Trends in the Management of Isolated SLAP Tears in the United States

Gregory L. Cvetanovich,* MD, Anirudh K. Gowd,[†] BS, Avinesh Agarwalla,[†] BS, Brian Forsythe,[†] MD, Anthony A. Romeo,[‡] MD, and Nikhil N. Verma,[†§] MD

Investigation performed at Rush University Medical Center, Chicago, Illinois, USA

Background: The management of superior labrum anterior and posterior (SLAP) tears remains controversial, with surgical treatment options including SLAP repair, debridement, and open or arthroscopic biceps tenodesis (BT), based on patient factors and the type of tear.

Hypothesis: We hypothesized that SLAP repair has become less frequently performed over time, while BT is more frequently performed, particularly in patients $\geq$ 40 years.

Study Design: Descriptive epidemiology study.

Methods: A retrospective query was performed using the Humana insurance database from years 2007 to 2016. For the management of a SLAP tear diagnosis (International Classification of Diseases–Ninth Edition [ICD-9] code: 840.7), independent and exclusive cohorts were formed using Current Procedural Terminology (CPT) codes for debridement (29822, 29823), SLAP repair (29807), open or arthroscopic BT (29828, 23430), and SLAP repair combined with BT (29828 OR 23430 AND 29807).

Results: Of 46,650 diagnoses of a SLAP tear, there were 3347 patients who underwent operative management for an isolated SLAP tear from 2007 to 2016. There was a linear increase of SLAP tear diagnoses per year ($r^2 = 0.800$, $P < .001$) during this period. Overall, SLAP repair was performed in 1629 patients (48.7%), debridement was performed in 1076 patients (32.1%), BT was performed in 552 patients (16.5%), and combined SLAP repair and BT was performed in 90 patients (2.7%). There was a 69.3% decrease in isolated SLAP repair from 2007 to 2016 ($r^2 = 0.882$, $P < .001$). BT for the diagnosis of an isolated SLAP tear increased by 370.0% over the same period ($r^2 = 0.800$, $P < .001$). SLAP repair had an equivalent percentage of being performed in patients both older and younger than 40 years ($P = .218$). There was a 1500.0% increase in BT performed in patients older than 40 years during the study period. There were no statistical differences in the postoperative incidence of stiffness, surgical site infections, and reoperations between all surgical treatment groups ($P > .05$).

Conclusion: An analysis of a large private-payer database revealed that surgical treatment of isolated SLAP tears in the United States has shifted from 2007 to 2016, with an increase in the frequency of BT and a decline in the frequency of SLAP repair, particularly in patients older than 40 years.

Keywords: superior labrum anterior and posterior; SLAP tears; bicipital-labral injury

Our understanding of superior labrum anterior and posterior (SLAP) tears has grown substantially since their initial description in 1985.[3,34] SLAP tears are common in overhead athletes in which abduction and maximal external rotation motion of the overhead throw result in such tears via the "peel-back" mechanism.[8,9] Several other mechanisms have been proposed, such as traction forces resulting in inferior subluxation of the humeral head, internal impingement of the labrum with the undersurface of the rotator cuff, and altered biomechanics from posterior capsular contracture.[4,7-9] SLAP tears may also be traumatic or degenerative and represent a common cause of shoulder pain and disability in the general population, with Snyder

et al[33,34] reporting a SLAP tear prevalence of 6% in a series of 2375 patients undergoing shoulder procedures. Since their description, there has been considerable interest in SLAP tears and SLAP repair, with a documented increase in the frequency of SLAP repair from database information spanning multiple centers.[28,39,42]

SLAP tears often occur with concomitant injuries such as rotator cuff tears, posterior labral tears, and Bankart lesions.[33] Treatment in such cases may be predicated on the most prominent defect, but the optimal treatment for managing a SLAP tear is of significant debate, especially with type 2 SLAP tears.[6] Nonoperative management is the initial treatment, as no injury is believed to be countered with acute surgery.[14,17,24] Classically, repair using suture anchors of the superior labrum has been the treatment of choice.[6,10,19] However, SLAP repair results have been quite variable in the literature, ranging from 40% to 94% good to

excellent results and 20% to 94% return-to-play rates.[21] Furthermore, SLAP repair results have been reported to be poor in patients older than 35 to 40 years, in patients with workers' compensation claims, and in patients involved in overhead-throwing sports.[6,12,16,32] An analysis of type 2 SLAP repair in a military population of 179 participants revealed a 37% failure rate, 28% revision rate, and higher chance of failure for patients older than 36 years.[32]

Biceps tenodesis (BT) has been suggested as an alternative treatment for isolated type 2 SLAP tears, with early data showing superior satisfaction and ability to return to sporting activities for BT compared with SLAP repair.[5] Although high-level evidence such as prospective randomized controlled trials is lacking, several other studies of isolated SLAP tears have described similar or superior outcomes for BT compared with SLAP repair, particularly for patients aged between 36 and 40 years.[13,15,22,31] Using a cost-effectiveness model, evidence has even suggested that primary BT was more cost-effective than SLAP repair in a 40-year-old man.[29] Despite the literature from single institutions on the topic in recent years, recent national trends in the United States for the treatment of isolated SLAP tears have not been well described.

