Performance and Return to Sport After Sports Hernia Surgery in NFL Players

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Background: Recognition, diagnosis, and treatment of athletic pubalgia (AP), also known as sports hernia, once underrecognized and undertreated in professional football, are becoming more common. Surgery as the final treatment for sports hernia when nonsurgical treatment fails remains controversial. Given the money involved and popularity of the National Football League (NFL), it is important to understand surgical outcomes in this patient population.

Hypothesis: After AP surgery, players would: (1) return to sport (RTS) at a greater than 90% rate, (2) play fewer games for fewer years than matched controls, (3) have no difference in performance compared with before AP surgery, and (4) have no difference in performance versus matched controls.

Study Design: Cohort study; Level of evidence, 3.

Methods: Internet-based injury reports identified players who underwent AP surgery from January 1996 to August 2015. Demographic and performance data were collected for each player. A 1:1 matched control group and an index year analog were identified. Control and case performance scores were calculated using a standardized scoring system. Groups were compared using paired Student *t* tests.

Results: Fifty-six NFL players (57 AP surgeries) were analyzed (mean age, 28.2 ± 3.1 years; mean years in NFL at surgery, 5.4 ± 3.2). Fifty-three players were able to RTS. Controls were in the NFL longer ($P < .05$) than players who underwent AP surgery (3.8 ± 2.4 vs 3.2 ± 2.1 years). Controls played more games per season ($P < .05$) than post-AP players (14.0 ± 2.3 vs 12.0 ± 3.4 games per season). There was no significant ($P > .05$) difference in pre- versus post-AP surgery performance scores and no significant ($P > .05$) difference in postoperative performance scores versus controls post-index.

Conclusion: There was a high RTS rate after AP surgery without a significant difference in postoperative performance, though career length and games per season after AP surgery were significantly less than that of matched controls.

Keywords: hip; groin; sports hernia; athletic pubalgia; core muscle injury

Groin injuries in professional football players are a common source of lost playing time and decreased performance.[39] The differential diagnosis of groin pain may involve osseous, static soft tissue, dynamic soft tissue, or neuromechanical structures.[10] These injuries may include structures in and around the hip joint, the pelvis, and the lumbosacral spine and may include one or more pathomorphologies accounting for the athlete's symptoms. Athletic pubalgia (AP) (also known as sports hernia, core muscle injury, Gilmore groin, or sportsman groin) is a common cause of groin pain in the National Football League (NFL).[20] The injury mechanism may involve hyperabduction of the thigh with associated trunk hyperextension, which produces shear forces to the pubic symphysis and surrounding musculature.[13,25] The injury may be acute trauma or chronic overuse microtrauma.

In 2015, a survey presenting 2 "typical, straightforward" cases of groin pain was sent to 23 experts for diagnosis, resulting in 9 different terms used as the likely diagnosis

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for the first case and 11 different terms for the second case.[39] This high variation in terms prompted the "Doha agreement meeting on terminology and definitions in groin pain in athletes" to establish guidelines regarding the diagnosis of groin pain in athletes.[37,38] The diagnosis is primarily based on physical examination and leads to 3 categories of groin pain: (1) adductor-related, iliopsoas-related, and pubic-related groin pain (or AP); (2) hip-related groin pain; and (3) other causes of groin pain in athletes (ie, intra-abdominal, nerve entrapment, genitourinary). The cause of AP emanates from the anterior and medial hip and abdominopelvic musculotendinous units. These structures are variable and highly intricate, leading to an often misunderstood, underrecognized, and undertreated entity.[21] The Manchester consensus statement described 5 physical examination findings, of which 3 must be present for diagnosis: (1) pinpoint tenderness over the pubic tubercle at the point of insertion of the conjoint tendon, (2) palpable tenderness over the deep inguinal ring, (3) pain or dilation of the external ring with no hernia, (4) pain at origin of adductor longus tendon, and (5) dull, diffuse groin pain.[9,30] Additionally, others report magnetic resonance imaging as a useful modality for diagnosis of AP.[17]

Treatment of AP begins with a nonoperative approach (rest, activity modification, anti-inflammatory medication, heat, ice, deep massage, and an AP physical therapy program with modalities).[25] Failure of nonsurgical treatment may be an indication for surgery. Electing surgery as the final treatment for sports hernia remains controversial. Primary repair, as described by Meyers et al,[24] tightens the attachments around the pubis through imbrication in the inferolateral border of the rectus abdominis to the pubis and inguinal ligament. It has also been described that the adductor compartment has a relative compartment syndrome at the time of the procedure due to the weakness of the abdominal musculature, thus requiring a release of the epimysium and debridement of fibrosis in the adductor musculature. This report, in combination with additional studies using an open or minimal repair technique, has indicated a rate of return to competitive sports from 80% to 97%.[1,14,19,26,29,31,34,36] Laparoscopic treatment has recently offered less invasive surgery with rapid return to sport (RTS). Using this technique, RTS occurred within 4 to 8 weeks in 87% to 97% of surgeries involving athletes.[3,18,32,35] Radiofrequency denervation of the inguinal nerve and inguinal ligament as both a primary treatment and for refractory pain after prior AP surgery has recently been described in athletes, with encouraging results up to 6 months postprocedure.[8]

With a total revenue expected to surpass 13 billion dollars in 2016, the NFL is recognized as one of the most popular professional sports leagues in America.[4] The average NFL player makes 1.9 million dollars annually, as reported in 2013.[23] Given the amount of money involved and the popularity of the sport, it is important to understand surgical outcomes in this patient population. The primary purpose of this study was to determine (1) the RTS rate in NFL players after AP surgery, (2) pre- and postoperative performance, (3) postoperative performance compared with matched controls, and (4) postsurgery career length and games per season. We hypothesized that NFL players who underwent AP surgery would (1) RTS at a greater than 90% rate, (2) have no difference in performance compared with before AP surgery, (3) have no difference in performance versus matched controls, and (4) play fewer games for fewer years than matched controls because of the athlete dealing with reinjury or chronic injury.

