Concomitant Cervical Spine Stenosis Negatively Affects Subpectoral Biceps Tenodesis Outcomes

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Purpose: To determine whether an association exists between the presence of cervical spine pathology and postoperative patient-reported outcomes (PROs) in patients undergoing open subpectoral biceps tenodesis (BT). Methods: A retrospective review of patients undergoing isolated BT from August 2011 to May 2019 was conducted. Cases were defined as patients with concomitant cervical spine disease (disc disease, disc herniations, neuroforaminal/central stenosis). Controls were patients without cervical spine disease. Postoperative PROs were collected from all patients with a minimum of 12-month follow-up. Cases and controls were matched 1:1 using age and body mass index. PROs were compared using the $\chi^2$ test, Fisher exact test, or analysis of variance. Results: A total of 23 cases and 23 controls were identified. Cases and controls had similar distributions of age (42.4 ± 4.4 years, 40.4 ± 4.5, $P = .15$), sex (83% male, 87% male, $P = .68$), body mass index (28.0 ± 4.0, 27.6 ± 4.3, $P = .78$), and percentage of athletes (65% athlete, 61% athlete, $P = .76$). All cases had evidence of neuroforaminal stenosis and multilevel degenerative disc disease, whereas 19 of 23 (83%) had evidence of central canal stenosis. Cases had a greater visual analog scale (VAS) score during Sport score (3.6 ± 0.7 vs 1.2 ± 0.6, $P = .013$) and lower Subjective Shoulder Value (69.5 ± 5.8 vs 84.1 ± 5.4, $P = .070$) and Shoulder Instability-Return to Sport after Injury score (60.4 ± 5.8 vs 77.4 ± 6.0, $P = .046$). There were no significant differences between groups’ ASES, baseline VAS, overall satisfaction scores, and willingness to undergo the same operation again. No significant differences were found in postoperative rate of return to sport, time to return, and return to preoperative competitiveness. Conclusions: Patients with SLAP tears undergoing isolated BT in the presence of cervical spinal stenosis may have inferior Subjective Shoulder Value, Shoulder Instability-Return to Sport after Injury, and VAS during sport scores as compared with controls, although many PROs were similar at follow-up. Athletes undergoing BT, particularly with concomitant cervical spine pathology, should be counseled appropriately before surgery. Level of Evidence: Level III, case—control study.

SLAP tears are reportedly present in up to 26% of shoulder arthroscopies and are often attributed to traumatic or overuse injuries. Although the surgical management of SLAP tears has been characterized predominantly by arthroscopic repair, open subpectoral biceps tenodesis (BT) has gained popularity in the last several decades as the primary surgical management option for symptomatic SLAP tears involving...
biceps–labral anchors.\textsuperscript{2,3} Studies comparing BT with arthroscopic repair have demonstrated greater rates of patient satisfaction and return to play and lower rates of revision in patients of all ages with BT.\textsuperscript{4,5} In patients with BT who experience poorer postoperative outcomes, anecdotally, a subset of patients report neck pain or a history of cervical spine pathology and related surgeries.

While there is a well-known relationship regarding the dermatomal overlap of pain pathways in the shoulder joint as originating from either the joint itself or the cervical spine, few studies have evaluated patient-reported outcomes (PROs) after shoulder arthroscopy in patients with concomitant cervical spine pathology.\textsuperscript{6-10} Dunn et al.\textsuperscript{7} demonstrated in an 86,501 patient analysis of prevalence across time that the number of patients with both rotator cuff pathology and cervical spine stenosis has increased significantly in the past decade. Moorthy et al.\textsuperscript{11} compared outcomes in patients undergoing arthroscopic rotator cuff repair with or without concomitant cervical radiculopathy but found no significant difference in postoperative functional outcomes between the 2 groups. In a cohort of patients with both cervical spine and shoulder pathology undergoing intervention for one or both pathologies, Malige et al.\textsuperscript{12} reported no statistically significant difference in patient-reported pain scores, functional outcomes, and postoperative opioid use between groups. However, patients who underwent both spine and shoulder surgery were significantly more likely to report complete cessation of shoulder symptoms compared with cohorts who underwent either spine or shoulder surgery alone.\textsuperscript{12} A majority of spine interventions targeted the C5–C6 nerve root levels, commonly implicated in shoulder pain.\textsuperscript{13} In addition, patients who underwent procedures for rotator cuff and biceps pathology repair reported the greatest levels of success with symptom relief.\textsuperscript{12} These findings suggest that further investigation of “shoulder-spine” PROs is warranted.