The purpose of this study was therefore to provide an updated analysis of trends in the surgical management of SLAP tears in the United States during the years 2007 to 2016 using data from a large private payer database. We hypothesized that for patients with a diagnosis of an isolated SLAP tear, SLAP repair became less frequent over time, whereas BT became more frequent. Furthermore, we hypothesized that age for SLAP repair became younger over time, with BT becoming more common in patients older than 40 years.

METHODS

Database

The present study was a retrospective analysis employing the Humana insurance database available on PearlDiver (http://www.pearldiverinc.com). This database employs insurance records to store data on demographics, comorbidities, diagnoses, and procedures performed. These data are organized by International Classification of Diseases–Ninth Revision and –Tenth Revision (ICD-9 and ICD-10, respectively) diagnosis and procedure codes or Current

TABLE 1
Boolean Search Criteria Used to Construct Cohorts of Surgical Management for Isolated SLAP Tears[a]

	Code
Included diagnosis	
SLAP tear	ICD-9: 840.7
	ICD-10: S43.431A,
	S43.432A, S43.439A
Procedure codes within the above diagnosis	
Debridement alone	CPT: 29822, 29823
SLAP repair	CPT: 29807
Biceps tenodesis	CPT: 29828 OR 23430
SLAP repair combined with biceps tenodesis	CPT: 29807 AND 23430 OR 29828
Procedure codes excluded from each cohort	
Rotator cuff repair	CPT: 29827
Bankart repair	CPT: 29806
Lysis of adhesions/manipulation under anesthesia	CPT: 29825
Distal clavicle excision	CPT: 29824
Loose body removal	CPT: 29819
Partial synovectomy	CPT: 29820
Subacromial decompression	CPT: 29826
Complete synovectomy	CPT: 29821

[a]CPT, Current Procedural Terminology; ICD-9/-10, International Classification of Diseases–Ninth Revision/Tenth Revision; SLAP, superior labrum anterior and posterior.

Procedural Terminology (CPT) codes. Independent databases are compiled from Medicare and private insurers. Data obtained from this database are deidentified and were deemed exempt from institutional review board approval.

Population Cohorts

The present study accessed the Humana database from 2007 to 2016 for all diagnoses of a SLAP tear (ICD-9: 840.7; ICD-10: S43.431A, S43.432A, S43.439A). The Humana database's diagnosis codes for a SLAP tear were combined with CPT procedure codes. Independent and exclusive cohorts were constructed using the following CPT codes: debridement (29822, 29823), SLAP repair (29807), open or arthroscopic BT (29828, 23430), and SLAP repair combined with BT (29828 OR 23430 AND 29807) (Table 1). In all cases, glenohumeral debridement codes (29822,

29823) were allowed in addition to the primary procedure code. Of note, biceps tenotomy is included within the billing code for glenohumeral debridement. Boolean search criteria were used to remove all concomitant shoulder procedures that were coded aside from these. Patient cohorts were adjusted to exclude the following concomitant shoulder procedures: rotator cuff repair (RCR) (29827), Bankart repair (29806), lysis of adhesions (29825), distal clavicle resection (29824), loose body removal (29819), partial synovectomy (29820), subacromial decompression (29826), and complete synovectomy (29821) (Table 1). A separate analysis was performed to analyze the incidence of SLAP repair or BT with concomitant RCR.

Study Outcomes

The population cohorts were analyzed for demographic differences with respect to age, sex, body mass index, smoking status, history of diabetes, and documented Charlson Comorbidity Index. The incidence of each procedure for the diagnosis of a SLAP tear was trended over the years analyzed within the study. The incidence of each procedure was reported as the number of procedures performed in a given year divided by the total number of SLAP tear diagnoses for that year. Specific complications were queried within the database based off ICD diagnosis codes. Specifically, surgical site infections (ICD-9/ICD-10: 998.51, 998.59, 996.66, 996.67, 730.01, 730.21, 730.81, 730.91, 711.01, 711.81, 711.91, 996.60, 996.69, T81.4XXA, K68.11, T81.4XXA, T85.79XA, T84.50XA, T84.60XA, T84.7XXA, T85.79XA, M86.119, M86.219, M86.619, M86.9, M90.819, M00.019, M01.X19) and stiffness (ICD-9/ICD-10: 719.50, M256.0, M256.11, M256.12, M256.19) were common to all procedures, and the postoperative incidence of either was queried within the database.

Statistical Analysis

Statistical analysis was performed using Stata 13.1 (StataCorp). A comparison of continuous variables was performed using 1-way analysis of variance, while categorical variables were performed using the chi-square test of independence. Linear regression was used to identify trends of each treatment modality.

RESULTS

Between 2007 and 2016, there were 46,650 diagnoses of a SLAP tear based on ICD-9 and ICD-10 diagnosis codes, of which 19,485 underwent surgical management of the bicipital-SLAP complex (41.8%). There was a linear increase of 168.6% in SLAP tear diagnoses ($r^2 = 0.800$, $P < .001$) during the study period. After excluding concomitant procedures, there were 3347 cases (7.2%) of surgical treatment for isolated SLAP tears. Overall, SLAP repair was performed in 1629 patients (48.7%), debridement was performed in 1076 patients (32.1%), BT was performed in 552 patients (16.5%), and combined SLAP repair and BT was performed in 90 patients (2.7%).

