Arthroscopic SLAP IIb Repair Using Knot-Tying Versus Knotless Suture Anchors: Is There a Difference?

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Take-Home Points

- SLAP IIb tears are common injuries in overhead athletes, yet surgical outcomes are variable, with throwers commonly having difficulty with return to play at the same level.
- In this study, 92% of athletes returned to play post-operatively, yet only around 55% returned at the same level.
- In overhead athletes, overall return to play was 85.7%, yet only 39.3% returned at the same level.
- Knotless fixation required less revision surgery and had higher outcome scores and return to play when compared to knotted fixation; however, this did not reach statistical significance.
- Knotless fixation should be considered in SLAP IIb repairs given their lower profile leading to less rotator cuff irritation, the ability to better provide more consistent tensioning, and decreased surgical time.

Injury of the anterosuperior labrum near the biceps origin was first described by Andrews and colleagues in 1985 in overhead athletes. The term SLAP, or a tear in the superior labrum anterior to posterior, was coined a few years later by Snyder and colleagues. They described an injury to the superior labrum beginning posteriorly and extending anteriorly, including the “anchor” of the biceps tendon to the labrum. Snyder further delineated SLAP lesions into 4 subtypes, the most common being type II, which he described as “degenerative fraying of the labrum with additional detachment of the superior labrum and biceps from the glenoid resulting in an unstable labral...
anchor.2,3 Type II tears are of particular importance as they are the most common SLAP lesions, with an incidence of 55%, and comprise nearly 75% of SLAP repairs performed.2,4

Morgan and colleagues further delineated type II SLAP tears into IIa (anterior), IIb (posterior), and IIc (combined). Their group found that SLAP IIb tears were the most common type in overhead throwers, accounting for 47% of overhead athletes with type II tears.5 Further, type IIb tears can have a significant impact in throwers, in part due to greater shoulder instability as well as anterior pseudolaxity.5 SLAP injuries typically have been difficult to successfully treat nonoperatively in overhead athletes.6 A study by Edwards and colleagues6 examined 39 patients with all types of SLAP tears. Although, in their study, nonoperative management failed in 20 patients and they required surgery, 10 of the 15 overhead athletes in whom nonoperative treatment did not fail initially returned to sport at a level equal to or better than their pre-injury level, indicating that nonoperative treatment may play a role in some patients’ recovery.6

Surgical outcomes of SLAP IIb repairs have traditionally been less predictable than those of other shoulder injuries. Some believe that traditional knotted anchors may be partially to blame by abrading the rotator cuff, possibly leading to rotator cuff tears and pain. Further, knotted anchors are typically bulkier and require more experience with tying and tensioning and, therefore, may lead to less consistent results.7 The purpose of this study was to investigate if knotless anchors result in more favorable outcomes in repair of type IIb SLAP lesions when compared with traditional knotted anchors. It was hypothesized that knotless fixation will provide superior clinical outcomes, improved return to play (RTP), and lower revision rates as compared with traditional knotted fixation in the repair of SLAP IIb tears.

Methods

Patient Selection

The authors retrospectively reviewed SLAP tears repaired by the senior author from June 2000 to September 2015. The inclusion criteria consisted of all athletes at any level who were diagnosed intraoperatively with a type IIb SLAP tear as defined by Morgan and colleagues5 with a minimum 2-year follow-up. The exclusion criteria were any patients with a previous shoulder surgery and the presence of any labral pathology aside from a SLAP IIb tear. Patients with rotator cuff or biceps pathologies were included. In all included patients, an initial course of preoperative physical therapy, including strengthening and stabilization of the scapulothoracic joint, had failed. Patient-directed surveys evaluated RTP, as well as the Kerlan-Jobe Orthopaedic Clinic (KJOC) score, American Shoulder and Elbow Surgeons (ASES) score, stability, range of motion (ROM), strength, and pain scores, as previously described.5,10 Institutional Review Board and informed consent approval were acquired prior to initiation of the study.

Patient Evaluation

An appropriate preoperative history was taken, and physical examinations were performed, including evaluation of the scapulothoracic joint, as well as tests to evaluate the presence of a SLAP tear, anterior instability, posterior instability, multi-directional instability, and rotator cuff tears, as previously described.11 Patients with a history and physical examination concerning SLAP pathology underwent an magnetic resonance imaging (MRI) arthrogram, which was used in conjunction with intraoperative findings to diagnose type IIb SLAP tears.
Surgical Technique

All surgeries were performed arthroscopically with the patient in the lateral decubitus position. The SLAP lesions were subsequently repaired using a technique similar to that described by Burkhart and colleagues. The traditional knotted fixation incorporated the use of 3.0 Bio-FASTak (Arthrex) with #2 FiberWire (Arthrex). Knotless anchor fixation was performed using 2.9 mm × 12.5 mm or 2.4 mm × 11.3 mm BioComposite PushLock (Arthrex) suture anchors, based on the size of the glenoid, with LabralTape or SutureTape (Arthrex). Patients who had surgery before January 1, 2013 underwent fixation with traditional knotted fixation; after that date, patients underwent fixation with knotless anchors.

Postoperative Rehabilitation

Patients underwent a strict postoperative protocol in which they were kept in a sling with an abduction pillow for the first 6 weeks and performed pendulum exercises and passive motion only. A formal physical therapy regimen started at 4 weeks with passive ROM, passive posterior capsular and internal rotation stretching, scapulothoracic mobility, and biceps, rotator cuff, and capsular stabilizer strengthening. At 10 weeks, patients began biceps, rotator cuff, and scapular stabilizer resistance exercises, and at 16 weeks, throwing athletes began an interval throwing program. Patients were first eligible to return to sport without limitation at 9 months.

