

Epidemiology of Operative Procedures in an NCAA Division I Football Team Over 10 Seasons

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Background: Injury rates are high for collegiate football players. Few studies have evaluated the epidemiology of surgical procedures in National Collegiate Athletic Association (NCAA) Division I collegiate football players.

Purpose: To determine the most common surgical procedures performed in collegiate football players over a 10-year period.

Study Design: Descriptive epidemiological study.

Methods: From the 2004-2005 season through the 2013-2014 season, all surgical procedures performed on athletes from a single NCAA Division I college football team during athletic participation were reviewed. Surgeries were categorized by anatomic location, and operative reports were used to obtain further surgical details. Data collected over this 10-season span included type of injury, primary procedures, reoperations, and cause of reoperation, all categorized by specific anatomic locations and position played.

Results: From the 2004-2005 through the 2013-2014 seasons, 254 operations were performed on 207 players, averaging 25.4 surgical procedures per year. The majority of surgeries performed were orthopaedic procedures (92.1%, n = 234). However, there were multiple nonorthopaedic procedures (7.9%, n = 20). The most common procedure performed was arthroscopic shoulder labral repair (12.2%, n = 31). Partial meniscectomy (11.8%, n = 30), arthroscopic anterior cruciate ligament (ACL) reconstruction (9.4% n = 24), and arthroscopic hip labral repair (5.9% n = 15) were the other commonly performed procedures. There were a total of 29 reoperations performed; thus, 12.9% of primary procedures had a reoperation. The most common revision procedure was a revision open reduction internal fixation of stress fractures in the foot as a result of a symptomatic nonunion (33.33%, n = 4) and revision ACL reconstruction (12.5%, n = 3). By position, relative to the number of athletes at each position, linebackers (30.5%) and defensive linemen (29.1%) were the most likely to undergo surgery while kickers (6%) were the least likely.

Conclusion: In NCAA Division I college football players, the most commonly performed surgeries conducted for injuries were orthopaedic in nature. Of these, arthroscopic shoulder labral repair was the most common, followed closely by partial meniscectomy. Nonorthopaedic procedures nonetheless accounted for a sizable portion of surgical volume. Familiarity with this injury and surgical spectrum is of utmost importance for the team physician treating these high-level contact athletes.

Keywords: football; orthopaedic surgery; meniscectomy; labral repair; ACL

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Participation in collegiate football is on the rise. Since 1978, the number of schools participating in National Collegiate Athletic Association (NCAA) football has steadily increased, from 484 in 1978, 524 in 1988, 621 in 2003, and to 773 in 2015.¹¹ The introduction of spring practice has made football more of a year-round sport. Though the total number of spring practices is not large when compared with the number of in-season practices, the increased number of contact activities during spring practice, in addition to year-round strength and conditioning, may increase an athlete's exposure to injury.

Despite advances in equipment technology for bracing and padding, injury rates remain high, particularly in game settings. Multiple descriptive epidemiological studies

have investigated the epidemiology of collegiate football injuries. The most recent data note an incidence of game-related injury ranging from 35.9 to 40.23 injuries per 1000 athlete-exposures (AEs) and 5.77 to 9.6 per 1000 AEs during practices.^{8,13} Spring practice appears to pose a significant injury risk, with multiple studies demonstrating nearly double the injury rate during spring practice as compared with regular fall practices.^{1,5}

Although overall injury rates are well established in the literature, few studies have evaluated the epidemiology of operative procedures a high-level football team may endure. Rechel et al¹² studied high school athletes and found an overall rate of injury requiring surgery of 2.52 per 10,000 AEs (8.65/10,000 AEs during competition and 1.27/10,000 AEs during practice); however, no such data exist for collegiate football to date.

The purpose of this study was to review the operative procedures undergone by athletes in an elite-level NCAA Division I college football team over 10 seasons of play.

METHODS

On approval from our institutional review board, surgical procedures performed on athletes from a single NCAA Division I college football team between 2004 and 2014 were reviewed. Both orthopaedic and nonorthopaedic surgeries over the course of the collegiate football season were included. However, orthopaedic procedures were excluded if they were not a result of an injury that occurred during practices, games, or strength and conditioning training. Over the 10-year period, only 1 procedure was excluded: a forearm laceration.