During the study period, there was a 32.0% decrease in the proportion of SLAP tear diagnoses that underwent operative management with a procedure isolated to the SLAP tear, from 948 to 645 cases per 10,000 diagnoses ($r^2 = 0.750$, $P = .001$) (Figure 1). There was a 69.3% decrease in the proportion of SLAP tear diagnoses managed with SLAP repair ($r^2 = 0.882$, $P < .001$). There was a 16.6% increase in the proportion of diagnoses managed with isolated debridement ($r^2 = 0.105$, $P = .294$) and a 346.7% increase in combined SLAP repair with BT ($r^2 = 0.041$, $P = .574$), although neither had a linear correlation. There was a 370.0% increase in the proportion of diagnoses managed with isolated BT ($r^2 = 0.800$, $P < .001$).

Demographic differences between patients undergoing each operative treatment are summarized in Table 2. Overall, there was a larger percentage of male patients (59.9%) undergoing debridement for SLAP tears versus female patients (40.1%). A pairwise comparison demonstrated that a statistically significantly greater percentage of female patients underwent debridement versus SLAP repair (40.1% vs 29.4%, respectively; $P < .001$) and combined SLAP repair and BT (40.1% vs 22.2%, respectively; $P = .001$). A greater percentage of female patients underwent BT versus SLAP repair (36.4% vs 29.4%, respectively; $P = .003$) and combined SLAP repair and BT (36.4% vs 22.2%, respectively; $P = .012$).

There was a statistically greater proportion of patients older than 40 years who underwent debridement versus SLAP repair (85.3% vs 50.7%, respectively; $P < .001$). A greater proportion of patients who underwent BT were older than 40 years in comparison with debridement (91.1% vs 85.3%, respectively; $P = .001$), SLAP repair (91.1% vs 50.7%, respectively; $P < .001$), and combined SLAP repair and BT (91.1% vs 77.8%, respectively; $P < .001$) (Figure 2). In patients older than 40 years, 40.1% underwent SLAP repair, 37.6% underwent debridement, 19.4% underwent BT, and 2.8% underwent combined SLAP repair and BT. In patients younger than 40 years, 79.2% underwent SLAP repair, 15.2% underwent debridement, 3.8% underwent BT, and 1.8% underwent combined SLAP repair and BT. There was a significantly lesser proportion of patients diagnosed with diabetes in the SLAP repair population compared with all other procedures ($P = .017$). Last, the Charlson Comorbidity Index was significantly less in the SLAP repair population compared with all other procedures ($P < .001$).

A statistically greater proportion of patients older than 40 years underwent debridement, BT, and combined SLAP repair and BT compared with patients younger than 40 ($P < .001$). Only SLAP repair had an equivalent percentage of being performed in patients both younger and older than 40 years ($P = .218$). SLAP repair was the dominant treatment choice for patients aged 10 to 59 years, while debridement was the more common treatment choice patients 60 years and older. The change in age distributions for patients undergoing SLAP repair and BT is shown in Figure 3. Of note, 57.0% of all BT procedures in patients older than 40 years were performed from 2013 to 2016.
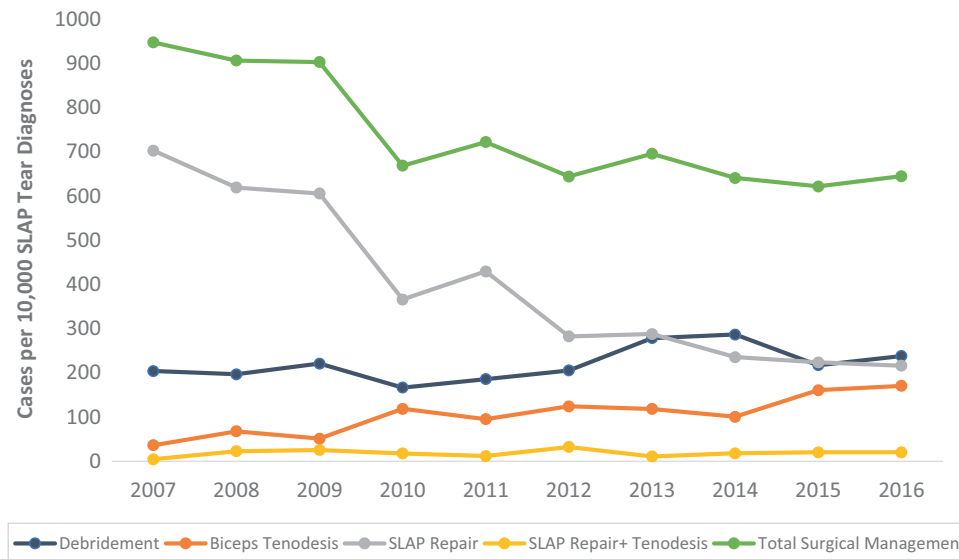
Figure 1. Trends in the surgical management of superior labrum anterior and posterior (SLAP) tears over time per 10,000 diagnoses of a SLAP tear.

