

Performance and Return-to-Sport After ACL Reconstruction in NFL Quarterbacks

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abstract

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Anterior cruciate ligament (ACL) rupture is a significant injury in National Football League (NFL) quarterbacks. The purpose of this study was to determine (1) return-to-sport (RTS) rate in NFL quarterbacks following ACL reconstruction, (2) performance upon RTS, and (3) the difference in RTS and performance between players who underwent ACL reconstruction and controls. Thirteen quarterbacks (14 knees) who met inclusion criteria underwent ACL reconstruction while in the NFL. Matched controls were selected from the NFL during the same time span to compare and analyze age, body mass index (BMI), position, performance, and NFL experience. Student *t* tests were performed for analysis of within- and between-group variables. Bonferroni correction was used in the setting of multiple comparisons. Twelve quarterbacks (13 knees; 92%) were able to RTS in the NFL. Mean player age was 27.2 ± 2.39 years. Mean career length in the NFL following ACL reconstruction was 4.85 ± 2.7 years. Only 1 player needed revision ACL reconstruction. In both cases and controls, player performance was not significantly different from preinjury performance after ACL reconstruction (or index year in controls). There was also no significant performance difference between case and control quarterbacks following ACL reconstruction (or index year in controls). There is a high rate of RTS in the NFL following ACL reconstruction. In-game performance following ACL reconstruction was not significantly different from pre-injury or from controls.

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Anterior cruciate ligament (ACL) tears are one of the most common knee injuries in both contact and noncontact sports.¹ With an incidence of approximately 0.07 per 1000 exposures in high school football players and 0.11 per 1000 exposures for professional football players, it is estimated that there will be up to 200,000 ACL tears annually.^{2,3} More than half of these ACL tears will be surgically reconstructed.⁴ Anterior cruciate ligament reconstruction is the standard of care in young athletes.

Although many studies report a high success rate following an ACL reconstruction, data concerning National Football League (NFL) quarterbacks and their return to sport (RTS) after an ACL reconstruction are sparse. Shah et al⁵ investigated RTS among 49 NFL players, 2 of whom were quarterbacks, but in-game performance before and after ACL reconstruction was not analyzed. The NFL is arguably the most popular sport among the American public, with a total revenue of \$9 billion in 2011.⁶ The average quarterback salary in 2011 was \$1.970 million, which was the highest average salary of any position in the NFL.⁷ Given the importance of the quarterback role within the team framework and the financial interests associated with these NFL players, it is important to determine both the ability to RTS and the player's postoperative performance following ACL reconstruction.

The primary purpose of this study was to determine (1) RTS rate in NFL quarterbacks following ACL reconstruction, (2) performance upon RTS, and (3) the difference in RTS and performance between players who underwent ACL reconstruction and controls. The authors hypothesized that NFL players who sustained an ACL tear and underwent reconstruction would have (1) a greater than 90% RTS rate; (2) no difference compared with age-, sex-, performance-, and experience-matched controls; and (3) no statistically significant difference in in-game performance parameters compared with controls.