The surgical data presented were prospectively collected from 2004 to 2014 by the team's head athletic trainer, who documented all injuries and surgical procedures into an electronic database immediately after the procedure. All procedures performed by associated team physicians were crosschecked between the trainer's database and operative reports. All procedures performed by physicians outside the institution were also recorded and cross-referenced with operative notes. Any surgical procedure that occurred after an athlete graduated from the institution or transferred was not included. Surgeries were categorized by anatomic location, and more specifically, by the exact procedure(s) performed. Injuries requiring more than 1 surgical procedure were categorized based on the primary billed procedure; for example, meniscectomies performed in conjunction with an anterior cruciate ligament (ACL) reconstruction were noted separately from an isolated meniscectomy. Knee reconstructions involving 2 or more ligaments were classified as a multiligament injury. Labral tears of the shoulder involving both anterior and posterior elements were noted separately from isolated anterior or posterior tears.

Data collected over this 10-season span included player position, type of injury, primary procedure performed, reoperations, and cause of reoperation. A reoperation was defined as any procedure performed in the same anatomic location as the index procedure. All players listed on the roster of the football team were included in this study.

RESULTS

Overall Surgery Epidemiology

Over 10 seasons, 1050 players participated in team workouts, practices, scrimmages, and games. Of these, 207 players (19.7%) underwent a minimum of 1 surgical procedure, accounting for a total of 254 operations over the study period, averaging 25.4 operations per year. Orthopaedic surgery accounted for 92.1% (n = 234) of surgeries, while 7.9% (n = 20) of surgeries were nonorthopaedic (including cardiac, head and neck trauma, or abdominal surgery). Of note, 6.7% (n = 17) of procedures were performed outside of the institution.

The most common overall procedure performed in college football players was a shoulder labral repair (12.2%, n = 31). For the other most commonly performed procedures, see Table 1.

Surgeries by Pathology

The most common cause of index surgery in these elite football players was due to a ligament injury (24.9%, n = 56). Labrum injuries (20.4%, n = 46), meniscus injuries (13.3%, n = 30), and fractures (13.3%, n = 30) were the other common pathologies that led to surgery. Tendon injuries (5.3%, n = 12), abdominal herniations (4.4%, n = 10), and disc herniations (2.2%, n = 5) were less common. The most common injuries leading to surgery are summarized in Table 2.

Surgeries by Anatomic Location

Knee. Knee surgeries were the most common type of operative procedure performed, accounting for 34.6% (n = 88) of all procedures performed. The most common procedure in the knee was an isolated partial meniscectomy (34.1%, n = 30), the majority of which were lateral (66.7%, n = 20) compared with isolated medial (26.7%, n = 8) or combined medial and lateral (6.7%, n = 2) (Table 3).

Shoulder. Shoulder surgery was the second most common surgery by anatomic location, with a total of 40 procedures in 36 players. The most common procedures performed overall were labral repair for glenohumeral instability (12.2% of total procedures performed, n = 31), of which the majority were anterior labral repairs (67.7%, n = 21). Arthroscopic posterior labral repairs (19.4%, n = 6), open Bristow procedures (6.5%, n = 2), combined anterior and posterior labral repair (3.2%, n = 1), and superior labral anterior posterior (SLAP) repair (3.2%, n = 1) accounted for the rest of the shoulder instability procedures.

Ankle. Ankle surgery was the third most common cause of surgery, with a total of 30 surgeries performed in 23 patients. Arthroscopic debridement was the most common procedure (46.7%, n = 14) and was performed for ankle impingement, low ankle sprains, and synovitis.

Foot. Foot surgery was the fourth most common cause of surgery in our series of college football players, with a total of 24 procedures performed in 19 players. The most common procedure performed was internal fixation of fifth metatarsal fractures (45.8%, n = 11).