TABLE 2
Demographics in Operative Management of Isolated SLAP Tears[a]

	Debridement (n = 1076)	BT (n = 552)	SLAP Repair (n = 1629)	SLAP Repair + BT (n = 93)	P Value
Sex					<.001
Female	431 (38.1)	201 (17.8)	479 (42.4)	20 (1.8)	
Male	645 (29.1)	351 (15.8)	1150 (51.9)	70 (3.2)	
Age group, y					<.001
10-19	35 (11.8)	4 (0.7)	256 (87.5)	0 (0.0)	
20-29	71 (19.1)	14 (2.9)	284 (76.3)	8 (1.7)	
30-39	52 (14.0)	31 (7.5)	263 (75.2)	16 (3.3)	
40-49	128 (24.9)	81 (12.6)	274 (58.9)	17 (3.6)	
50-59	210 (31.3)	129 (19.5)	254 (46.5)	17 (2.6)	
60-69	326 (43.7)	169 (22.7)	186 (30.7)	22 (2.9)	
70-79	222 (49.3)	111 (21.8)	102 (26.4)	13 (2.5)	
80-89	30 (60.5)	13 (23.3)	8 (16.3)	0 (0.0)	
≥90	2 (50.0)	0 (0.0)	2 (50.0)	0 (0.0)	
Body mass index, kg/m^2					<.001
<30	793 (29.8)	413 (15.5)	1380 (51.9)	75 (2.8)	
≥30	283 (41.3)	139 (20.3)	249 (36.3)	15 (2.2)	
Smoking	192 (33.8)	115 (20.2)	242 (42.6)	19 (3.3)	.437
Diabetes	325 (42.3)	162 (21.1)	250 (32.6)	31 (4.0)	.017
Charlson Comorbidity Index, mean ± SD	1.37 ± 2.09	1.25 ± 1.75	0.65 ± 1.40	1.32 ± 1.86	<.001

[a]Data are reported as n (%) unless otherwise indicated. BT, biceps tenodesis; SLAP, superior labrum anterior and posterior.

Stiffness was the most common complication with respect to all procedures (4.7% overall). There was no statistical difference between the incidence of stiffness, surgical site infections, and reoperations between the surgical treatment groups for isolated SLAP tears ($P > .05$ for all) (Table 3).

From a separate analysis of patients with a diagnosis of SLAP tears between 2007 and 2016, there were 14,558 patients who underwent isolated RCR, 1700 patients who underwent RCR and SLAP repair, and 2222 patients who underwent RCR and BT. The incidence of those undergoing isolated RCR increased by 12.8%, those undergoing RCR and SLAP repair decreased by 42.3%, and those undergoing RCR and BT increased by 1417.0% (Figure 4).

DISCUSSION

The management of SLAP tears is noted to have changed significantly over the past decade. The operative management of isolated SLAP tears has decreased over time, while

A

B
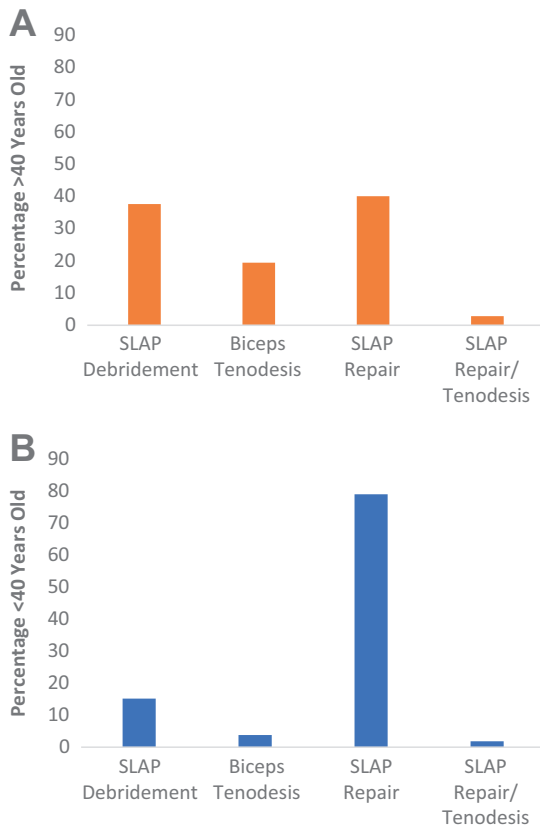
Figure 2. Distribution of operative treatments for superior labrum anterior and posterior (SLAP) tears in patients (A) younger and (B) ≥ 40 years.

the number of diagnoses has increased. It is unclear whether this finding is a result of the increased number of diagnoses, a shift in management toward conservative treatment, or reluctance to operate without concomitant defects. However, in our relatively homogeneous population of isolated SLAP tear diagnoses, it is clear that the proportion of patients managed with BT has increased in frequency, whereas SLAP repair has decreased in frequency. A further analysis for age demonstrated a large increase in patients older than 40 years undergoing BT for this diagnosis over time. SLAP repair was still the predominant treatment in patients younger than 60 years. An analysis of trends in a national private-payer database of 46,650 SLAP tear diagnoses and 3347 procedures specifically for this abnormality demonstrated significant trends that reflect research regarding this defect.