METHODS

A series of Google searches was performed by 2 authors in August 2016 to identify NFL players who underwent AP surgery, also known as sports hernia surgery (Figure 1).

The 5 search phrases paired with each NFL team included the following: "athletic pubalgia," "osteitis pubis," "sports hernia," "groin injury," and "core muscle injury." Internet-based injury reports, press releases, and player profiles were used to identify players who underwent surgery. All information was publicly available and not extracted from the NFL Orthopedic Surgery Outcomes Database. Players were included if they were found to have AP surgery as reported by at least 2 separate online sources (including but not limited to profootballreference.com, ESPN.com, prosportstransactions.com, and local news reports). Players were excluded from the study if they did not play in the NFL for at least 1 full season prior to surgery. Players were also excluded if they did not have 1 full season of follow-up since the date of surgery. Surgeries that were isolated central or peripheral compartment hip procedures, unspecified hernia surgeries, or abdominal/inguinal hernia surgeries were excluded. In addition, online reports that were conflicting, incomplete, or did not have a date of surgery were also excluded from the study. Players who underwent AP surgery combined with hip arthroscopy were not excluded.

After application of exclusion criteria, the remaining AP surgeries included in the study ranged from February 2003 to August 2015. The search intended to determine the location of each surgery, but in the majority of reports, information on treating surgeon and location was poor. Statistics were collected from profootballreference.com for each of the players identified, including position, age, years of experience, and performance data specific to the player's position before and after the surgery (Appendix 1). Statistics were collected for regular-season NFL games only. Players were categorized by their positions, including quarterback (QB), running back (RB), tight end (TE), wide receiver (WR), offensive lineman (OL), defensive lineman (DL), linebacker (LB), defensive back (DB), kicker (K), or punter (P).

Control Group

A control group was selected to compare data with the study group. Controls were matched to study cases based on position, age, years of experience, and performance data prior to the surgery date. Ages and years of experience for control players were always within 3 years (most frequently within 1 year) of the case players. Total career statistics were used for performance data for each case and control. Each control was given an index date, which matched the case player's surgery date. For example, if a player had AP

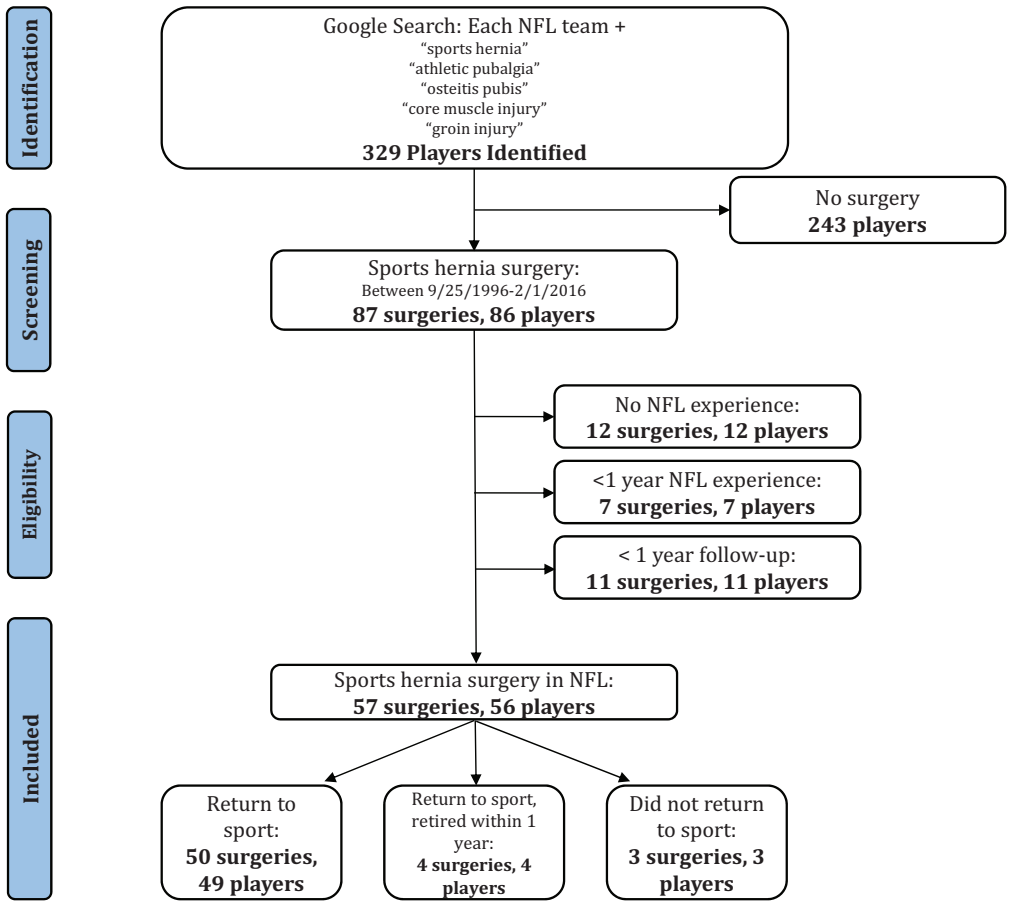

Figure 1. Flowchart illustrating application of exclusion criteria.