TABLE 1
Top 10 Procedures Performed in 10 Seasons of NCAA Division I College Football^a

Surgical Procedure	No.
Shoulder labral repair	31
Partial meniscectomy (isolated)	30
ACL reconstruction	24
Hip labral repair with femoral and acetabular osteoplasty	15
Arthroscopic loose body removal from the knee	15
Arthroscopic ankle debridement	14
Fifth metatarsal ORIF	11
Arthroscopic chondroplasty of the knee	7
Endoscopic hernia repair	6
Thumb ulnar collateral ligament repair	5

^aACL, anterior cruciate ligament; NCAA, National Collegiate Athletic Association; ORIF, open reduction internal fixation.

TABLE 2
Most Common Injuries Leading to Surgery in a Division I College Football Team^a

Surgical Procedure	No.
Shoulder labral repair	31
Meniscus injury	30
ACL tear	24
Hip labral tear	15
Fifth metatarsal fracture	11
Hernia	10
Ankle impingement	7
Ankle sprain	6
Thumb collateral ligament tear	6
Patellar dislocation	5
Ankle fracture	5
Lumbar disc herniation	5

^aACL, anterior cruciate ligament.

Hand. A total of 20 procedures were performed on the hand in 19 players. The majority of these procedures were to repair a finger ligament (40%, n = 8). Specifically, the most common procedure was repair of the ulnar collateral ligament of the thumb (20%, n = 5).

Hip. A total of 19 procedures on the hip were performed on 13 patients. The most common procedure performed was an arthroscopic labral repair, with combined femoral neck and acetabular osteoplasty in 78.9% of cases (n = 15).

Abdomen. The abdomen was the most common location for a nonorthopaedic procedure. A total of 15 abdominal procedures were performed on 12 patients. The most common procedure was an arthroscopic sports hernia repair (40%, n = 6), followed by an open hernia repair (26.7%, n = 4).

Spine. Spinal procedures were relatively uncommon, with a total of 6 procedures performed on 6 patients. The most common procedure was a microdiscectomy between L3 and S1 (83.3%, n = 5).

Miscellaneous Procedures. Several of the procedures performed could not be grouped into anatomic location because of small sample size. The more uncommon procedures include cardiac ablation for hypertrophic

TABLE 3
Most Common Knee Procedures in a Single Division I Football Team^a

Surgical Procedure	No.
ACL reconstruction (with or without meniscectomy)	24
Lateral meniscectomy	20
Loose body removal	15
Medial meniscectomy	8
Chondroplasty with or without microfracture	7
Revision ACL reconstruction	3
Synovectomy	3
Multiligament reconstruction (involving ≥2 ligaments)	2
Medial + lateral meniscectomy	2
Incision and drainage	2
Patella ORIF	1
Medial plica excision	1

^aACL, anterior cruciate ligament; ORIF, open reduction internal fixation.

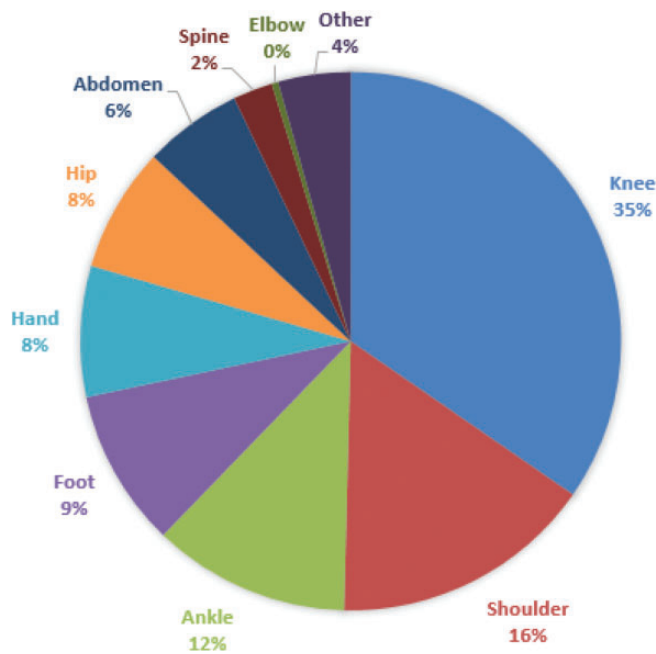


Figure 1. Pie chart representation of percentage of surgeries by anatomic location over 10 seasons of play in a Division I football team.

cardiomyopathy and an arrhythmia (n = 2), fasciotomy of lower leg for compartment syndrome (n = 2), as well as surgery for a larynx fracture (n = 1), zygomatic arch fracture (n = 1), and eye orbit fracture (n = 1). Aggregate surgery data by anatomic location are provided in Figure 1.