Andrews et al[3] and Snyder et al[34] popularized SLAP tears as prevalent injuries in the overhead athlete. Yet, treatment options are challenging because of poor vascularity of the superior labrum, which decreases with age,[11,40] and the high functional demand of the athletic populations that sustain this injury. Repair of the superior labrum with suture anchors is the traditional mode of management. In isolated management of this injury in baseball players, Gilliam et al[20] reported improvement in functional outcomes, but pitchers had worse return-to-play rates than

nonpitchers (59% vs 76%, respectively). BT has been discussed as an alternative procedure that is able to remove a significant pain generator within the glenohumeral joint and limit the peel back of the superior labrum. Werner et al[41] initially suggested this as a salvage procedure for failed SLAP repair, reporting improved functional outcomes and range of motion at 2-year follow-up after previous SLAP repair. BT has also been suggested as a reasonable primary procedure in middle-aged patients because of the reduced vascularity of the superior labrum in older patients and an increased risk of stiffness postoperatively.[23,25,27,38,40]

Boileau et al[5] were the first to compare BT with SLAP repair in a heterogeneous population and found that a greater proportion of patients after BT were satisfied than after SLAP repair. A recent systematic review has demonstrated superior rates of patient satisfaction and return to sport in patients after BT when compared with SLAP repair, with moderate overall heterogeneity of articles.[23] A cost-effectiveness analysis between these 2 procedures for SLAP tears in middle-aged patients also revealed that BT is a more cost-effective strategy; however, this study assumed equal utilities gained from either procedure and can attribute these results primarily to the lower failure rate reported in the literature of BT.[29]

The literature addressing modes of management regarding this topic has escalated within the past 10 years to provide appropriate indications for the management of all types of SLAP tears.[2] This is most appreciable by the finding that patients older than 40 years have the fastest rising incidence of BT. SLAP repair still remains the preferred option for younger patients, but it is important to note the decreasing incidence of this procedure for isolated tears. Provencher et al[32] have demonstrated up to 40% failure after SLAP repair in young active patients with a confirmed SLAP tear, while Waterman et al[36] reported that lower occupational demands and combined injury patterns were associated with improved outcomes in a military subset. These studies may suggest that clinicians are more sensitive to the high incidence of failure, which would cause some reluctance in performing this procedure without exhausting conservative measures. Additionally, numerous prospective studies have reported inferior outcomes for RCR when combined with SLAP repair over biceps tenotomy and glenohumeral debridement.[1,18,26] The present study's finding that RCR with SLAP repair is decreasing relative to RCR with BT is substantiated by these studies.

Three studies demonstrated the rising incidence of SLAP repair performed in the United States during 2002-2010, 2004-2009, and 2002-2009 using the Statewide Planning and Research Cooperative System database from the New York State Department of Health,[28] the PearlDiver database,[42] and the Defense Medical Epidemiology Database,[37] respectively. These epidemiological studies demonstrate the increasing incidence of SLAP repair in their respective populations but lack a comparison of procedures, which may limit the conclusions that may be drawn toward surgeon decision making. This trend was not appreciated within the included years of our search; however, the search performed within this study excluded any
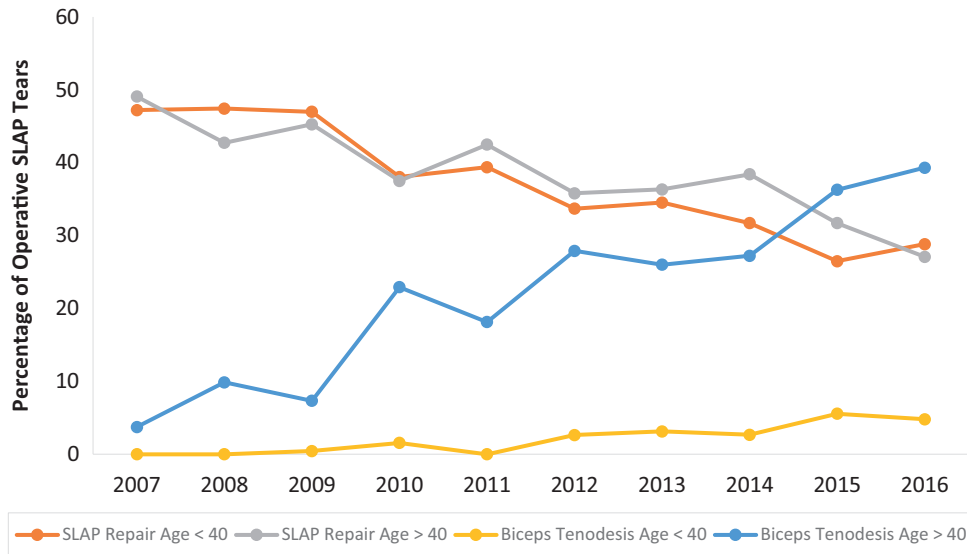
Figure 3. Trends in patients undergoing superior labrum anterior and posterior (SLAP) repair and biceps tenodesis stratified by age.