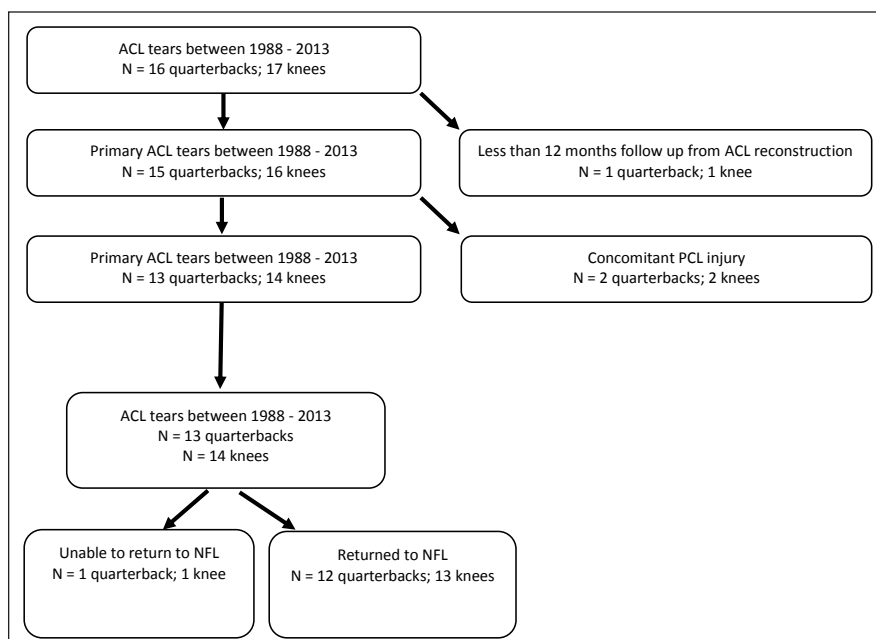


Figure: Flowchart of selection process for inclusion of National Football League (NFL) players. Abbreviations: ACL, anterior cruciate ligament; PCL, posterior cruciate ligament.

Table 1

| Pre-ACL Reconstruction in Cases vs Pre-Index Year in Controls | | | |
|---|-------------|-----------|----------------|
| Preoperative (or Index) Variable | Mean±SD | | P ^a |
| | Study Cases | Controls | |
| Age, y | 27.2±2.39 | 26.8±2.48 | .717 |
| BMI, kg/m ² | 27.4±1.41 | 27.3±0.95 | .897 |
| Seasons NFL experience | 3.77±2.77 | 3.77±2.77 | .999 |
| Games played | 35.2±38.8 | 37.1±20.6 | .890 |
| Games played per season | 7.52±4.45 | 10.5±2.71 | .063 |
| Completions per season | 114±106 | 174±81.4 | .140 |
| Passing attempts | 192±170 | 298±127 | .109 |
| Passing attempts per game | 17.4±11.3 | 25.7±6.70 | .057 |
| Completion % per season | 42.9±17.6 | 57.6±3.92 | .016 |
| Passing yards per season | 1296±1210 | 1992±954 | .139 |
| Passing yards per attempt | 4.38±2.18 | 6.59±0.58 | .005 |
| Passing yards per game | 114±77.8 | 171±50.8 | .061 |
| Passing touchdowns per season | 8.34±8.83 | 11.7±6.35 | .313 |
| Interceptions per season | 5.73±4.41 | 8.52±2.92 | .116 |
| Sacks per season | 13.7±10.9 | 23.3±11.7 | .067 |
| Quarterback passer rating | 51.3±28.1 | 79.7±10.3 | .006 |
| Fumbles per season | 3.20±3.24 | 5.20±2.22 | .114 |

Abbreviations: ACL, anterior cruciate ligament; BMI, body mass index; NFL, National Football League.
^aPaired-samples Student t test.

Table 2

Pre- vs Post-ACL Reconstruction for Cases

| Variable | Mean±SD | | P ^a |
|--------------------------------------|-----------|-----------|----------------|
| | Before | After | |
| Games played per season | 7.52±4.45 | 7.86±4.28 | .655 |
| Completions per season | 114±106 | 126±128 | .950 |
| Passing attempts per season | 192±170 | 206±200 | .935 |
| Passing attempts per game | 17.4±11.3 | 19.7±12.0 | .690 |
| Completion % per season | 42.9±17.6 | 46.2±15.6 | .537 |
| Passing yards per season | 1296±1210 | 1358±1499 | .824 |
| Passing yards per attempt | 4.38±2.18 | 5.07±2.03 | .298 |
| Passing yards per game | 114±77.8 | 126±94.1 | .564 |
| Passing touchdowns per season | 8.34±8.83 | 8.06±10.3 | .860 |
| Interceptions per season | 5.73±4.41 | 5.44±4.57 | .823 |
| Sacks per season | 13.7±10.9 | 10.8±10.4 | .280 |
| Quarterback passer rating per season | 51.3±28.1 | 58.5±25.2 | .386 |
| Fumbles per season | 3.20±3.24 | 2.88±2.07 | .694 |

Abbreviation: ACL, anterior cruciate ligament.
^aPaired-samples Student t test.