surgery on August 1, 2008, the control's index date was assigned as August 1, 2008. Demographic and performance data specific to each control's playing position were collected and categorized as pre- or postindex data.

Player statistics for cases pre- and postsurgery and controls pre- and postindex were collected and aggregated. Each statistical category was divided by games played to account for discrepancies in number of games played per season. A player's performance score (Appendix 2) was then calculated by using a previously published and standardized scoring system based on metrics important to the player's specific position.[6,16,22] The scoring system is much like current fantasy football scoring systems. For example, a running back would receive 6 points per touchdown and one-tenth of a point for each rushing or receiving yard. Statistics per game were used to calculate each performance score per game, which was defined as "performance score." RTS was defined as a player playing in a regular-season NFL game after surgery.

Statistical Analysis

There were 3 groups excluded from statistical analysis. First, positions without previously defined performance scores (punters, kickers, and offensive lineman) were excluded from statistical analysis (n = 11). Second, players who returned to sports but retired without a full year of statistics were excluded from statistical analysis (n = 4). Third and finally, players who did not RTS were excluded from statistical analysis (n = 3). The first 2 groups were not excluded from survivor analysis, games per season, and career length analysis. Paired 2-tailed Student *t* tests were used to compare cases and controls for the remaining players (n = 40). Career length was defined by number of seasons with a recorded game after the injury or index date, regardless of whether the player was retired or still active. Comparisons were made between performance statistics pre- and post-AP surgery in cases, pre- and postindex date in controls, and postsurgery and postindex for cases and controls. Statistical significance was defined as $P < .05$.

RESULTS

Fifty-six players (57 AP/sports hernia surgeries) were analyzed (Table 1). One player had 2 sports hernia surgeries (of unknown laterality) greater than 2 years apart. The performance statistics for this player were included as if each surgery was a separate event. Fifty-three (94.7%) players (54 AP/sports hernia surgeries) achieved RTS in the NFL. Four players (4 AP/sports hernia surgeries) achieved RTS in the NFL and ended up playing their last game within 1 year of surgery. The

TABLE 1
Number of Surgeries With Return to Sport (RTS) Numbers by Position[a]

Position	n	RTS, n	RTS, %	RTS, Retired Within 1 Full Season, n
QB	2	2	100	0
RB	4	4	100	0
TE	7	7	100	1
WR	8	8	100	2
DB	11	10	90.9	0
LB	7	6	85.7	0
DL	7	7	100	1
OL	8	7	87.5	0
K	2	2	100	0
P	1	1	100	0
Total	57	54	94.7	4

[a]DB, defensive back; DL, defensive lineman; K, kicker; LB, linebacker; OL, offensive lineman; P, punter; QB, quarterback; RB, running back; TE, tight end; WR, wide receiver.

TABLE 2
Age and Experience for Each Position at Time of Surgery (for Cases) and Index Time (for Controls)[a]

		Age, y			Experience, y		
Position	n	Cases	Controls	*P*	Cases	Controls	*P*
QB	2	28.1 ± 1.3	28.6 ± 2.3	.592	5.3 ± 1.8	5.3 ± 3.2	>.999
RB	4	25.9 ± 1.9	25.3 ± 2.1	.481	3.0 ± 2.1	3.0 ± 2.1	>.999
TE	7	27.0 ± 2.7	27.0 ± 2.4	.924	4.3 ± 2.5	4.3 ± 2.2	.999
WR	8	28.6 ± 3.8	28.4 ± 3.6	.387	5.7 ± 3.5	5.6 ± 3.4	.598
DB	10	27.6 ± 2.2	27.6 ± 2.4	.925	5.0 ± 2.3	4.9 ± 2.2	.678
LB	6	28.5 ± 3.6	28.1 ± 3.4	.458	5.4 ± 3.5	5.1 ± 3.0	.363
DL	7	29.2 ± 2.2	29.7 ± 2.2	.217	6.8 ± 1.9	7.3 ± 2.1	.210
OL	7	27.4 ± 2.7	27.6 ± 2.5	.760	4.5 ± 2.7	4.9 ± 2.4	.513
K	2	32.2 ± 7.1	32.8 ± 6.1	.561	9.3 ± 7.8	9.3 ± 5.0	>.999
P	1	30.1	28.7		3.2	6.2	
Overall	54	28.1 ± 3.0	28.0 ± 2.9	.870	5.2 ± 3.0	5.3 ± 2.7	.469

[a]Values are expressed as mean ± SD. DB, defensive back; DL, defensive lineman; K, kicker; LB, linebacker; OL, offensive lineman; P, punter; QB, quarterback; RB, running back; TE, tight end; WR, wide receiver.

