a regularly scheduled bye week. In 2020, teams played games following 59 midseason facility- or schedule-related contiguous interruptions that were not solely regularly scheduled bye weeks. In 2020, 16 of 42 (38.1%) of tears were sustained in games after a COVID-19-related midseason interruption. Of 42 (38.1%)

ACL tears in 2020, 16 were sustained in games after a COVID-19-related midseason interruption.

DISCUSSION

This study identified a higher proportion of in-season ACL tears in 2020 than in 2013 to 2018 and an elevated IRR per total 1000 AEs of ACL tears in 2020 relative to 2014 to 2019. However, there was no increased incidence of in-season tears per 1000 AEs in 2020. Furthermore, there was an increase in the month of September 2020 relative to all other years studied. There was no difference in snaps by game or by season.

A recent study by Baker et al⁴ identified a significantly increased proportion of general injuries in the NFL in the first 4 weeks of the regular season in 2020 relative to prior years. Our study corroborates these findings over a longer time frame and also adds that later months in the season

TABLE 4
ACL Tears by Month Between 2013 and 2020 (n = 375)^a

Month	ACL tears, n (%)	No. of Games, 2013-2020	No. of 1000 AEs (% of total AEs)	Tears per 1000 AEs
August	125 (33.3)	421	1,174,080 (24.1)	0.106×10^{-3}
September	47 (12.5)	474	826,432 (16.9)	0.057×10^{-3}
October	66 (17.6)	495	839,520 (17.2)	0.079×10^{-3}
November	37 (9.9)	495	839,520 (17.2)	0.044×10^{-3}
December	36 (9.6)	568	963,328 (19.8)	0.037×10^{-3}
January ^{b,c}	10 (2.7)	130	220,480 (4.5)	0.045×10^{-3}
February ^b	1 (0.3)	8	13,568 (0.3)	0.073×10^{-3}
March	0 (0)	0	0	-
April	1 (0.3)	0	0	-
May	16 (4.3)	0	0	-
June	13 (3.5)	0	0	-
July	23 (6.1)	0	0	-

^aFor 4 tears, the exact month of injury was unable to be confirmed; therefore, the total is 375. ACL, anterior cruciate ligament; AE, athlete-exposure.

^bPlayoff period.

^cOf the 130 January games, 82 were playoff games (16 January games in each year 2015, 2016, 2020 were part of the regular season).

did not see increased rates of injuries for ACL tears specifically. Given that the first 4 weeks of the regular season begin in September, the trend identified in that study was also found in the current study with respect to ACL injuries, specifically with 2020 having an increased proportion of injuries in that month relative to 2013 to 2019. We also found that the most common month of injuries for ACL tears identified in the total cohort and years prior to 2020 was August, which is the 1st month of game play after summer training and is consistent with prior studies.^{6,11}

In the current study, the tear proportion in September 2020 did not differ from the tear proportion in August 2013 to 2019. Therefore, the trend that the first month of return to formal game play having the highest proportion of ACL tears remained constant, just frameshifted to the regular season for the 2020 season. This trend has also been demonstrated in the 1st week of return to training camp.¹⁵ Moreover, the 2020 season also had a delay in training camp return, which may have further contributed to early season ACL tears.²⁵ Return to high level of competitive play is a likely risk factor for ACL injuries, and therefore, extra precaution should be taken early in competitive play periods. This may take the form of gradually ramping up play minutes, using more personnel during early season games, or maintaining a continued focus on ACL tear-prevention training. A similar trend with Achilles tendon ruptures was seen in the season following the 2011 NFL lockout, when there was an increase in these soft tissue injuries in the early return-to-play period.²²

In general, the rate of NFL ACL tears, when calculated per 1000 AEs, is significantly higher in the preseason compared with regular season and postseason. Our study identified an IRR of 2.67 from 2013 to 2019 in preseason relative to the remainder of the season. This is consistent with prior data demonstrating an IRR of 2.30 for game-related tears.²⁸ Reasons for increased tear rates in the preseason have been speculated to be related to the larger roster sizes, less experience, and either not enough or too much conditioning.²⁸

Furthermore, we identified a significantly higher proportion of injuries in practice in the preseason relative to in-season, which is also consistent with prior data²⁸; this may be due to heightened competitiveness of preseason practice settings in addition to the increased emphasis on conditioning relative to recovery from games during the in-season. We did not identify differences in tear proportions by position by season.