Surgeries by Reoperation

The most common orthopaedic reoperations occurred in the foot (20.5%) and knee (20%) (Table 4). After foot surgery, 3 of the 11 stress fractures of the fifth metatarsal underwent

TABLE 4
Primary Surgeries and Reoperations Based on Anatomic Location Over 10 Seasons of Play in a Division I Football Team

Anatomic Location	Surgeries, n	Players Requiring Surgery, n	Reoperations, n	Reoperation Rate, %
Knee	88	70	15	20.5
Shoulder	40	36	2	5.3
Ankle	30	23	3	11.1
Foot	24	19	4	20.0
Hand	20	19	1	5.3
Hip	19	13	2	11.8
Abdomen	15	14	1	7.1
Spine	6	5	0	0.0
Elbow	1	1	0	0.0
Other	11	7	1	10.0
Total	254	207	29	12.9

revision ORIF (27.3%). The only other reoperation performed was a revision ORIF of a navicular stress fracture (100%, n = 1). The majority of reoperations after knee surgery were for loose body removal after previous arthroscopic surgery (14.3%). Additionally, 3 athletes with a history of ACL reconstruction required a revision reconstruction (12.5%).

Most Common Player Positions Requiring Primary Surgery

Positional injuries were stratified by total player exposure over 10 seasons (number of procedures per position/total number of players per position) over this same period (Table 5). Linebackers, defensive linemen, and running backs had the highest incidence of injury requiring operative intervention. Both offensive and defensive linemen alone accounted for close to half of all surgical procedures.

DISCUSSION

Numerous authors have described the epidemiology of football injuries at the high school, collegiate, and professional levels, but little work in the literature has focused on the epidemiology of operative treatment among football players. This study is the first descriptive epidemiologic investigation of operative conditions among an elite Division I football program, noting that nearly 20% of our athletes required operative management for both orthopaedic and nonorthopaedic diagnoses during 10 seasons of play, with a particularly greater rate of surgery in linebackers. Several recent studies have examined the distribution of injuries in high school and collegiate athletes and have reported their data as injury rates per AE. Given these methodologic differences from our study, injury prevalence may not be directly comparable with our study results. Despite these differences, we find the distribution of injuries in these studies to be similar to our findings. In 2011,

TABLE 5
Epidemiology of Operative Injuries Based on Player Position Exposure

Position	Operative Injuries, n	Players at Each Position, n	Players with Operative Injuries, %
Linebacker	36	118	30.5
Defensive lineman	44	151	29.1
Running back	19	69	27.5
Offensive lineman	39	170	22.9
Wide receiver	25	121	20.7
Defensive back	35	199	17.6
Tight end	11	72	15.3
Fullback	7	51	13.7
Quarterback	4	49	8.2
Kicker	3	50	6.0

Rechel et al¹² reported on the epidemiology of injuries requiring surgery from 100 high schools between 2005 and 2010. When examining all high school sports, knee injuries (49.4%) were most common, followed by head/face/mouth injuries (9.7%), and shoulder injuries (8.7%). When evaluating football injuries, the authors again found the knee (44.9%) and shoulder (12.9%) to be most common. This distribution was further corroborated by Shankar et al¹³ and Brophy et al,³ who likewise revealed the preponderance of knee and shoulder injuries in their studies evaluating injury trends in collegiate and professional football players.

The high prevalence of arthroscopic partial meniscectomy in elite football players has been described in previous studies. In 2007, Brophy et al³ examined the surgical histories of all athletes participating in the National Football League (NFL) Combine in 1987 and 2000. The authors found that partial meniscectomy was the most common procedure performed, with an incidence of 10.3 per 100 players evaluated. Partial meniscectomy was also prevalent in our cohort, following only arthroscopic shoulder labral repairs.