TABLE 3
Preoperative and Preindex Performance Scores for Cases and Matched Controls[a]

		Performance Score ± SD		
Position	n	Cases	Controls	*P* Value
QB	2	11.1 ± 9.7	12.3 ± 1.5	.872
RB	4	9.5 ± 5.9	9.7 ± 2.7	.934
TE	6	4.5 ± 1.9	4.3 ± 2.2	.735
WR	6	6.0 ± 2.8	6.8 ± 3.9	.363
DB	10	4.2 ± 1.3	3.9 ± 1.4	.358
LB	6	3.8 ± 2.4	4.2 ± 1.4	.391
DL	6	3.8 ± 1.5	3.5 ± 0.8	.546

[a]DB, defensive back; DL, defensive lineman; LB, linebacker; QB, quarterback; RB, running back; TE, tight end; WR, wide receiver.

TABLE 4
Mean Games per Season for Cases and Controls Presurgery and Preindex[a]

	Games/Season		
Position	Case Presurgery	Control Preindex	*P* Value
QB	9.1 ± 6.1	7.8 ± 6.0	.042[b]
RB	13.8 ± 1.3	13.9 ± 1.3	.760
TE	15.0 ± 1.7	13.5 ± 2.8	.126
WR	13.6 ± 2.1	14.0 ± 1.2	.605
DB	13.8 ± 1.2	13.9 ± 1.4	.918
LB	13.2 ± 1.7	13.1 ± 3.3	.964
DL	13.6 ± 2.5	13.6 ± 2.3	.996
OL	12.3 ± 4.0	13.5 ± 2.3	.267
K	15.1 ± 0.6	15.7 ± 0.5	.090
P	11.0	10.8	

[a]Values are expressed as mean ± SD. DB, defensive back; DL, defensive lineman; K, kicker; LB, linebacker; OL, offensive lineman; P, punter; QB, quarterback; RB, running back; TE, tight end; WR, wide receiver.
[b]Statistically significant ($P < .05$).

overall 1-year career survival rate of players undergoing AP surgery was 87.7%.

There were no significant differences ($P > .05$) in demographic, performance, and games per season data between cases and matched controls presurgery and preindex, with the exception of games per season for quarterbacks (Tables 2-4).

Players in the control group (3.8 ± 2.4 years) were in the NFL longer ($P < .05$) than players who underwent AP surgery (3.2 ± 2.1 years) after index and surgery date, respectively (Table 5). Players in the control group (14.0 ± 2.3 games per season) played in more games per season ($P < .05$) than players who underwent AP surgery (12.0 ± 3.4).

Twenty-two (69%) of the 32 NFL teams had at least 1 player who underwent AP surgery. The team with the greatest number of players undergoing AP surgery was 8 (14%) players. The most common position to undergo AP surgery was defensive back, with 11 (19%) players (Table 1). Time to RTS was difficult to quantify due to a large number of players (65%) undergoing surgery in the offseason. Comparing case performance scores pre- and postsurgery also yielded no statistically significant differences (Table 6).

There was a statistically significant ($P < .05$) decrease in games per season for tight ends after surgery (Table 7).

Finally, there were no statistically significant differences in performance scores between the cases postsurgery and controls postindex (Table 8).

The time to RTS in players who underwent AP surgery during the season was 119.1 days (range, 26-353 days). For players who underwent AP surgery during the season and did not have surgery within the last month of the season, the time to RTS was 58.3 days (range, 26-286 days). Overall, the total number of AP surgeries has increased over the years (Figure 2).

TABLE 5
Games per Season and Career Length Postsurgery and Postindex for Cases and Controls[a]

		Games/Season			Career Length, y		
Position	n	Cases	Controls	*P* Value	Cases	Controls	*P* Value
QB	2	8.7 ± 4.9	7.7 ± 3.5	.500	5.0 ± 1.4	7.0 ± 4.2	.500
RB	4	10.8 ± 0.7	13.2 ± 2.0	.157	4.5 ± 3.4	4.5 ± 3.4	>.999
TE	7	12.7 ± 3.2	13.3 ± 1.7	.446	3.1 ± 1.8	3.7 ± 2.7	.387
WR	8	11.6 ± 4.0	14.3 ± 1.4	.165	2.5 ± 1.9	3.4 ± 1.5	.056
DB	10	13.6 ± 2.2	14.2 ± 1.9	.400	3.7 ± 2.6	4.3 ± 2.9	.329
LB	6	11.5 ± 3.9	15.0 ± 1.8	.141	2.3 ± 0.8	2.5 ± 1.0	.611
DL	7	12.0 ± 4.7	14.9 ± 2.1	.188	2.2 ± 1.5	2.7 ± 1.2	.218
OL	7	11.8 ± 3.7	13.6 ± 2.4	.191	3.3 ± 2.4	3.7 ± 2.4	.200
K	2	12.7 ± 4.7	16.0 ± 0.0	.500	3.5 ± 2.1	6.5 ± 3.5	.205
P	1	9.4	16.0		5.0	5.0	
Overall	54	12.0 ± 3.4	14.0 ± 2.3	<.001	3.2 ± 2.1	3.8 ± 2.4	.001

[a]Values are expressed as mean ± SD. DB, defensive back; DL, defensive lineman; K, kicker; LB, linebacker; OL, offensive lineman; P, punter; QB, quarterback; RB, running back; TE, tight end; WR, wide receiver.