Interestingly, in addition to 2020 having a greater IRR for in-season ACL injuries, 2013 had a greater total ACL injury IRR and the highest number of ACL tears at 63 tears utilizing this methodology. Another study utilizing online search methodology identified 65 ACL tears in the 2013 season relative to 46 in 2010, 48 in 2011, and 50 in 2012 in that study.¹¹ Furthermore, the IRR for in-season ACL injuries in 2013 was not different from that of 2020. It is unclear why the ACL injuries were as high as they were in 2013 relative to other years in this study sample. The 2020 season only had an elevated IRR for 1000 AEs relative to 2019 but not any other year for total ACL tears. This may indicate a relatively consistent total ACL tear rate despite outside influences such as the pandemic; however, it is difficult to interpret this data as other factors for exposures, such as practices and training camps, that would have been lower in 2020 are not accurately captured in our definition of AE for active-roster athletes.

Other studies have looked at the impact of quarters played as a surrogate for fatigue on the impact of ACL injury risk.^{6,28} Most recently, the number of tears has been noted to be relatively consistent across quarters.²⁸ Although quarters may capture an element of fatigue, we sought to evaluate the number of snaps played as another, possibly more specific, measure of fatigue, which no prior study has performed. However, despite a strength of our study in analyzing snaps in the game of injury and the season during which the injury occurred, we did not identify snaps prior to the injury to be higher in years with more ACL tears. Since snaps counts at the time of injury were not

different in 2020, it is difficult to conclude that players had a baseline increased risk for injury due to limited preparation starting that season. Rather, the high proportion of tears in the first month of play (September) being in the regular season as opposed to the preseason likely increased media attention around ACL tears and soft tissue injuries. Looking ahead to the 2021 to 2022 NFL season, the NFL has announced an expansion of the regular season by 1 week, with an increase in total games from 256 to 272.¹ Evaluation of the impact of this expansion on injuries in general and ACL tears or other soft tissue injuries is yet to be determined.

Limitations

Numerous limitations exist in this study. Given that the study was based on an online search of publicly available data, data may have been erroneously not captured, and data accuracy is limited to the search results. This may limit conclusions relative to data that may derive from league-derived electronic health systems; similar inconsistencies in the literature based on data sources have been found in both professional football and basketball.^{3,19} The number of tears identified through this methodology was fewer than that identified using the NFL electronic health record, which includes all players.²⁸ Moreover, developing an accurate assessment of AEs is challenging. Our definition was limited to game exposures and therefore did not account for practice time, training camp time, or individual training sessions. Cutting practices and training camps during the 2020 preseason and season could have therefore increased the injury rate further per total exposures if nongame exposures could be better captured. Furthermore, because our exposure calculations included only active roster players, they may not accurately depict exposure rates that involve injuries to practice squad players.

While we examined midseason interruptions secondary to the pandemic, these interruptions were only those affecting full teams and facilities and does not appropriately capture individual player level COVID protocols, illnesses, injuries, or rest. We did not distinguish between initial tears and retears, which has been previously studied.¹¹ Furthermore, ACL tears were not stratified by mechanism of injury (ie, contact vs noncontact) due to inconsistent availability of these data. Future study examining mechanism of injury could shed light on whether suboptimal conditioning for noncontact ACL injuries or suboptimal collision exposure for contact ACL injuries is at play, although the present study did not find different positions that tend to be of more contact to have different tear rates in 2020. Furthermore, this study did not compare risk factors for ACL injuries relative to a noninjured controlled cohort. The conclusions of this study are not generalizable to other leagues, levels of competitive play, or other soft tissue injuries sustained in the NFL. Despite these limitations, this data provides insight into the trends in ACL tears in the season of the current height of the COVID-19 pandemic relative to prior years.

CONCLUSION

There was an increased proportion of in-season ACL tears in the 2020 NFL season relative to 2014 to 2019; this is attributable to a frameshift in the consistent trend of injuries in the first month to return of competitive play, with 2020 being in the regular season in September as opposed to the preseason in August. Practice-based injuries remain significantly higher in the preseason than in the regular season. Snaps and games played at the time of ACL injury did not differ by seasons.

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