Several recent epidemiologic studies have helped elucidate the current epidemiology of shoulder injury in football at the collegiate level. Kaplan et al⁹ reported on the prevalence and variance of shoulder injuries in 336 elite American collegiate football players who were invited to participate in the 2004 NFL Combine. The authors discovered that of all athletes, 50% had a history of shoulder injury and 34% (56 players) had a history of shoulder surgery for injuries sustained during athletic participation. The most commonly performed procedures were anterior instability reconstruction (48%), Mumford/Weaver-Dunn surgery (15%), posterior instability reconstruction (10%), and rotator cuff surgery (12%). Our results are consistent with these study findings: arthroscopic surgery for glenoid labral injury represented the overwhelming majority of shoulder procedures, followed by less common procedures, such as clavicle fixation and acromioclavicular joint reconstruction.

Although shoulder surgeries were less common than knee surgeries, arthroscopic shoulder labral surgery was the most common overall procedure in this cohort. The high incidence of this surgery, particularly in defensive backs, offensive linemen, and defensive linemen, may be related to the high number of tackles, the velocity of tackles, and the position of the arm during tackles. Regardless of the mechanism of injury, shoulder instability can truly impact an athlete's longevity. Brophy et al,⁴ for example, noted a statistically significant reduction in length of player career among NFL players who required operative stabilization for shoulder instability.

Hip surgery represented 19 of 254 procedures performed within our study cohort. The most commonly performed procedures included arthroscopic hip labral repair and arthroscopic femoral neck/acetabular osteoplasty. Although groin pain in the athlete has been poorly understood, femoroacetabular impingement (FAI) is becoming an increasingly recognized cause of pain since its initial description by Ganz et al⁷ in 2003. Several studies have examined the prevalence of FAI in the elite athlete and effects of arthroscopic osteoplasty in the management of this condition. Feeley et al⁶ reported on hip injuries and labral tears in the NFL and revealed that persistent groin pain in this athletic cohort was frequently associated with FAI. Amenabar and O'Donnell² retrospectively examined 36 professional Australian Football League players who underwent arthroscopic FAI treatment and found a 96% return-to-sport rate and global improvement in functional outcome scores. Although these numbers are encouraging, further studies are still required to examine the natural history of this condition and long-term results after surgical intervention. As our understanding of FAI in elite athletes continues to grow, surely too will our understanding of surgical indications and treatment options.

Moreover, our study highlighted the significant morbidity of foot injuries, specifically fractures of the fifth metatarsal. Although these fractures accounted for 38% of all operative foot injuries, they accounted for the majority of the revision surgeries performed in the foot. The proximal metaphyseal/diaphyseal fifth metatarsal fracture presents a challenge to the orthopaedic surgeon, especially with regard to the competitive athlete. This is often ascribed to the tenuous blood supply to the area combined with the significant demands placed on the lower extremity during athletic participation. Low et al¹⁰ reported on 4758 football players who participated in the NFL Combine between 1998 and 2002 and found the incidence of proximal fifth metatarsal fractures to be 1.8%. Nonunion was seen in 7% of the fractures treated surgically and 20% of the fractures treated nonsurgically. Likewise, a questionnaire was sent to all NFL team physicians, and surgical repair with intramedullary screw fixation was the recommended choice for most physicians who treat elite and collegiate football players. The high revision rate of fifth metatarsal surgery deserves further study, and players who sustain this type of injury must be counseled as to the problematic nature of this condition.

Despite the natural preponderance of musculoskeletal injury among football athletes, our study shows that not all

injuries warranting surgery are orthopaedic in nature. Of the 254 operations, 19 (7.48%) were for nonorthopaedic procedures, including hernia repair, appendectomy, facial fracture repair, and surgery for abdominal strain. Although less common, familiarity with these procedures and an understanding of their underlying pathologies are critical for team physicians treating such high-level athletes.