TABLE 6
Pre- and Postsurgery Performance Scores by Position for Cases[a]

	Performance Score ± SD		
Position	Presurgery	Postsurgery	*P* Value
QB	11.1 ± 9.7	14.5 ± 3.9	.566
RB	9.5 ± 5.9	8.6 ± 4.4	.526
TE	4.5 ± 1.9	3.9 ± 2.0	.304
WR	6.0 ± 2.8	4.9 ± 2.1	.434
DB	4.2 ± 1.3	5.1 ± 0.9	.096
LB	3.8 ± 2.4	2.6 ± 1.1	.129
DL	3.8 ± 1.5	3.1 ± 2.0	.343

[a]DB, defensive back; DL, defensive lineman; LB, linebacker; QB, quarterback; RB, running back; TE, tight end; WR, wide receiver.

TABLE 7
Mean Games per Season Pre- and Postsurgery for Cases[a]

	Games/Season		
Position	Presurgery	Postsurgery	*P*
QB	9.1 ± 6.1	8.7 ± 4.9	.740
RB	13.8 ± 1.3	10.8 ± 0.7	.068
TE	15.0 ± 1.7	12.7 ± 3.2	.022
WR	13.6 ± 2.1	11.6 ± 4.0	.262
DB	13.8 ± 1.2	13.6 ± 2.2	.690
LB	13.2 ± 1.7	11.5 ± 3.9	.429
DL	13.6 ± 2.5	12.0 ± 4.7	.496
OL	12.3 ± 4.0	11.8 ± 3.7	.785
K	15.1 ± 0.6	12.7 ± 4.7	.640
P	11.0	9.4	

[a]Values are expressed as mean ± SD. DB, defensive back; DL, defensive lineman; K, kicker; LB, linebacker; OL, offensive lineman; P, punter; QB, quarterback; RB, running back; TE, tight end; WR, wide receiver.

TABLE 8
Postoperative and Postindex Performance Scores for Cases and Matched Controls[a]

	Performance Score ± SD		
Position	Cases	Controls	*P* Value
QB	14.5 ± 3.9	12.1 ± 1.8	.366
RB	8.6 ± 4.4	9.8 ± 3.9	.075
TE	3.9 ± 2.0	6.1 ± 3.7	.052
WR	4.9 ± 2.1	6.6 ± 4.1	.350
DB	5.1 ± 0.9	5.4 ± 1.1	.542
LB	2.6 ± 1.1	3.8 ± 2.3	.090
DL	3.1 ± 2.0	3.0 ± 1.2	.912

[a]DB, defensive back; DL, defensive lineman; LB, linebacker; QB, quarterback; RB, running back; TE, tight end; WR, wide receiver.

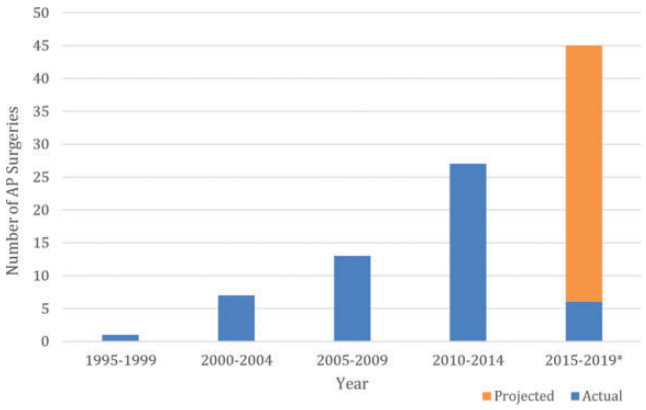

Figure 2. Number of sports hernia surgeries by year in the National Football League (NFL). * = projected.

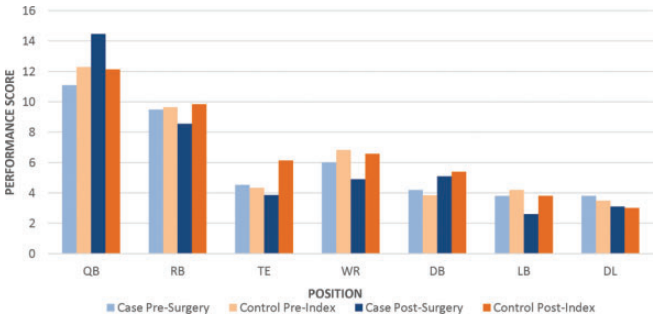

Figure 3. Performance scores by position before and after surgery compared with controls pre- and postindex. DB, defensive back; DL, defensive lineman; LB, linebacker; QB, quarterback; RB, running back; TE, tight end; WR, wide receiver.

