Prevalence and Impact of Glenoid Augmentation in American Football Athletes Participating in the National Football League Scouting Combine

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Background: Bony augmentation of the anterior glenoid is used in athletes with recurrent shoulder instability and bone loss; however, the prevalence and impact of repair in elite American football athletes are unknown.

Purpose: To evaluate the prevalence and impact of glenoid augmentation in athletes invited to the National Football League (NFL) Scouting Combine from 2012 to 2015.

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

Methods: A total of 1311 athletes invited to the NFL Combine from 2012 to 2015 were evaluated for history of either Bristow or Latarjet surgery for recurrent anterior shoulder instability. Athlete demographics, surgical history, imaging, and physical examination results were recorded using the NFL Combine database. Prospective participation data with regard to draft status, games played, games started, and status after the athletes' first season in the NFL were gathered using publicly available databases.

Results: Surgical repair was performed on 10 shoulders in 10 athletes (0.76%), with the highest prevalence in defensive backs (30%; n = 3). Deficits in shoulder motion were exhibited in 70% (n = 7) of athletes, while 40% (n = 4) had evidence of mild glenohumeral arthritis and 80% demonstrated imaging findings consistent with a prior instability episode (8 labral tears, 2 Hill-Sachs lesions). Prospectively, 40% (n = 4) of athletes were drafted into the NFL. In the first season after the combine, athletes with a history of glenoid augmentation were not found to be at significant risk for diminished participation with regard to games played or started when compared with athletes with no history of glenoid augmentation or athletes undergoing isolated shoulder soft tissue repair. After the conclusion of the first NFL season, 60% (n = 6 athletes) were on an active NFL roster.

Conclusion: Despite being drafted at a lower rate than their peers, there were no significant limitations in NFL participation for athletes with a history of glenoid augmentation when compared with athletes without a history of shoulder surgery or those with isolated soft tissue shoulder repair. Glenohumeral arthritis and advanced imaging findings of labral tearing and Hill-Sachs lesions in elite American football players with a history of glenoid augmentation did not significantly affect NFL participation 1 year after the combine.

Keywords: coracoid; glenoid; American football; shoulder instability; augmentation

As the shoulder is the most unstable joint in the body, injuries to the shoulder with resultant glenohumeral dislocation are common in American football athletes.[33,40] Shoulder trauma composes roughly 10% to 20% of injuries in American football, the fourth most common musculoskeletal injury behind hand, knee, and ankle injuries.[27,38] Shoulder injury with resultant dislocation and/or subluxation is often accompanied by a bony avulsion fracture from the anteroinferior glenoid, a "bony Bankart lesion."[14,41] In the presence of bony damage, continued participation places athletes at high risk for recurrent injury, time lost from sport, and long-term damage to the shoulder.[3]

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Bony injury occurs secondary to acute fracturing or attritional bone loss from recurrent episodes of dislocation or subluxation.[4] Because of the high rate of continued instability after nonsurgical management, surgical correction using the Bristow or Latarjet techniques is preferred in elite-level athletes to restore glenohumeral stability and to minimize additional injury and time lost from play.[5,11,16,40] Transfer of the coracoid to the anterior glenoid allows for restoration of the inherent articular arc of the glenoid, helping maintain the humeral head within the glenoid fossa during range of motion, preventing engagement of Hill-Sachs lesions, and effectively restoring stability.[3,34] Compared to the use of structural bone graft or allograft alone, transfer of the coracoid also allows for associated repositioning of the conjoint tendon (short head of the biceps and coracobrachialis), providing increased dynamic stability to the glenohumeral joint, known as the "sling effect."[9]

Elite-level athletes undergoing bony glenoid augmentation have demonstrated high return-to-play rates, with decreased recurrence of shoulder instability. However, no study has analyzed the prevalence and impact after repair in elite American collegiate football athletes. The purpose of this study was to evaluate: (1) the prevalence of glenoid augmentation surgery in American football athletes participating in the National Football League (NFL) Scouting Combine from 2012 to 2015, (2) the prevalence of postoperative limitations in range of motion and strength to the operative shoulder and concurrent shoulder pathology based on imaging, and (3) the prospective participation of athletes with a history of Bristow or Latarjet repair during their first season in the NFL compared to athletes with no history of glenoid bone augmentation and to those with isolated soft tissue augmentation procedures to the shoulder.