The purpose of this study is to determine whether an association exists between the presence of cervical spine pathology and postoperative PROs in patients undergoing open subpectoral BT. We hypothesized that patients undergoing BT with concurrent cervical spine disease would have inferior clinical outcomes compared with the general BT population without cervical spine disease.

**Methods**

**Patient Selection**

A retrospective review of patients undergoing isolated BT from August 2011 to May 2019 was conducted after institutional review board approval (protocol: i20-01027). All patients had shoulder pain incited by overhead and strenuous activity with pain elicited on SLAP and biceps provocative examination maneuvers (Yergason test, Speed test, the O’Brien Active Compression test) that corresponded to magnetic resonance imaging findings consistent with tearing of the biceps–superior labrum anchor and SLAP type I-IV pathology. Patients were indicated for surgery if their pain did not resolve to a dedicated course of physical therapy and anti-inflammatory medications. Inclusion criteria consisted of all patients undergoing isolated BT within the aforementioned period, older than 16 years of age at the time of surgery, and with a minimum of 12-month follow-up. Patients undergoing SLAP repair, rotator cuff repair, or labral repair in addition to BT, with preoperative glenohumeral instability, and revision shoulder arthroscopies were excluded. Patients were allocated into the Shoulder-Spine group if there was evidence of radicular symptoms, neck pain, and sensorimotor symptoms correlating with cervical dermatomal distribution on history corresponding to neurologic examination findings and presence of cervical degenerative disc disease, disc herniations, neuroforaminal stenosis, and central canal stenosis on dedicated advanced imaging of the cervical spine.

**Biceps Tenodesis**

A standard mini-open subpectoral BT was performed in all patients as previously described.\textsuperscript{14} Preoperatively, patients underwent an interscalene nerve block. Standard shoulder arthroscopy portals including posterior and high-interval anterior superior portals were made followed by a diagnostic arthroscopy. The SLAP tear involving the biceps–labral complex was confirmed and a biceps tenotomy was performed. Positioning was either lateral decubitus or beach chair, dependent upon surgeon preference. If lateral decubitus was used, the arm was taken down from traction and inserted into an impervious, sterile sleeve for the remainder of the procedure. The arm was abducted and externally rotated onto a padded sterile stand to gain access to the axilla for the incision centered over the inferior border of the pectoralis major muscle. Blunt dissection was performed down to the clavicular fascia, which was incised sharply. The long head of the biceps tendon was identified and retrieved. A looped high-strength suture was then passed in a retrograde fashion through the tendon starting at the musculotendinous junction. The stitch was locked proximally after 25 mm of tendon was traversed. A cortical button fixation method (BicepsButton; Arthrex, Naples, FL) and tension-slide technique was employed for bicortical fixation.

**Postoperative Protocol**

The postoperative rehabilitation protocol consisted of 2 weeks of sling immobilization followed by progressive shoulder range-of-motion and strengthening. A sport-
specific training program was initiated once range-of-motion and strength parameters were met. All patients were permitted to return to sports at 6 months if rehabilitation criteria were successfully met.