Table 3

Pre- and Post-Index Year for Controls

| Variable | Mean±SD | | P ^a |
|--------------------------------------|-----------|-----------|----------------|
| | Before | After | |
| Games played per season | 10.5±2.71 | 6.41±5.26 | .017 |
| Completions per season | 174±81.4 | 146±100 | .012 |
| Passing attempts per season | 298±127 | 239±159 | .008 |
| Passing attempts per game | 25.7±6.70 | 24.1±11.2 | .059 |
| Completion % per season | 57.6±3.92 | 55.8±6.35 | .023 |
| Passing yards per season | 1992±954 | 1198±1296 | .017 |
| Passing yards per attempt | 6.59±0.58 | 4.35±3.11 | .022 |
| Passing yards per game | 171±50.8 | 107±98.9 | .035 |
| Passing touchdowns per season | 11.7±6.35 | 6.87±7.60 | .007 |
| Interceptions per season | 8.52±2.92 | 4.77±4.59 | .009 |
| Sacks per season | 23.3±11.7 | 12.7±12.6 | .015 |
| Quarterback passer rating per season | 79.7±10.3 | 53.5±37.9 | .020 |
| Fumbles per season | 5.20±2.22 | 3.64±3.93 | .485 |

^aPaired-samples Student t test.

Internet-based injury reports, player profiles/biographies, and press releases. The search was conducted by an orthopedic surgery resident (B.J.E.) and a board-eligible orthopedic surgeon in sports medicine fellowship training (J.D.H.). All players who met the inclusion criteria were included in this study. A player was deemed to RTS if he played in any NFL game after surgery. A player did not RTS if he did not play in any NFL game after surgery. Certain concomitant knee injuries, when known, were deemed acceptable for inclusion, including articular cartilage injury, meniscal tear, and medial or lateral collateral ligament injury (but not both at the same time). The data search was limited to NFL players playing the quarterback position. Additional exclusion criteria included those who sustained bicruciate (ACL and complete posterior cruciate ligament [PCL]) or combined ACL and bicollateral ligament injuries, indicating a more serious knee injury. One quarterback retore his ACL-reconstructed knee. He played 4 seasons prior to retear. The performance statistics from this player were included as if each ACL tear was a separate event. One quarterback was excluded because the tear occurred less than 12 months ago, and 2 were excluded for concomitant PCL injury. One quarterback did not return to the NFL. Therefore, the total number of ACL tears analyzed in this portion of the study was 13 (Figure).

Demographic data were collected and analyzed, including age at injury, body mass index (BMI), months from injury to RTS, side of injury, quarter of the game in which the injury occurred, years played before and after the injury, and whether the player returned to the NFL the season following the injury. Average in-game performance data were also collected and analyzed, including completions per season, pass attempts per season, completion percentage per season, pass attempts per game, yards per season, yards per attempt, yards per game, touchdowns per season, interceptions per season, number of times

MATERIALS AND METHODS

Sixteen NFL quarterbacks (17 knees) who tore their ACL and underwent re-

constructive surgery were identified. These players were discovered through NFL team websites, publicly available

sacked per season, average rating per season, and number of fumbles per season. In-game performance variables were analyzed as an average over the preinjury and post-ACL reconstruction course of the players' careers. In addition, in-game performance variables were analyzed separately in each of the first 4 subsequent seasons after the player returned to the NFL following the injury.

A control group was selected to compare the data to the study group. Controls were matched to study cases based on sex, age, BMI, years of experience in the NFL, and all measured performance variables (Table 1). Anterior cruciate ligament reconstruction occurred at mean of 3.77±2.77 years into a quarterback's NFL career. An index year was designated for controls, analogous to ACL reconstruction year in cases, as a matched reference year (relative to years' experience in the NFL) to compare post-ACL reconstruction or post-index year performance. Hence, if a quarterback tore his ACL 4 years into his career, a control was selected with an index year of 4 years into his career. Demographic data (BMI, age, years in the NFL) and in-game performance data were collected and analyzed over the course of their career before and after the index year (each season analyzed individually and collectively).