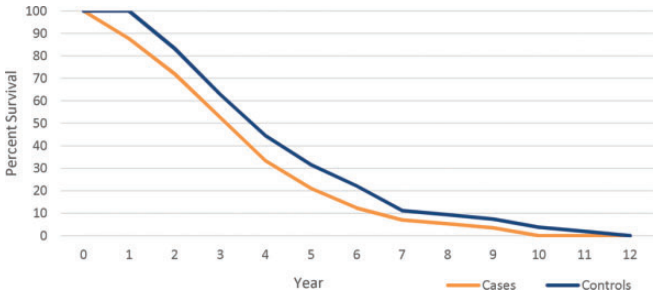

Figure 4. Kaplan-Meier survival analysis for cases and controls. Zero (0) signifies year of surgery for cases and index year for controls.

DISCUSSION

The purpose of this study was to determine (1) the RTS rate in NFL players after AP surgery, (2) performance for players undergoing AP surgery pre- and postsurgery, (3) performance on RTS between players who underwent AP surgery and controls, and (4) postsurgery career length and games per season. The hypotheses were confirmed. There was a 94.7% RTS rate, no statistically significant differences between pre- and postsurgery performance scores, no statistically significant differences between case and control performance numbers, and shortened career length and less games per season when compared with controls.

One previous study investigated RTS and performance for players who underwent AP surgery in the NFL.[22] It showed an RTS rate of 90.2% (n = 51) and no statistically significant differences in performance statistics. It also did not have a true control group, as players were used as controls for themselves. The current study found a similar RTS of 94.7% (n = 57) and no significant differences in performance statistics. By using controls that were matched for age, NFL experience, and performance, the current study was able to improve performance data comparisons for case players against controls at the same juncture of their career. By simply comparing a player with himself, rapid improvements (or regressions) in performance that are prevalent among similar players in the league may otherwise not be accounted for. Furthermore, there may be the same pathology present on the contralateral side similar to that of the surgical side. There may also be a biomechanical relationship between the hip and groin from underlying femoroacetabular impingement (FAI). Birmingham et al,[5] in a cadaver model, observed stress transfer in cam FAI with increasing hip internal rotation imparting increased rotational motion at the pubic symphysis. There may also be a biomechanical relationship to the contralateral side after correction of the ipsilateral pathology.

Prior studies have also failed to comment on specific differences between positions that exist. For example, the defensive back and defensive lineman positions, compared with their respective controls, tend to improve and regress statistically at roughly the same rates (Figure 3).

The RTS rate was high (94.7%); however, there were a large number of players who retired within the next few seasons after surgery and index year (Figure 4).

By year 3 postsurgery, the percentage of players who underwent AP surgery and were still playing was 52.6%. The average career length in the NFL is reported as 6 years for players making the opening-day roster in their rookie season and 3.3 years for all NFL players overall.[33] The average experience for players in this investigation was 5.2 years, already surpassing the overall career length average. The average career length after AP surgery has previously been described as 2.5 years.[22] The current investigation found an average career length of 3.2 years after AP surgery (Table 5). The increase in career length in this investigation compared with that previously reported is likely due to more seasons being included in the current study (an additional 3 NFL seasons). The current investigation found a statistically significant ($P < .05$) difference in career length after surgery and index when comparing cases (3.2 years) with controls (3.8 years). Additionally, players in the control group (14.0 ± 2.3 games per season) played in more games per season postindex ($P < .05$) than players who underwent AP surgery (12.0 ± 3.4 games per season) postsurgery (Table 5).

The majority (65%) of NFL players in this study underwent AP surgery in the offseason, typically just after the previous season. Therefore, the average time to RTS could not be calculated as it would have been inaccurately inflated. Every player who returned to play after surgery in the offseason did so during the first game of the subsequent season. For players who had surgery during the season, the time to RTS was 119 days. For players who underwent surgery during the season and not in the final month of the season, the time to RTS was 58 days.

The amount of AP surgeries has increased significantly over the years (Figure 2). This is possibly due to the increasing awareness of AP in athletes. Because of the nature of the data collection method in this study, it is possible the increase in AP surgeries seen is attributable to the increased availability of injury reports on the Internet.

Limitations and Strengths

Limitations of the study include the use of publicly available data, which may be subject to observer bias and may

not completely contain all patients undergoing AP surgery. As such, we were unable to include player demographics such as height, weight, and body mass index at time of surgery. Nonetheless, this method of data acquisition has been used in multiple previous studies.[2,7,11,12,15,22,27,28] Additional limitations were the absence of patient-reported outcomes, small number of subjects, single sport, incomplete follow-up and career length for players still in the NFL, and inability to compare offensive lineman or special teams players with performance scoring. Additionally, inherent to this type of study, there are multiple unknown confounding variables, such as: underlying hip pathology (FAI or labral pathology) that may or may not have been corrected, unknown presurgical course including unknown conservative treatments, no direct physical contact to corroborate diagnosis or range of motion, and no access to operative reports to determine which operative technique was used. Strengths of this study include its case-control comparative design as well as the performance scoring system, which was used to easily compare across positions. However, the performance scoring system is not a validated outcome measure and is not applicable in all positions.

CONCLUSION

There is a high RTS rate in the NFL after AP/sports hernia surgery. There were no significant differences in performance measures for any position comparing pre– versus post–AP surgery. There were no significant differences in performance measures post–AP surgery compared with controls. Career length and games per season after AP surgery were significantly less than those of matched controls.