METHODS

The study protocol was preapproved by our institutional review board and the NFL Research Committee. Evaluations of 1311 athletes participating in the NFL Scouting Combine from 2012 to 2015 were retrospectively reviewed using the NFL Combine database. Information collected from the database consisted of athlete position, year at the combine, ethnicity, medical and surgical history, radiographic magnetic resonance imaging (MRI) without arthrography and/or computed tomography (CT) findings, along with physical examination results.

Inclusion criteria consisted of athletes with a history of Bristow or Latarjet surgery with physical examination and imaging recorded at the NFL Combine. Athletes were excluded if they had no history of shoulder surgery (n = 1123 athletes) or a history of bony or soft tissue shoulder surgery not consistent with Bristow or Latarjet repair (n = 178 athletes). One athlete was currently undergoing rehabilitation following repair performed 1 month prior to the combine and was excluded, as no physical examination to the operative shoulder was performed.

Surgical history was evaluated for athlete age at the time of glenoid augmentation surgery and time from surgery to participation in the NFL Combine, as well as whether other procedures to the shoulder were performed to address additional pathologies in the operative shoulder. Imaging was assessed by the senior authors and an independent musculoskeletal radiologist at the NFL Combine to evaluate the status of the coracoid bone block and screw integrity, as well as the presence of additional shoulder pathology (presence and location of labral tearing, rotator cuff disease, Hill-Sachs lesions). The extent of arthritic changes in the shoulder was independently graded as stage I (normal), stage II (minimal joint space narrowing), stage III (moderate joint space narrowing), or stage IV (severe loss of joint space with osteophyte formation) by the senior authors using the classification system described by Weinstein et al.[44] Physical examination results were reviewed for the presence of any deficits in shoulder strength (tested in flexion, extension, abduction, external and internal rotation at 90° of abduction, graded subjectively by physicians) or range of motion (tested in flexion, extension, abduction, external and internal rotation at 90° of abduction). Physician's notes on the presence of subjective discomfort, specifically with regard to pain, instability, or laxity to the operative shoulder throughout range of motion, during strength testing, or during practice and game play, were recorded. Prospective information on NFL participation with regard to draft status, along with games played and games started in the first NFL year after the combine, was compared between athletes with a history of glenoid augmentation and all other athletes participating in the NFL Combine from 2012 to 2015 (n = 1303). In addition, NFL participation in athletes with glenoid augmentation was further compared against athletes with a history of isolated shoulder soft tissue repair without bony augmentation or fracture fixation (n = 144 athletes), specifically athletes with a history of labral repair (n = 132), rotator cuff repair (n = 9), and acromioclavicular joint reconstruction (n = 3). Continuous variables were compared using the Student *t* test.

RESULTS

Ten athletes (0.76%; 10 shoulders) who were invited to the NFL Combine from 2012 to 2015 reported a history of glenoid augmentation surgery for recurrent anterior shoulder instability (Table 1). Glenoid augmentation repair was performed in 3 defensive backs (30%), 2 wide receivers (20%), 2 defensive linemen (20%), as well as 1 running back, linebacker, and offensive lineman each. The mean age at the time of surgery was 19.3 years, and surgery was performed an average of 3.2 years prior to participation in the NFL Combine. The cohort consisted of 100% black athletes. No athletes reported any subjective complaints with regard to pain or instability during range of motion, strength testing, or practice or game play after augmentation. One athlete demonstrated 2+ anterior laxity on physical examination; however, he reported no limitations and denied any pain. Two athletes reported a history of surgery to the operative shoulder before glenoid augmentation; however, no athlete reported repeat surgery for continued laxity or episodes of instability after repair and before the combine.

TABLE 1
Overview of Athletes With History of Glenoid Augmentation at the NFL Combine[a]

Athlete	Combine Year	Position	Years From Surgery to Combine	Age at Surgery	Functional Deficits	Recurrent Instability on Exam	OA Grading on X-Ray	Concomitant Pathology on MRI/CT	Prior Shoulder Surgery
1	2012	OL	4	20	Decreased IR 5°	No	Stage 1	+Posterior labral tear	+Labral repair
2	2012	DB	4	21	Decreased ER 20°	No	Stage 2	+Anteroinferior labral tear	+RTC repair
3[b]	2013	WO	2	20	Decreased ER 20°	2+ anterior laxity	Stage 2	+Anterior labral tear	None
4[b]	2013	LB	5	18	Decreased IR 5°	No	Stage 2	No	None
5	2014	RB	4	18	None	No	Stage 2	+Posterior labral tear	None
6	2014	DB	3	21	Decreased IR 20°, abduction 20°	No	Stage 1	+Hill-Sachs lesion, +anterior labral tear	None
7	2014	DL	4	19	None	No	Stage 1	+Hill-Sachs lesion, +anterosuperior labral tear	None
8	2014	DB	1	24	None	No	Stage 1	+Posterior labral tear	None
9	2015	WO	2	21	Decreased ER 5°	No	Stage 1	No	None
10	2015	DL	3	20	Decreased ER 10°	No	Stage 1	+Posterior labral tear	None