Data Collection and Clinical Outcomes
A retrospective review of patient records was performed to collect preoperative demographic and intraoperative criteria as well as imaging findings. All perioperative complications were also recorded when applicable. Postoperative PROs were tabulated via telephone survey including visual analog scale (VAS) score at baseline and during sports, Subjective Shoulder Value (SSV), American Shoulder and Elbow Surgeons (ASES) score, overall satisfaction, Shoulder Instability-Return to Sport after Injury (SIRSI) score, and whether patients would undergo the same surgery again. Further, patients identifying as athletes at the time of surgery were asked regarding rate of return to sports, time to return, and whether they were able to achieve the same level of athletic competitiveness postoperatively. The presence of Popeye sign was assessed at each postoperative visit with the operating surgeon. All patients in the control cohort were called retrospectively to confirm the absence of cervical radiculopathy, previous cervical spine injuries, previous neck surgery, or spine symptoms.

Statistical Analysis
A case-control matching was performed using age and body mass index (BMI) to generate a 1:1 control group for the Shoulder-Spine group. All categorical variables were reported as frequencies and percentages. Categorical variables were compared between groups using the $\chi^2$ or Fisher exact test, depending upon the sample size used. All continuous preoperative and demographic characteristics (mean ± standard deviation) and continuous postoperative measures alongside PROs (mean ± standard error of the mean) were described using descriptive statistics. Continuous variables were compared using one-way analysis of variance testing between the experimental and control group. $P$ values $<.05$ were considered statistically significant. A post-hoc power analysis was conducted evaluating the current power of comparison for all outcomes as well as the needed sample size to achieve 80% power and $P <.05$ for all outcomes with $P >.05$. All statistical analysis was performed using SPSS Statistics version 25 (IBM Corp., Armonk, NY).

Results

Clinical Outcomes
From August 2011 to May 2019, 23 patients (mean age ± standard deviation: 42.4 ± 4.4 years; BMI: 28.0 ± 4.0; 83% male) identified meeting Shoulder-Spine cohort inclusion and exclusion criteria who were successfully case-matched to 23 controls (age: 40.4 ± 4.5 years, $P = .15$; BMI: 27.6 ± 4.3, $P = .78$; 87% male, $P = .68$) based on age and BMI at time of surgery (mean follow-up Shoulder-Spine cohort: 4.6 ± 2.3 years, control cohort: 4.6 ± 2.2 years, $P = .97$). The inclusion rate of the BT cohort was 87% overall, of which patients were sampled to generate the subcohorts for this study. All patients in the Shoulder-Spine group had evidence of neuroforaminal stenosis and multilevel degenerative disc disease, whereas 19 of 23 (83%) had evidence of central canal stenosis on advanced imaging. There were 29 athletes in the study: 65% of the Shoulder-Spine versus 61% of the control group were athletes ($P = .76$). Of the athletes, 80% of the Shoulder-Spine group were overhead athletes, and 79% of the control group were overhead athletes ($P = 1.0$) (Tables 1 and 2). One patient in each cohort underwent a revision procedure during follow-up ($P = 1.0$); otherwise, there were no additional complications perioperatively.

Patient-Reported Outcomes
The Shoulder-Spine group had a significantly more severe VAS during Sport score versus the control group.

| Table 2. Sport Involvement |
|---------------------------|
| Sport Type               | N (%) |
| Overhead                 |       |
| Basketball               | 4 (9%) |
| Swimming                 | 4 (9%) |
| Baseball                 | 3 (7%) |
| Weightlifting            | 8 (17%)|
| Tennis                   | 3 (7%) |
| Golf                     | 4 (9%) |
| Boxing                   | 1 (2%) |
| Nonoverhead              |       |
| Wrestling                | 6 (13%)|
| Handball                 | 2 (4%) |
| Surfing                  | 1 (2%) |
| Soccer                   | 1 (2%) |
| Cycling                  | 4 (9%) |
| Running                  | 5 (11%)|
| Yoga                     | 1 (2%) |
(3.6 ± 0.7 vs 1.2 ± 0.6, \( P = .013 \)) at follow-up. The Shoulder-Spine group also had a lower postoperative return to sport rate (67% vs 86%, \( P = .39 \)) and longer duration of time to return (10.7 vs 6.3 months, \( P = .10 \)) versus the control group, however, without statistical significance. Lastly, of patients returning to sports, a similar portion in both cohorts (80% vs 83%, \( P = .63 \)) achieved preoperative competitiveness of sport (Table 3).