REFERENCES

1. Ahumada LA, Ashruf S, Espinosa-de-los-Monteros A, et al. Athletic pubalgia: definition and surgical treatment. *Ann Plast Surg*. 2005;55:393-396.
2. Amin NH, Old AB, Tabb LP, Garg R, Toossi N, Cerynik DL. Performance outcomes after repair of complete Achilles tendon ruptures in National Basketball Association players. *Am J Sports Med*. 2013;41:1864-1868.
3. Azurin DJ, Go LS, Schuricht A, McShane J, Bartolozzi A. Endoscopic preperitoneal herniorrhaphy in professional athletes with groin pain. *J Laparoendosc Adv Surg Tech A*. 1997;7:7-12.
4. Belzer J. Thanks to Roger Goodell, NFL revenues projected to surpass $13 billion in 2016. Forbes. http://www.forbes.com/sites/jasonbelzer/2016/02/29/thanks-to-roger-goodell-nfl-revenues-projected-to-surpass-13-billion-in-2016/#2b7847823278. Published February 9, 2016. Accessed July 27, 2016.
5. Birmingham PM, Kelly BT, Jacobs R, McGrady L, Wang M. The effect of dynamic femoroacetabular impingement on pubic symphysis motion: a cadaveric study. *Am J Sports Med*. 2012;40:1113-1118.
6. Carey JL, Huffman GR, Parekh SG, Sennett BJ. Outcomes of anterior cruciate ligament injuries to running backs and wide receivers in the National Football League. *Am J Sports Med*. 2006;34:1911-1917.
7. Cerynik DL, Lewullis GE, Joves BC, Palmer MP, Tom JA. Outcomes of microfracture in professional basketball players. *Knee Surg Sports Traumatol Arthrosc*. 2009;17:1135-1139.
8. Comin J, Obaid H, Lammers G, Moore J, Wotherspoon M, Connell D. Radiofrequency denervation of the inguinal ligament for the treatment of 'Sportsman's Hernia': a pilot study. *Br J Sports Med*. 2013;47:380-386.
9. Dimitrakopoulou A, Schilders E. Sportsman's hernia? An ambiguous term. *J Hip Preserv Surg*. 2016;3:16-22.
10. Draovitch P, Edelstein J, Kelly BT. The layer concept: utilization in determining the pain generators, pathology and how structure determines treatment. *Curr Rev Musculoskelet Med*. 2012;5:1-8.
11. Erickson BJ, Harris JD, Cvetanovich GL, et al. Performance and return to sport after anterior cruciate ligament reconstruction in male Major League Soccer players. *Orthop J Sports Med*. 2013;1:2325967113497189.
12. Erickson BJ, Harris JD, Heninger JR, et al. Performance and return-to-sport after ACL reconstruction in NFL quarterbacks. *Orthopedics*. 2014;37:e728-e734.
13. Farber AJ, Wilckens JH. Sports hernia: diagnosis and therapeutic approach. *J Am Acad Orthop Surg*. 2007;15:507-514.
14. Hackney RG. The sports hernia: a cause of chronic groin pain. *Br J Sports Med*. 1993;27:58-62.
15. Harris JD, Erickson BJ, Bach BR Jr, et al. Return-to-sport and performance after anterior cruciate ligament reconstruction in National Basketball Association players. *Sports Health*. 2013;5:562-568.
16. Hsu WK. Performance-based outcomes following lumbar discectomy in professional athletes in the National Football League. *Spine*. 2010;35:1247-1251.
17. Khan W, Zoga AC, Meyers WC. Magnetic resonance imaging of athletic pubalgia and the sports hernia: current understanding and practice. *Magn Reson Imaging Clin N Am*. 2013;21:97-110.
18. Kluin J, den Hoed PT, van Linschoten R, IJzerman JC, van Steensel CJ. Endoscopic evaluation and treatment of groin pain in the athlete. *Am J Sports Med*. 2004;32:944-949.
19. Kumar A, Doran J, Batt ME, Nguyen-Van-Tam JS, Beckingham IJ. Results of inguinal canal repair in athletes with sports hernia. *J R Coll Surg Edinb*. 2002;47:561-565.
20. Larson CM, Sikka RS, Sardelli MC, et al. Increasing alpha angle is predictive of athletic-related "hip" and "groin" pain in collegiate National Football League prospects. *Arthroscopy*. 2013;29:405-410.
21. Lovell G. The diagnosis of chronic groin pain in athletes: a review of 189 cases. *Aust J Sci Med Sport*. 1995;27(3):76-79.
22. Mai HT, Alvarez AP, Freshman RD, et al. The NFL Orthopaedic Surgery Outcomes Database (NO-SOD): the effect of common orthopaedic procedures on football careers. *Am J Sports Med*. 2016;44:2255-2262.
23. Manfred T. Two charts that expose how badly NFL players get paid. Business Insider. http://www.businessinsider.com/charts-expose-how-badly-nfl-players-get-paid-2013-9. Accessed August 27, 2016.
24. Meyers WC, Foley DP, Garrett WE, Lohnes JH, Mandlebaum BR. Management of severe lower abdominal or inguinal pain in high-performance athletes. PAIN (Performing Athletes with Abdominal or Inguinal Neuromuscular Pain Study Group). *Am J Sports Med*. 2000;28:2-8.
25. Minnich JM, Hanks JB, Muschaweck U, Brunt LM, Diduch DR. Sports hernia diagnosis and treatment highlighting a minimal repair surgical technique. *Am J Sports Med*. 2011;39:1341-1349.
26. Muschaweck U, Berger L. Minimal repair technique of sportsmen's groin: an innovative open-suture repair to treat chronic inguinal pain. *Hernia*. 2010;14:27-33.
27. Namdari S, Baldwin K, Anakwenze O, Park MJ, Huffman GR, Sennett BJ. Results and performance after microfracture in National Basketball Association athletes. *Am J Sports Med*. 2009;37:943-948.
28. Namdari S, Scott K, Milby A, Baldwin K, Lee GC. Athletic performance after ACL reconstruction in the Women's National Basketball Association. *Phys Sportsmed*. 2015;39:36-41.
29. Polglase AL, Frydman GM, Farmer KC. Inguinal surgery for debilitating chronic groin pain in athletes. *Med J Aust*. 1991;155:674-677.
30. Sheen AJ, Stephenson BM, Lloyd DM, et al. "Treatment of the sportsman's groin": British Hernia Society's 2014 position statement based