TABLE 3
Complications Associated With Operative Management of Isolated SLAP Tears[a]

	Debridement	BT	SLAP Repair	SLAP Repair + BT	P
Surgical site infection	9 (0.8)	6 (1.1)	8 (0.5)	1 (1.1)	.734
Stiffness	65 (6.0)	30 (5.4)	58 (3.6)	4 (4.4)	.586
Reoperation	11 (1.0)	7 (1.3)	25 (1.5)	2 (2.2)	.508

[a]Data are reported as n (%). BT, biceps tenodesis; SLAP, superior labrum anterior and posterior.

concomitant procedures performed so that we could analyze a relatively homogeneous population. Furthermore, only Waterman et al[37] considered the rate of diagnosis of SLAP tears, which would increase the pool of patients who are eligible for operative management.

Patterson et al[30] performed a similar trend analysis using the American Board of Orthopaedic Surgery Certification Examination Database on both isolated SLAP lesions and those with concomitant RCR. Similar to the findings of the present study, this group found a decrease in the rate of SLAP repair and an increase in the incidence of BT performed for both isolated SLAP lesions and those with concomitant RCR. However, this database has high
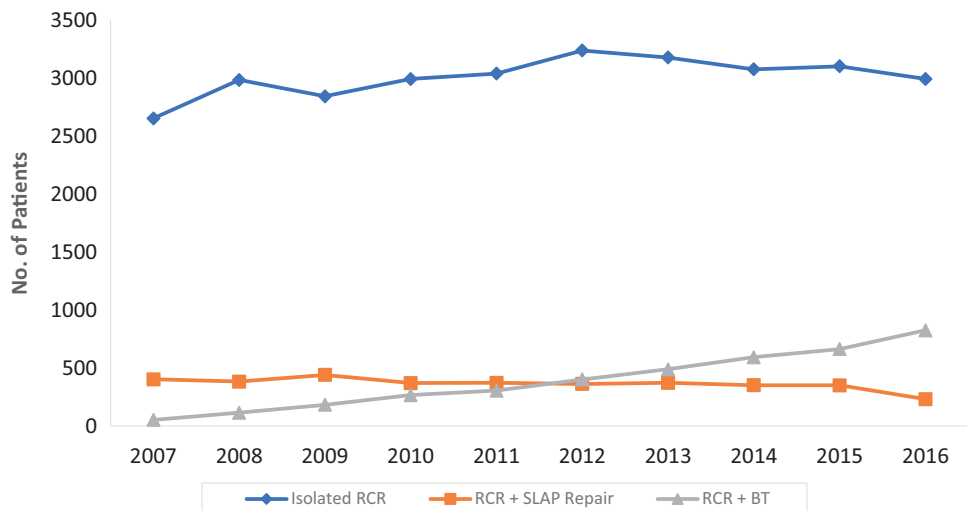
Figure 4. Trends in isolated rotator cuff repair (RCR), RCR with superior labrum anterior and posterior (SLAP) repair, and RCR with biceps tenodesis in the management of patients with diagnosed SLAP tears.

selection bias because it is constructed from case logs of candidate orthopaedic surgeons sitting for the Part II examination.[30] Using the PearlDiver database, Taylor et al[35] found that age older than 40 years was a risk factor for revision surgery, along with female sex, obesity, smoking, and a concomitant diagnosis of biceps tendinitis at or before the time of surgery.

The trends of the present study provide a valuable update to previous reports by incorporating the proportion of patients who undergo each procedure. The inadequacy of SLAP repair for patients above the age of 40 years is reflected by the large increase in BT performed in this age group. Authors have suggested lowering the age threshold for the performance of BT because of inferior outcomes in SLAP repair beyond the age of 36 years.[32] Postoperative stiffness is also a concern after these surgical procedures. The proportions of this complication did not significantly differ based on surgery and ranged between 3.6% and 6.0%. However, the demographics of patients undergoing each procedure are different, which may have confounded the rates of postoperative stiffness. For example, patients undergoing debridement may have the highest rate of stiffness because they were also the oldest.

Limitations of this study relate primarily to the limitations of using a national private-payer insurance database. Although the use of the Humana database allowed us to determine broad trends in the treatment of isolated SLAP tears in the United States over the study period, the database also comes with multiple limitations. This includes potential limitations in the quality of data and accuracy of diagnosis and procedure coding. Biceps tenotomy, for example, is not routinely coded after procedures; rather, it is often grouped within debridement codes. Therefore, it is potentially confounding whether patients are truly undergoing tenotomy versus debridement. The data are limited to the United States and may not extrapolate to trends elsewhere in the world. The Humana database also has an increased concentration of patients specifically in the northeastern United States compared with other regions. Furthermore, the database consists of patients from a single private payer insurance company and may not extrapolate to other privately or publicly insured patients in the United States.

Additionally, we could determine intraoperative findings regarding the type and nature of the SLAP tear as well as associated defects to the biceps tendon or elsewhere in the shoulder. We did attempt as best as possible to achieve a series of patients with a SLAP tear diagnosis who underwent isolated surgical treatment by limiting our search to patients with a diagnosis code for a SLAP tear and excluding a range of concomitant shoulder surgical CPT codes that are not isolated SLAP tear treatment options. Also because of the database limitations, we were unable to determine an array of patient preoperative factors that influence surgical treatment decisions, such as nonoperative treatment, duration of symptoms, nature of patient symptoms, physical examination and radiographic findings, workers' compensation status, and sports participation such as overhead athletes. We were similarly limited postoperatively, as the database lacked postoperative radiographic or physical examination findings, lacked patient-reported outcomes, and did not indicate if patients returned to their recreational and occupational demands.