The Shoulder-Spine group achieved significantly lower SSV (69.5 ± 5.8 vs 84.1 ± 5.4, \( P = .070 \)) and SIRSI (60.4 ± 5.8 vs 77.4 ± 6.0, \( P = .046 \)) versus the control group. Fewer patients in the Shoulder-Spine group trended toward agreeing they would undergo the same operation again if they could choose (78% vs 96%, \( P = .093 \)) (Table 4). ASES, VAS, and overall satisfaction scores appeared to be lower in the Shoulder-Spine versus control group, but these findings were not statistically significant.

### Post-Hoc Power Analysis

Post-hoc power analysis demonstrated time to return had the greatest power among the outcomes evaluated (69.4%), whereas return to same level of sport had the lowest power (4.5%). Each cohort would require a sample size of 49 patients for adequate power in the time to return comparison while return to same level of sport would require 2,629 patients for adequate power (Table 5).

### Discussion

This study demonstrates patients undergoing BT in the presence of concomitant cervical spine stenosis (Shoulder-Spine) have inferior clinical outcomes as compared with controls matched for age and BMI without cervical spine pathology at a 1-year minimum follow-up. Functionally, the Shoulder-Spine group had lower SSV and SIRSI scores at final follow-up. Regardless of the group, the majority of patients in this study were athletes, of whom the majority participated in overhead sports. While the majority of patients returned to sports and the same level of competition in both groups, patients in the Shoulder-Spine group had significantly greater VAS scores during sports participation compared with the control group. There was a trend toward increased time to return in the Shoulder-Spine versus control group, which may be of clinical relevance, given the time was almost twice as long and may be applicable when considering the timing of surgery with respect to sport season. A lower portion (78% vs 96%) of patients in the Shoulder-Spine versus control group said they would undergo BT again if given the choice that was trending; however, may be of clinical significance when considering counseling these patients preoperatively. Our study supports further investigation of the “shoulder-spine” cohort and implications for return to play is needed, as these patients may benefit from preoperative targeting their concomitant cervical spine stenosis.

While there are limited data evaluating isolated BT in the setting of cervical spine pathology, there have been investigations regarding shoulder arthroscopy outcomes in the presence of spine pathology. Malige et al.\(^{12}\) studied patients undergoing cervical spine procedures, shoulder procedures, or a combination of both in a 154-patient cohort evaluating outcomes. However, there were only 2 patients with isolated BT in their cohort. The study sought to evaluate whether the order of procedure in terms of shoulder versus cervical spine surgery to address shoulder pain and symptomatology plays a role in outcomes. Malige et al.\(^{12}\) demonstrated the order of intervention did not significantly affect PROs or postoperative opioid consumption.

Moorthy et al.\(^{11}\) investigated arthroscopic rotator cuff repair outcomes in the presence versus absence of cervical radiculopathy in a 33-patient cohort versus 324 controls. Interestingly, both cohorts performed similarly at follow-up with respect to PROs; however, the cervical radiculopathy group had lower preoperative PROs or postoperative opioid consumption.

### Table 3. Return to Play Outcomes

|                        | Shoulder-Spine | Control | \( P \) Value* |
|------------------------|----------------|---------|---------------|
| Returned to sport, n (%) | 10 (67%)       | 12 (86%) | .39           |
| Returned to same level of sport, n (%) | 8 (80%)       | 10 (83%) | .63           |
| Time to return, mean, months ± SD | 10.7 ± 7.8    | 6.3 ± 3.5 | .10           |
| VAS during sport, mean ± SEM | 3.6 ± 0.7     | 1.2 ± 0.6 | .013          |

*Continuous variables analyzed with one-way analysis of variance; categorical variables analyzed with \( \chi^2 \) versus Fisher test, depending on sample size.