[a]CT, computed tomography; DB, defensive back; DL, defensive linemen; ER, external rotation; IR, internal rotation; LB, linebacker; MRI, magnetic resonance imaging; NFL, National Football League; OA, osteoarthritis; OL, offensive linemen; RB, running back; RTC, rotator cuff; WO, wide out.
[b]Evidence of screw breakage on imaging.

When compared to the contralateral shoulder, limitations in range of motion on physical examination were present in 70% (n = 7 athletes), specifically, decreased external rotation (n = 4 athletes; mean, 14°; range, 5°-20°), internal rotation (n = 3 athletes; mean, 10°; range, 5°-20°), and abduction (n = 1 athlete; mean, 20°) (Table 1). No deficits in shoulder strength in the tested planes were appreciated as subjectively graded and recorded by NFL physicians.

All athletes underwent radiographic and MRI evaluation, while only 20% (n = 2) underwent CT evaluation at the combine. Consensus between the 2 senior authors regarding the presence of mild glenohumeral joint space narrowing (stage II) on radiographs was present in 40% (n = 4) of athletes, with the remaining athletes (n = 6) demonstrating no evidence of arthritic changes (stage I). Eighty percent (n = 8) of athletes had evidence of labral tearing, while 20% (n = 2) possessed associated Hill-Sachs lesions based on postoperative imaging obtained at the combine (Table 1). Anatomic alignment of the coracoid on the glenoid rim without evidence of bone block fracture or graft resorption was appreciated on radiographs and MRI examination in all athletes. However, evidence of screw breakage was present in 20% (n = 2) of athletes, with both demonstrating limitations in range of motion (Table 1). In the 2 athletes undergoing CT scan to the shoulder, both demonstrated the coracoid to be flush with the glenoid rim, with evidence of bony healing across the augmentation site and without evidence of lateral overhang or screw breakage.

Athletes with a history of glenoid augmentation were drafted into the NFL (40%; 4/10 athletes) at a lower rate than were athletes without a history of glenoid augmentation (66.6%; 866 drafted of 1301 athletes) or those with a history of isolated soft tissue procedures to the shoulder (68%; 98/144 athletes) (Tables 2 and 3). Athletes with a history of glenoid augmentation did not play ($P = .59$) or start ($P = .12$) in significantly fewer regular-season games compared to athletes who had not undergone shoulder surgery (Table 3). Similarly, athletes with glenoid augmentation did not play ($P = .77$) or start ($P = .12$) in fewer regular-season games compared to athletes with a history of isolated soft tissue shoulder surgery. Following the conclusion of their respective first seasons, 60% (n = 6) of athletes with glenoid augmentation remained on an active NFL roster.

DISCUSSION

Despite the low prevalence of glenoid augmentation surgery present in this cohort of athletes, the true prevalence of shoulder instability secondary to bony Bankart lesions in athletes is likely significantly greater.[32,35,42] However, the presence of shoulder instability in elite American football athletes following shoulder trauma is difficult to determine, as many confounding factors may limit reporting of these injuries, resulting in minimal data available for them. During competition, anterior shoulder instability arises secondary to traumatic dislocation or subluxation of the glenohumeral joint. Injury typically occurs during tackling when the abducted arm is forced into external rotation.[18,32,41,46] When encountered in the open field, these contact forces are greater, increasing the risk for injury and reflective of the high shoulder injury rates observed in defensive backs in this and other studies.[27] Neyton et al[32] found that, after initial dislocation in young athletes secondary to sports-related trauma, 73% had evidence of glenoid bone loss. Meanwhile, in athletes with prior shoulder injury

TABLE 2
Participation in the National Football League (NFL) of Cohort in the Year After the NFL Combine

Athlete	Combine Year	Drafted (Round)	Total NFL Games Played[a]	Total NFL Games Started	Status After Season Conclusion
1	2012	No	0	0	Practice squad
2	2012	No	0	0	Out of league[b]
3	2013	No	0	0	Practice squad
4	2013	Yes (6)	4	0	Active roster
5	2014	No	0	0	Free agent
6	2014	Yes (7)	13	4	Active roster
7	2014	Yes (1)	16	0	Active roster
8	2014	No	12	1	Active roster
9	2015	Yes (3)	16	8	Active roster
10	2015	No	0	0	Active roster

[a]Excluding preseason games.
[b]Retirement.