CONCLUSION

An analysis of a large private-payer database revealed that the surgical treatment of isolated SLAP tears in the United States shifted from 2007 to 2016, with an increase in the frequency of BT and a decline in the frequency of SLAP repair, particularly in patients older than 40 years.

REFERENCES

1. Abbot AE, Li X, Busconi BD. Arthroscopic treatment of concomitant superior labral anterior posterior (SLAP) lesions and rotator cuff tears in patients over the age of 45 years. *Am J Sports Med*. 2009;37(7): 1358-1362.
2. Ahsan ZS, Hsu JE, Gee AO. The Snyder classification of superior labrum anterior and posterior (SLAP) lesions. *Clin Orthop Relat Res*. 2016;474(9):2075-2078.
3. Andrews JR, Carson WG, Mcleod WD. Glenoid labrum tears related to the long head of the biceps. *Am J Sports Med*. 1985;13(5):337-341.
4. Bey MJ, Elders GJ, Huston LJ, Kuhn JE, Blasier RB, Soslowsky LJ. The mechanism of creation of superior labrum, anterior, and posterior lesions in a dynamic biomechanical model of the shoulder: the role of inferior subluxation. *J Shoulder Elbow Surg*. 1998;7(4):397-401.
5. Boileau P, Parratte S, Chuinard C, Roussanne Y, Shia D, Bicknell R. Arthroscopic treatment of isolated type II SLAP lesions: biceps tenodesis as an alternative to reinsertion. *Am J Sports Med*. 2009;37(5): 929-936.
6. Brockmeyer M, Tompkins M, Kohn DM, Lorbach O. SLAP lesions: a treatment algorithm. *Knee Surg Sports Traumatol Arthrosc*. 2016; 24(2):447-455.
7. Burkhart SS, Morgan CD. The peel-back mechanism: its role in producing and extending posterior type II SLAP lesions and its effect on SLAP repair rehabilitation. *Arthroscopy*. 1998;14(6):637-640.
8. Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology. Part I: pathoanatomy and biomechanics. *Arthroscopy*. 2003;19(4):404-420.
9. Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology. Part III: the SICK scapula, scapular dyskinesis, the kinetic chain, and rehabilitation. *Arthroscopy*. 2003;19(6): 641-661.
10. Cohen DB, Coleman S, Drakos MC, et al. Outcomes of isolated type II SLAP lesions treated with arthroscopic fixation using a bioabsorbable tack. *Arthroscopy*. 2006;22(2):136-142.
11. Cooper DE, Arnoczky SP, O'Brien SJ, Warren RF, DiCarlo E, Allen AA. Anatomy, histology, and vascularity of the glenoid labrum: an anatomical study. *J Bone Joint Surg Am*. 1992;74(1):46-52.
12. Denard PJ, Lädermann A, Burkhart SS. Long-term outcome after arthroscopic repair of type II SLAP lesions: results according to age and workers' compensation status. *Arthroscopy*. 2012;28(4):451-457.
13. Denard PJ, Lädermann A, Parsley BK, Burkhart SS. Arthroscopic biceps tenodesis compared with repair of isolated type II SLAP lesions in patients older than 35 years. *Orthopedics*. 2014;37(3): e292-e297.
14. Edwards SL, Lee JA, Bell JE, et al. Nonoperative treatment of superior labrum anterior posterior tears: improvements in pain, function, and quality of life. *Am J Sports Med*. 2010;38(7):1456-1461.
15. Ek ET, Shi LL, Tompson JD, Freehill MT, Warner JJP. Surgical treatment of isolated type II superior labrum anterior-posterior (SLAP) lesions: repair versus biceps tenodesis. *J Shoulder Elbow Surg*. 2014;23(7):1059-1065.
16. Erickson J, Lavery K, Monica J, Gatt C, Dhawan A. Surgical treatment of symptomatic superior labrum anterior-posterior tears in patients

older than 40 years: a systematic review. *Am J Sports Med*. 2015; 43(5):1274-1282.

17. Fedoriw WW, Ramkumar P, McCulloch PC, Lintner DM. Return to play after treatment of superior labral tears in professional baseball players. *Am J Sports Med*. 2014;42(5):1155-1160.

18. Franceschi F, Longo UG, Ruzzini L, Rizzello G, Maffulli N, Denaro V. No advantages in repairing a type II superior labrum anterior and posterior (SLAP) lesion when associated with rotator cuff repair in patients over age 50: a randomized controlled trial. *Am J Sports Med*. 2008;36(2):247-253.

19. Friel NA, Karas V, Slabaugh MA, Cole BJ. Outcomes of type II superior labrum, anterior to posterior (SLAP) repair: prospective evaluation at a minimum two-year follow-up. *J Shoulder Elbow Surg*. 2010;19(6): 859-867.

20. Gilliam BD, Douglas L, Fleisig GS, et al. Return to play and outcomes in baseball players after superior labral anterior-posterior repairs. *Am J Sports Med*. 2018;46(1):109-115.