on the Manchester Consensus Conference. *Br J Sports Med*. 2014; 48:1079-1087.
31. Smedberg SG, Broomé AE, Elmér O, Gullmo A. Herniography: a diagnostic tool in groin symptoms following hernial surgery. *Acta Chir Scand*. 1986;152:273-277.
32. Srinivasan A, Schuricht A. Long-term follow-up of laparoscopic preperitoneal hernia repair in professional athletes. *J Laparoendosc Adv Surg Tech A*. 2002;12:101-106.
33. Statista. Average playing career length in the National Football League (in years). http://www.statista.com/statistics/240102/average-player-career-length-in-the-national-football-league/. Accessed August 31, 2016.
34. Steele P, Annear P, Grove JR. Surgery for posterior inguinal wall deficiency in athletes. *J Sci Med Sport*. 2004;7:415-421.
35. Susmallian S, Ezri T, Elis M, Warters R, Charuzi I, Muggia-Sullam M. Laparoscopic repair of "sportsman's hernia" in soccer players as treatment of chronic inguinal pain. *Med Sci Monit*. 2004;10: CR52-CR54.
36. Van Der Donckt K, Steenbrugge F, Van Den Abbeele K, Verdonk R, Verhelst M. Bassini's hernial repair and adductor longus tenotomy in the treatment of chronic groin pain in athletes. *Acta Orthop Belg*. 2003;69:35-41.
37. Weir A, Brukner P, Delahunt E, et al. Doha agreement meeting on terminology and definitions in groin pain in athletes. *Br J Sports Med*. 2015;49:768-774.
38. Weir A, Hölmich P, Schache AG, Delahunt E, de Vos RJ. Terminology and definitions on groin pain in athletes: building agreement using a short Delphi method. *Br J Sports Med*. 2015;49: 825-827.
39. Zarins B, Moncure A, Wakamatsu MM. Management of severe lower abdominal or inguinal pain in high-performance athletes. *Am J Sports Med*. 2000;28:616-617.

APPENDIX 1

Position	Variables Collected
Quarterback	*Demographic:* Age, experience *Presurgery and postsurgery (and index) variables:* Number of seasons, games *Total, per game, and per season variables collected pre- and postsurgery (and index):* Completions, attempts, completion percentage, passing yards, passing touchdowns, interceptions, sacks, fumbles, rushing yards, rushing touchdowns
Running back	*Demographic:* Age, experience *Presurgery and postsurgery (and index) variables:* Number of seasons, games *Total, per game, and per season variables collected pre- and postsurgery (and index):* Rushing attempts, rushing yards, rushing yards per attempt, rushing touchdowns, receptions, receiving yards, receiving touchdowns, fumbles
Tight end/wide receiver	*Demographic:* Age, experience *Presurgery and postsurgery (and index) variables:* Number of seasons, games *Total, per game, and per season variables collected pre- and postsurgery (and index):* Receptions, receiving yards, receiving yards per reception, receiving touchdowns, fumbles
Offensive lineman/punter/kicker	*Demographic:* Age, experience *Presurgery and postsurgery (and index) variables:* Number of seasons, games
Defensive back/linebacker/ defensive lineman	*Demographic:* Age, experience *Presurgery and postsurgery (and index) variables:* Number of seasons, games *Total, per game, and per season variables collected pre- and postsurgery (and index):* Tackles, assisted tackles, total tackles, sacks, safeties, interceptions, forced fumbles, touchdowns, passes deflected

APPENDIX 2

Position	Performance Score Formula
Quarterback	(Passing yards ÷ 25) + (Passing touchdowns × 4) + (Rushing yards ÷ 10) + (Rushing touchdowns × 6)
Running back/wide receiver/ tight end	(Receiving yards ÷ 10) + (Receiving touchdowns × 6) + (Rushing yards ÷ 10) + (Rushing touchdowns × 6)
Defensive players	(Tackles) + (Assists ÷ 2) + (Sacks × 4) + (Passes defended) + (Interceptions × 5) + (Interceptions/Fumbles returned for touchdowns × 6) + (Forced fumbles × 3) + (Fumbles recovered × 2) + (Safeties × 2)