### Table 4. Functional Outcomes

|                        | Shoulder-Spine | Control | \( P \) Value* |
|------------------------|----------------|---------|---------------|
| ASES, mean ± SEM       | 80.4 ± 4.9     | 90.2 ± 3.9 | .12           |
| VAS, mean ± SEM        | 2.3 ± 0.7      | 1.3 ± 0.6 | .25           |
| SSV, mean ± SEM        | 69.5 ± 5.8     | 84.1 ± 5.4 | .070          |
| Satisfaction, mean ± SEM | 77.5 ± 6.4    | 88.5 ± 5.9 | .21           |
| SIRSI, mean ± SEM      | 60.4 ± 5.8     | 77.4 ± 6.0 | .046          |
| Would undergo surgery again, n (%) | 18 (78%)      | 22 (96%) | .093          |

*Continuous variables analyzed with one-way analysis of variance; categorical variables analyzed with \( \chi^2 \) versus Fisher test, depending on sample size.
scores. Possible rationale for lack of significant outcome differences may be the heterogeneity of the groups as 36% of their experimental group versus 2% of their control group had biceps pathology. In addition, the experimental cohort was much older as compared with the current study (63 vs 42 years).11

Li et al.9 evaluated perioperative complications, opioid use, and follow-up revision rates in a cohort study evaluating patients undergoing shoulder arthroscopy with versus without a history of anterior cervical disectomy and fusion (ACDF).9 They identified a 91,029-patient cohort, of whom 1,267 patients (1.4%) had previous ACDF after a query of the Pearl-Diver Patient Records Database. Patients with a history of ACDF had an increased rate of pulmonary complications, 3-day complications, 1-year revision rates, and postoperative opioid use versus controls. While there was no discussion regarding athletics, the findings of this study agree with those of Li et al. in that the Shoulder-Spine group performed inferiorly at follow-up with respect to PROs.

The current study provides a case—control investigation of patients undergoing isolated BT with or without cervical spine stenosis as compared with the aforementioned studies. While the aforementioned studies evaluate shoulder arthroscopy outcomes in the presence of cervical spine pathology, the current study demonstrates inferior athletic performance postoperatively associated with concomitant cervical spine stenosis in this patient population. An additional strength of our study includes case-matching to age and BMI to ensure reduced confounding of outcomes.

Limitations

Limitations of this study include biases associated with retrospective review. While the current study inclusion rate was acceptable (87%), it is underpowered as demonstrated by our results, which show apparent differences in certain outcomes that were unable to reach statistical significance due to limited cohort size. Our population lacks preoperative PRO scores, which may confound our outcomes, given there is a possibility the evaluated patient populations may have had differing baseline symptomatology severity, although this is unlikely, given the same rate of athletics performance. However, Gotlin et al.16 suggest that preoperative patient-reported ASES scores are subject to significant recall bias when compared with postoperatively recorded counterparts, reducing the ability to confidently use preoperative ASES scores as a baseline at all. Our study used the SIRSI score, which has not been validated in the setting of BT; however, the questions posed in the metric are directly applicable to sport participation, shoulder pathology, and the management evaluated in this study. In addition, the case—control matching scheme did not incorporate follow-up time periods; however, this fortunately was not found to be different between the experimental and control cohort.

Conclusions

Patients with SLAP tears undergoing isolated BT in the presence of cervical spinal stenosis may have inferior SSV, SIRSI, and VAS during sport scores as compared with controls, although many PROs were similar at follow-up. Athletes undergoing BT, particularly with concomitant cervical spine pathology, should be counseled appropriately before surgery.

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