TABLE 3
Participation Outcomes in Athletes Based on Surgical History[a]

	+Glenoid Augmentation	–Glenoid Augmentation Shoulder Surgery[b]	*P* Value	+Glenoid Augmentation	+Isolated Soft Tissue Repair[c]	*P* Value
Total No. of athletes	10	1301		10	144	
Mean No. NFL regular-season games played	6.2	7.5	.59	6.2	6.9	.77
Mean No. NFL regular-season games started	1.3	2.8	.12	1.3	2.8	.12

[a]NFL, National Football League.
[b]Athletes with or without a history of shoulder surgery, not involving glenoid augmentation (n = 1301).
[c]Athletes with a history of shoulder soft tissue repair (n = 144 athletes: 132, labral repair; 9, rotator cuff repair; 3, acromioclavicular joint reconstruction).

and evidence of recurrent anterior shoulder instability, bony injury has been observed in up to 90%.[42] As such, athletes are at higher risk than the general population for recurrent injury and exacerbation of bony and/or soft tissue damage with continued participation.[8,29,35,37] Moreover, studies have found that young athletes playing contact sports are more prone to recurrent instability in the presence of bony defects measuring >30% of the glenoid width,[35] and as low as 21%,[24] increasing the likelihood of requiring bony reconstruction for continued sports participation.[8]

Shoulder instability in the presence of glenoid bone loss in contact athletes requires surgical repair with bony augmentation to improve clinical outcomes and minimize the potential for recurrent instability.[8,24] Due to the high degree of stress placed on the shoulder during competition, outcomes following nonsurgical management of shoulder injury in contact athletes with glenoid bone loss are suboptimal,[6,15,25,28] with instability rates ranging between 55% and 82% in young male athletes.[36] The current study found that in comparison to athletes undergoing isolated soft tissue shoulder repair, those with glenoid augmentation were not at significant risk for diminished NFL participation in the year after the combine. This finding is likely related to appropriate surgical intervention based on proper assessment of physical examination findings and imaging results in these athletes, as those with glenoid bone loss undergoing isolated soft tissue and/or Bankart repair have been noted to experience poor clinical and functional outcomes.[4,8,9,21,23,24,43] Burkhart and De Beer[8] found that in professional rugby and American football players with glenoid bone loss treated arthroscopically without bony reconstruction, 89% of athletes experienced recurrence of shoulder instability. Bessiere et al[2] reported a 2-fold increase in recurrence of instability following isolated Bankart repair (23.5%) versus open Latarjet (11.7%) in competitive athletes at 5-year follow-up. Furthermore, shoulder stability appeared to decline over time following isolated Bankart repair when compared to coracoid transfer procedures, with failures generally occurring within the first 2 years.[2]

While good outcomes have been reported with both techniques, the Latarjet procedure is preferred by many surgeons for glenoid augmentation.[35] Compared to the Bristow technique, the Latarjet procedure provides a more anatomic reconstruction of the glenoid arc by using a longer segment of the coracoid.[8,17,20] However, as both techniques provide a combination of bony, muscular, and capsular repair, known as the "triple blocking effect," instability rates after repair are significantly lower, yielding high satisfaction and return-to-play rates.[1,8,20]

Other investigations examining limitations after bony repair have reported stiffness and loss of external rotation in up to 89% of patients,[1,39] with multiple studies citing an average loss of 9° to 20° of external rotation.[1,22,26,39] Castagna et al[13] found >15° loss of external rotation in 42.8% of athletes, while Hovelius et al[20] reported a mean loss of 12.4° of external rotation with the arm in the abducted position. Tenotomy of the subscapularis during glenoid exposure has been implicated as a potential cause for the loss in external rotation, shown to persist despite tendon reattachment.[1,20,39] In contrast, multiple authors have reported improved outcomes with splitting of the subscapularis, citing benefit by allowing the tendon to remain functional as an effective sling.[26,30] While screw breakage was discovered in 2 cases in the current study, other reported complications after repair, such as screw migration, fracture, lateral overhang, and nonunion of the coracoid bone block,[1,19,45] were not encountered in any athlete.