Single-variable analyses for all continuous variables (performance measures) within groups were performed using Student *t* tests. One-sample Kolmogorov-Smirnov goodness-of-fit tests for Gaussian data distribution were performed and confirmed normality of all data. Comparisons between study and control groups were made using paired-sample Student *t* tests. Comparisons were made between study cases and controls for survival in the NFL and each individual parameter's overall mean (all years before and all years after ACL reconstruction [or index year]), and each individual year (up to 4 years) following ACL reconstruction (or index year in controls). Bonferroni correction was used to determine significance

Table 4

| Post-ACL Reconstruction in Cases vs Post-Index Year in Controls | | | |
|---|-------------|-----------|----------------|
| Postoperative (or Index) Variable | Mean±SD | | P ^a |
| | Study Cases | Controls | |
| Seasons NFL experience | 4.85±2.70 | 3.85±3.69 | .354 |
| Games played | 39.9±31.7 | 34.2±32.9 | .648 |
| Games played per season | 7.86±4.28 | 6.41±5.26 | .417 |
| Completions per season | 126±128 | 146±100 | .727 |
| Passing attempts per season | 206±200 | 239±159 | .711 |
| Passing attempts per game | 19.7±12.0 | 24.1±11.2 | .451 |
| Completion % per season | 46.2±15.6 | 55.8±6.35 | .144 |
| Passing yards per season | 1358±1499 | 1198±1296 | .766 |
| Passing yards per attempt | 5.07±2.03 | 4.35±3.11 | .490 |
| Passing yards per game | 126±94.1 | 107±98.9 | .604 |
| Passing touchdowns per season | 8.06±10.3 | 6.87±7.60 | .729 |
| Interceptions per season | 5.44±4.57 | 4.77±4.59 | .704 |
| Sacks per season | 10.8±10.4 | 12.7±12.6 | .670 |
| Quarterback passer rating | 58.5±25.2 | 53.5±37.9 | .698 |
| Fumbles per season | 2.88±2.07 | 3.64±3.93 | .447 |

Abbreviations: ACL, anterior cruciate ligament; NFL, National Football League.
^aPaired-samples Student *t* test.

Table 5

| Cases vs Controls: Year One | | | |
|-----------------------------------|-------------|-----------|----------------|
| Postoperative (or Index) Variable | Mean±SD | | P ^a |
| | Study Cases | Controls | |
| Completions per season | 122±136 | 177±135 | .359 |
| Completion % per season | 58.5±6.50 | 56.6±5.55 | .483 |
| Passing attempts per season | 197±208 | 281±205 | .360 |
| Passing attempts per game | 19.6±11.0 | 23.6±13.5 | .454 |
| Passing yards per season | 1407±1570 | 2152±1720 | .305 |
| Passing yards per attempt | 6.71±1.41 | 6.64±1.06 | .911 |
| Passing yards per game | 140±93.1 | 167±106 | .525 |
| Passing touchdowns per season | 8.23±10.3 | 13.0±10.7 | .305 |
| Interceptions per season | 5.31±5.53 | 6.56±5.68 | .612 |
| Sacks per season | 11.4±12.5 | 20.9±14.7 | .118 |
| Quarterback passer rating | 75.6±23.3 | 82.6±11.5 | .362 |
| Fumbles per season | 2.62±2.53 | 5.67±3.94 | .038 |

^aPaired-samples Student *t* test.

in the setting of multiple comparisons. All statistical analyses were performed using PASW Statistics Student Version 18.0.0 (Chicago, Illinois).