There are several important limitations to this study. First, this study represents a retrospective review of prospectively collected data in a single institution, and our study findings may thus be limited by the common biases frequently seen in retrospective reviews. Injury data over the study period were collected and inputted into the database by a single athletic trainer during this time frame to help ensure that athletes who had surgery outside our institution during their time at the university were included in our database; however, athletes who had surgery after graduation for injuries or conditions arising from their athletic participation would not have been identified with our data collection algorithm.

Neither did the study differentiate between scholarship and nonscholarship players nor did we perform our calculation with respect to total number of athletic exposures. The purpose of this study was to describe the epidemiology of surgeries performed in a single NCAA Division I football team, whose operative indications may not be representative of those at other institutions or at other levels of participation of collegiate football. The collection of information regarding mechanism of injury, athlete demographics (age, height, body mass index), playing conditions (practice vs game), articular supports (bracing vs taping), timing of injury and surgical intervention, and return to play was not performed. Assimilation of such information with our current surgical data would undoubtedly help further our understanding of athletic injury, and further studies investigating such parameters would thus be warranted. Despite these important limitations, our study provides valuable insight into the distribution of surgical procedures in Division I football players from a single institution over a long-term period.

CONCLUSION

Injuries sustained during athletic participation are commonplace among football athletes. The present study reviews conditions requiring operative intervention in an elite NCAA Division I college football team over 10 seasons of play, noting that overall, 19.7% of athletes underwent at least 1 operative procedure during this time period. The vast majority of surgical procedures performed were orthopaedic in nature, with shoulder labral repair and partial meniscectomy as the most commonly performed surgeries. These trends may help institutions identify areas for injury prevention in this athletic population.

REFERENCES

1. Albright JP, Powell JW, Martindale A, et al. Injury patterns in big ten conference football. *Am J Sports Med.* 2004;32:1394-1404.

2. Amenabar T, O'Donnell J. Return to sport in Australian Football League footballers after hip arthroscopy and midterm outcome. *Arthroscopy*. 2013;29:1188-1194.
3. Brophy RH, Barnes R, Rodeo SA, Warren RF. Prevalence of musculoskeletal disorders at the NFL Combine—trends from 1987 to 2000. *Med Sci Sports Exerc*. 2007;39:22-27.
4. Brophy RH, Gill CS, Lyman S, Barnes RP, Rodeo SA, Warren RF. Effect of shoulder stabilization on career length in National Football League athletes. *Am J Sports Med*. 2011;39:704-709.
5. Dick R, Ferrara MS, Agel J, et al. Descriptive epidemiology of collegiate men's football injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train*. 2007;42:221-233.
6. Feeley BT, Powell JW, Muller MS, Barnes RP, Warren RF, Kelly BT. Hip injuries and labral tears in the National Football League. *Am J Sports Med*. 2008;36:2187-2195.
7. Ganz R, Parvizi J, Beck M, Leunig M, Notzli H, Siebenrock KA. Femoroacetabular impingement: a cause for osteoarthritis of the hip. *Clin Orthop Relat Res*. 2003;417:112-120.
8. Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: summary and recommendations for injury prevention initiatives. *J Athl Train*. 2007;42:311-319.
9. Kaplan LD, Flanigan DC, Norwig J, Jost P, Bradley J. Prevalence and variance of shoulder injuries in elite collegiate football players. *Am J Sports Med*. 2005;33:1142-1146.
10. Low K, Noblin JD, Browne JE, Barnhouse CD, Scott AR. Jones fractures in the elite football player. *J Surg Orthop Adv*. 2004;13:156-160.
11. National Football Foundation. Colleges and universities offering football increases to all-time high of 773. <http://www.footballfoundation.org/News/NewsDetail/tabid/567/Article/55373/colleges-and-universities-offering-football-increases-to-all-time-high-of-773.aspx>. Accessed July 23, 2015.
12. Rechel JA, Collins CL, Comstock RD. Epidemiology of injuries requiring surgery among high school athletes in the United States, 2005 to 2010. *J Trauma*. 2011;71:982-989.
13. Shankar PR, Fields SK, Collins CL, Dick RW, Comstock RD. Epidemiology of high school and collegiate football injuries in the United States, 2005-2006. *Am J Sports Med*. 2007;35:1295-1303.