No prior study in the literature has reported on the impact of concurrent lesions (labral tears, rotator cuff disease, Hill-Sachs lesions) on the risk of recurrent instability, complications, or time away from sport for rehabilitation following glenoid augmentation. Within the current study cohort, advanced imaging reports noted concurrent pathology in 80% (8 athletes) of the study cohort (labral tearing, n = 8; Hill-Sachs lesions, n = 2). Only Neyton et al,[32] reporting on 34 rugby athletes who underwent Latarjet repair, found that 68% of the athletes demonstrated Hill-Sachs lesions; however, the authors did not comment on outcome comparisons in patients with and without lesions. As such, future studies enrolling large cohorts of athletes after Bristow and Latarjet repair with and without concurrent shoulder pathology are needed to determine if additional injuries effectively have an impact on athlete participation in the NFL.

Concern for late-onset glenohumeral arthrosis following coracoid transfer has been well documented,[35] with continued participation in competitive contact sports representing a serious risk factor for arthritic development and progression.[31] Hovelius et al[20] found the incidence of osteoarthritis at 15-year follow-up to be twice as high in athletes with projecting bone blocks (17%) when compared to well-positioned, flush blocks (8%).[20] Meanwhile, Bouju et al[7] found osteoarthritis in 8.5% of a cohort of 76 patients, including 59 high-level athletes, at a minimum 10-year follow-up. Other reported risk factors for arthritic development include advanced age during first dislocation and surgery, recurrence of instability, presence of arthritis before surgery, presence of rotator cuff disease, lateral overhang of the coracoid, accidental intra-articular screw placement, excessive anterior tightening, and longer follow-up.[1,8,10,12,31,47] Within this study, the average time from surgery to participation in the NFL Combine (3.2 years) likely underestimates the true incidence of glenohumeral arthrosis after reconstruction, warranting longer follow-up within this athletic population given the repetitive trauma placed on the repair following return to sport. It is important to note that the athletes in this cohort demonstrated only mild-to-moderate radiographic findings of arthritis. Athletes with more severe arthritis may not demonstrate the same functional ability; therefore, the results of this study cannot be extrapolated to this group.

This study is not without limitations. The collection of data was retrospective in nature, and history was taken from athletes at a single point in time at the NFL Scouting Combine. Specific details regarding injury mechanisms and the date of injury were infrequently reported and thus not included in the analysis. Moreover, surgery dates and time away from play were likely not precise because of potential recall bias by the athletes. We did not have access to operative reports, limiting information regarding surgical indications, surgical approach, type of repair (Bristow vs Latarjet), whether subscapularis was split or detached, the degree of bony or soft tissue damage, or the incidence of any peri-or postoperative complications. Only 2 athletes underwent CT scan, which at the time of the combine is decided by NFL physicians, preventing thorough assessment of bony union and the presence of potential lateral overhang in the operative shoulder. Furthermore, MRI was performed without arthrography, resulting in a small degree of decreased visibility in assessment of labral integrity in the presence of metal screws. Because of the small sample size of athletes with a history of repair, no meaningful statistical analysis examining for position- or injury-specific predictors for future participation in NFL, such as the presence of screw breakage, osteoarthritis, or concomitant pathology, could be evaluated. Moreover, only athletes with successful augmentation repair, enabling a return to elite-level football, were invited to the NFL Combine and included within the study. Athletes with failed repairs or persistent symptoms limiting optimal performance were likely not invited to the combine, leading to a selection bias within our results and preventing an evaluation of the true success rate of glenoid augmentation in this population. Finally, due to lack of publicly available information, we were unable to prospectively examine athlete data after the combine with regard to recurrent episodes of instability or the development of new or existing shoulder injuries requiring medical or surgical intervention.

While the prevalence of glenoid augmentation in elite American football athletes for anterior shoulder instability remains low, athletes undergoing repair frequently demonstrate limitations in range of motion, with concurrent lesions in the operative shoulder. However, when compared to athletes without a history of glenoid augmentation or those with only soft tissue repair, no significant limitations in games played or started in the season after participation in the NFL Combine were appreciated in athletes with glenoid augmentation and mild-to-moderate degenerative changes on imaging. Regardless, surgeons and team physicians must be aware of the potential for the development of glenohumeral arthritis and associated shoulder pathology after glenoid augmentation in elite-level athletes involved in contact sports. Prospective, long-term studies analyzing the influence of Bristow and Latarjet repair on participation, performance, and career length in NFL players are warranted to better understand the impact of glenoid augmentation in athletes with recurrent anterior shoulder instability.

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