Table 6

| Cases vs Controls: Year Two | | | |
|-----------------------------------|-------------|-----------|----------------|
| Postoperative (or Index) Variable | Mean±SD | | P ^a |
| | Study Cases | Controls | |
| Completions per season | 146±137 | 125±70.3 | .667 |
| Completion % per season | 56.4±23.4 | 62.1±4.93 | .516 |
| Passing attempts per season | 246±230 | 202±117 | .596 |
| Passing attempts per game | 20.7±14.8 | 24.6±11.6 | .551 |
| Passing yards per season | 1724±1668 | 1357±808 | .534 |
| Passing yards per attempt | 5.89±2.51 | 6.63±0.76 | .438 |
| Passing yards per game | 138±107 | 167±90.2 | .542 |
| Passing touchdowns per season | 11.3±12.1 | 7.50±4.31 | .356 |
| Interceptions per season | 7.73±8.36 | 6.00±3.16 | .541 |
| Sacks per season | 13.5±12.4 | 14.5±9.43 | .844 |
| Quarterback passer rating | 75.4±24.7 | 81.5±8.90 | .519 |
| Fumbles per season | 3.64±3.78 | 4.00±2.27 | .812 |

^aPaired-samples Student t test.

Table 7

| Cases vs Controls: Year Three | | | |
|-----------------------------------|-------------|-----------|----------------|
| Postoperative (or Index) Variable | Mean±SD | | P ^a |
| | Study Cases | Controls | |
| Completions per season | 166±136 | 155±128 | .870 |
| Completion % per season | 51.2±20.2 | 59.8±4.43 | .255 |
| Passing attempts per season | 272±212 | 254±200 | .855 |
| Passing attempts per game | 25.3±14.2 | 22.8±11.0 | .681 |
| Passing yards per season | 2007±1770 | 1817±1490 | .812 |
| Passing yards per attempt | 5.67±2.95 | 7.28±1.09 | .165 |
| Passing yards per game | 177±106 | 163±79.1 | .755 |
| Passing touchdowns per season | 13.0±13.2 | 9.25±8.40 | .495 |
| Interceptions per season | 7.50±5.02 | 8.00±6.70 | .858 |
| Sacks per season | 16.8±13.3 | 17.1±15.9 | .963 |
| Quarterback passer rating | 70.5±30.3 | 83.7±20.7 | .311 |
| Fumbles per season | 3.40±3.37 | 5.00±4.41 | .395 |

^aPaired-samples Student t test.

RESULTS

Thirteen quarterbacks (14 knees) with ACL tears who underwent reconstruction met inclusion criteria and were analyzed. Twelve (92%) quarterbacks (13 knees) were able to RTS in the NFL.

Quarterbacks returned to the NFL at a mean of 13±3.9 months following their ACL tear. Mean length of career in the NFL following ACL reconstruction was 4.8±2.7 years. Five (42%) of these quarterbacks are still active in the NFL. An-

terior cruciate ligament tears occurred most commonly in the second quarter (57%).

Prior to ACL reconstruction (or index year in controls), quarterbacks who tore their ACL and matched controls had no statistically significant differences in any demographic or performance variable (Table 1). Following ACL reconstruction, quarterbacks showed no significant differences in any of the measured in-game performance variables vs preinjury (Table 2). Likewise, following the index year in controls (Table 3), quarterbacks showed no significant difference in any of the in-game performance variables from pre-index year. Following ACL reconstruction (or index year in controls), there were no significant differences in any of the measured in-game performance variables between study cases and controls as an average over the remainder of their career (Table 4). For each individual year following ACL reconstruction (or index year in controls), there were no significant differences in any of the measured in-game performance variables between study cases and controls (Tables 5-8).

DISCUSSION

The purpose of this study was to determine (1) RTS rate in NFL quarterbacks following ACL reconstruction, (2) performance upon RTS, and (3) the difference in RTS and performance between players who underwent ACL reconstruction and controls. The authors hypothesized that NFL players who sustained an ACL tear and underwent reconstruction would have (1) greater than a 90% RTS rate, (2) no statistically significant decrease in in-game performance parameters, and (3) no difference between age-, sex-, BMI-, and experience-matched control players. The study hypotheses were confirmed because there was a 92% rate of RTS in NFL quarterbacks, with no statistically significant decrease in in-game performance parameters from preinjury to postoperatively and no difference in

any measured performance variable between study cases and matched controls.