21. Gorantla K, Gill C, Wright RW. The outcome of type II SLAP repair: a systematic review. *Arthroscopy*. 2010;26(4):537-545.

22. Gottschalk MB, Karas SG, Ghattas TN, Burdette R. Subpectoral biceps tenodesis for the treatment of type II and IV superior labral anterior and posterior lesions. *Am J Sports Med*. 2014;42(9): 2128-2135.

23. Hurley ET, Fat DL, Duigenan CM, Miller JC, Mullett H, Moran CJ. Biceps tenodesis versus labral repair for superior labrum anterior-to-posterior tears: a systematic review and meta-analysis. *J Shoulder Elbow Surg*. 2018;27(10):1913-1919.

24. Jang SH, Seo JG, Jang HS, Jung JE, Kim JG. Predictive factors associated with failure of nonoperative treatment of superior labrum anterior-posterior tears. *J Shoulder Elbow Surg*. 2016;25(3):428-434.

25. Katz LM, Hsu S, Miller SL, et al. Poor outcomes after SLAP repair: descriptive analysis and prognosis. *Arthroscopy*. 2009;25(8):849-855.

26. Kim S-J, Lee I-S, Kim S-H, Woo C-M, Chun Y-M. Arthroscopic repair of concomitant type II SLAP lesions in large to massive rotator cuff tears: comparison with biceps tenotomy. *Am J Sports Med*. 2012; 40(12):2786-2793.

27. Knesek M, Skendzel JG, Dines JS, Altchek DW, Allen AA, Bedi A. Diagnosis and management of superior labral anterior posterior tears in throwing athletes. *Am J Sports Med*. 2013;41(2):444-460.

28. Onyekwelu I, Khatib O, Zuckerman JD, Rokito AS, Kwon YW. The rising incidence of arthroscopic superior labrum anterior and posterior (SLAP) repairs. *J Shoulder Elbow Surg*. 2012;21(6):728-731.

29. Paoli AR, Gold HT, Mahure SA, et al. Treatment for symptomatic SLAP tears in middle-aged patients comparing repair, biceps tenodesis, and nonoperative approaches: a cost-effectiveness analysis. *Arthroscopy*. 2018;34(7):2019-2029.

30. Patterson BM, Creighton RA, Spang JT, Roberson JR, Kamath GV. Surgical trends in the treatment of superior labrum anterior and posterior lesions of the shoulder: analysis of data from the American Board of Orthopaedic Surgery Certification Examination Database. *Am J Sports Med*. 2014;42(8):1904-1910.

31. Pogorzelski J, Horan MP, Hussain ZB, Vap A, Fritz EM, Millett PJ. Subpectoral biceps tenodesis for treatment of isolated type II SLAP lesions in a young and active population. *Arthroscopy*. 2018;34(2): 371-376.

32. Provencher MT, McCormick F, Dewing C, McIntire S, Solomon D. A prospective analysis of 179 type 2 superior labrum anterior and posterior repairs: outcomes and factors associated with success and failure. *Am J Sports Med*. 2013;41(4):880-886.

33. Snyder SJ, Banas MP, Karzel RP. An analysis of 140 injuries to the superior glenoid labrum. *J Shoulder Elbow Surg*. 1995;4(4):243-248.

34. Snyder SJ, Karzel RP, Del Pizzo W, Ferkel RD, Friedman MJ. SLAP lesions of the shoulder. *Arthroscopy*. 1990;6(4):274-279.

35. Taylor SA, Degen RM, White AE, et al. Risk factors for revision surgery after superior labral anterior-posterior repair: a national perspective. *Am J Sports Med*. 2017;45(7):1640-1644.

36. Waterman BR, Arroyo W, Heida K, Burks R, Pallis M. SLAP repairs with combined procedures have lower failure rate than isolated repairs in a military population: surgical outcomes with minimum 2-year follow-up. *Orthop J Sports Med*. 2015;3(8):2325967115599154.

37. Waterman BR, Cameron KL, Hsiao M, Langston JR, Clark NJ, Owens BD. Trends in the diagnosis of SLAP lesions in the US military. *Knee Surg Sports Traumatol Arthrosc*. 2015;23(5):1453-1459.

38. Weber SC. Surgical management of the failed SLAP repair. *Sports Med Arthrosc*. 2010;18(3):162-166.

39. Weber SC, Martin DF, Seiler JG, Harrast JJ. Superior labrum anterior and posterior lesions of the shoulder: incidence rates, complications, and outcomes as reported by American Board of Orthopedic Surgery Part II candidates. *Am J Sports Med*. 2012;40(7):1538-1543.

40. Werner BC, Brockmeier SF, Miller MD. Etiology, diagnosis, and management of failed SLAP repair. *J Am Acad Orthop Surg*. 2014;22(9): 554-565.

41. Werner BC, Pehlivan HC, Hart JM, et al. Biceps tenodesis is a viable option for salvage of failed SLAP repair. *J Shoulder Elbow Surg*. 2014; 23(8):e179-e184.

42. Zhang AL, Kreulen C, Ngo SS, Hame SL, Wang JC, Gamradt SC. Demographic trends in arthroscopic SLAP repair in the United States. *Am J Sports Med*. 2012;40(5):1144-1147.