Anterior cruciate ligament tears are common and serious injuries that, if not reconstructed and rehabilitated properly, can signal the end of a NFL quarterback's career.⁸ With advances in surgical techniques and technology over the past several decades, a greater number of athletes are recovering from, and playing well after, ACL tears and surgical treatment. The current study sought to determine whether NFL quarterbacks are able to return to the NFL and how well they performed after their ACL reconstruction compared with their preinjury level and compared with a matched control group without an ACL tear. The results showed no difference in performance between pre-ACL tear and post-ACL reconstruction in quarterbacks and no difference in performance when compared with matched NFL control quarterbacks. Prior studies have examined various high school, collegiate, and NFL players with all positions grouped together, but this is the first study to analyze quarterbacks specifically.^{9,10} These data are encouraging for current NFL quarterbacks who have sustained, or may sustain, an ACL tear in their career.

In this study, almost 60% of ACL tears in NFL quarterbacks occurred in the second quarter vs 14% in each of the first, third, and fourth quarters. Bradley et al¹¹ examined 209 ACL injuries in NFL players and found that they occurred most frequently in the second quarter. Although their study looked at ACL injuries in all NFL players, quarterbacks were included in the study, and, like the current study, it found the highest rate of ACL injuries occurred in the second quarter. Another study examined ACL tears in National Basketball Association players and found that 40% occurred in the fourth quarter.¹² Although these studies do not prove a link between fatigue and ACL tears, further studies addressing this in more detail are necessary to elucidate this point further.

Table 8

| Cases vs Controls: Year Four | | | |
|-----------------------------------|-------------|-----------|----------------|
| Postoperative (or Index) Variable | Mean±SD | | P ^a |
| | Study Cases | Controls | |
| Completions per season | 221±158 | 165±170 | .533 |
| Completion % per season | 58.3±4.59 | 60.9±14.1 | .655 |
| Passing attempts per season | 364±248 | 273±267 | .523 |
| Passing attempts per game | 28.8±10.4 | 22.4±13.0 | .332 |
| Passing yards per season | 2628±1881 | 1906±2002 | .500 |
| Passing yards per attempt | 6.63±1.40 | 6.83±1.21 | .780 |
| Passing yards per game | 201±94.3 | 154±99.0 | .384 |
| Passing touchdowns per season | 15.4±12.9 | 9.00±9.02 | .302 |
| Interceptions per season | 9.29±6.65 | 7.00±7.33 | .552 |
| Sacks per season | 18.3±12.9 | 19.6±18.9 | .884 |
| Quarterback passer rating | 76.6±20.7 | 84.2±27.1 | .565 |
| Fumbles per season | 4.71±3.55 | 3.57±3.05 | .530 |

^aPaired-samples Student t test.

Strengths of the current study include its case-control comparative design and use of sport-specific performance parameters. In addition, demographic- and performance-matched controls were used as a comparison group. Limitations of the study include the use of publicly available data, which can be subject to observer bias due to anticipated media and/or public scrutiny. However, this method of subject selection has been used in multiple studies in high-level-evidence sports medicine journals.¹²⁻¹⁷ Furthermore, no patient-reported or clinician-measured outcomes were available. This includes general health (eg, Short Form 36) and joint-specific (eg, Knee Society Score) scores. Furthermore, patient satisfaction and personal perception of knee pain, function, and stability were unable to be assessed vs preinjury. These factors may influence RTS performance.

Surgical technique information was unobtainable from publicly available sources, although it can be inferred by the treating surgeon based on preferences expressed in publications and/or presentations. Due to the high-profile

nature of these athletes, they are unable to be easily contacted to assess these outcome measures. Additionally, the rehabilitation program used postoperatively was unavailable. Although only 1 quarterback was unable to RTS in the NFL following ACL reconstruction, the inability to return cannot solely be attributed to ACL injury and surgery because other confounders inevitably coexist. Furthermore, although all performance-based measures were used to compare pre- and postoperative outcomes and between study cases and controls, other intangibles (eg, team leadership, teammate motivation) cannot be assessed for relationships.

CONCLUSION

There is a high rate of RTS in the NFL following ACL reconstruction. In-game performance following ACL reconstruction was not significantly different from preinjury. There was no significant difference in performance between study case and control quarterbacks following ACL reconstruction (or index year in controls).

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