Statistical Analysis

Return to play, KJOC, ASES, stability, ROM, strength, and pain scores were analyzed and compared using Fisher exact test, the Kruskal-Wallis test, and the Wilcoxon rank sum test, where appropriate. The level of statistical significance was α = 0.05.

Results

Of the 74 athletes who met inclusion criteria, 28 were female (37.8%) and 46 (62.2%) were male. The average follow-up was 6.5 years with a minimum of 2 years and a maximum of 12 years. Forty-two (56.8%) patients underwent traditional knotted suture anchor fixation and 32 (43.2%) underwent knotless anchor fixation. The average age was 30.1 +/- 13.6 years, with a range of 14 to 64 years. The majority of athletes were right hand dominant (79.9%). Fifty-three (72%) were overhead athletes and 29 (39%) were throwing athletes (Table 1). The average age in the knotted group was 33.3 years: 29 of 42 (69%) were overhead athletes and 20 (47.6%) were throwing athletes. In the knotless group, the average age was 25.8 years: 24 of 32 (75.0%) were overhead athletes and 9 (28.1%) were throwing athletes. Primary sports at the time of injury are listed in Table 2. The average number of anchors used was 3.1, with 17 patients (23.0%) requiring ≤2 anchors, 39 (52.7%) requiring 3 anchors, and 18 (24.3%) requiring ≥4 anchors for repair. The number of anchors used was determined intraoperatively by the surgeon on the basis of the size and extent of the tear. Of the entire group of 74 patients, 91.9% returned to sport, 56.8% returned to the same level, 35.1% returned at a lower capacity, and 8.1% were unable to return to sport. Knotless anchors had a slightly higher overall RTP compared with traditional anchors (93.5% vs 90.2%, P = .94), as well as a higher RTP at the same level (58.1% vs 53.7%, P = .81). These differences were, however, not statistically significant (Table 3).

Knotless anchors were less likely to require revision surgery than traditional anchors (9% vs 17%, P = .50), but this difference was not statistically significant (Table 3). In the knotted group, 5 patients had revision surgery for rotator cuff tears, and 2 patients had recurrent SLAP tears. In the knotless group, 2 patients had revision...
surgeries for a torn rotator cuff, and 1 patient had a snapping scapula. A power analysis found that it would take over 300 athletes in each group to detect a significant difference in the revision rate between knotless and traditional anchors.

Although KJOC (66.1 vs 65.6 P = .61) and ASES (86.3 vs 85.3 P = .79) scores were also superior with knotless anchors, these differences in scores were not statistically significant (Table 3). Pain was the only variable that was linked to decreased RTP, as patients who rated higher on a pain scale of 0 to 10 were less likely to return to their sport (P < .0001). There was no correlation in outcome measures or RTP with gender, age, number of anchors, or sport type (P > .05). There was no statistically significant difference in RTP, KJOC, or ASES scores between non-overhead and overhead athletes (Table 4). Overall return to sport in throwers was 85.7% (24/28), while 39.3% (11/28) returned at the same level, 46.4% (13/28) at a lower level, and 14.3% (4/28) did not return to sport.

**Discussion**

There was no significant difference between knotted and knotless fixation in clinical outcomes or return to sport in the repair of SLAP IIb tears; however, there was a trend toward knotless anchors requiring less revision surgery and having higher RTP, ASES, and KJOC scores than knotted fixation. Despite the inclusion of 74 patients, this study was significantly underpowered, as a power analysis calculated that over 300 athletes would be required in each group to detect a difference in the revision rate.

SLAP tears, traditionally treated with knotted suture anchors, have yielded varying results in the literature, with good to excellent results being reported in 65% to 94% of patients. The success of SLAP repairs in athletes, especially overhead athletes, remains a difficult problem, as they are common injuries, and RTP is less predictable. Studies differ with regard to the percentage of overhead athletes who are able to return to their previous level of sport, with ranges being reported from 22% to 92%. In a systematic review of 198 patients, Sayde and colleagues found that 63% of overhead athletes treated with anchor fixation, tacks, or staples were able to return to their previous level of play. Morgan and colleagues found a higher return to sport when compared with other studies, reporting that 83% of patients undergoing SLAP repairs using traditional suture anchors had excellent results, and 87% of the 53 overhead athletes had excellent results based on UCLA shoulder scores. Further, 37 of the 44 pitchers examined (84%) were able to return to their pre-injury levels. This is in contrast to Friel and colleagues who found that in 48 patients with type II SLAP tears treated with traditional anchors, 23% reported excellent and 56% reported good results in regards to UCLA shoulder scores. Friel and colleagues also found that 62% of all athletes and 59% of overhead athletes were able to return to their previous levels of sport, which is similar to the current study. The large discrepancy in RTP at the pre-injury level between this study and that of Morgan and colleagues may be due to the shorter minimum follow-up of 1 year as well as the inclusion of all subtypes of SLAP II tears in the latter. The current study had a minimum 2-year follow-up period, with an average of 6.5 years, and was limited to SLAP IIb tears. With a longer follow-up period, patient outcomes and RTP, particularly in overhead sports, may deteriorate; therefore, the current study likely shows a more complete and accurate result.

Knotless anchors were originally introduced as a less time consuming, lower profile, and simpler device to learn and use for arthroscopic procedures. Kocaoglu and colleagues found that in Bankart repairs, the mean time per anchor placement for knotted anchors was 380 seconds, whereas placement of knotless anchors took on average 225 seconds. A learning curve also exists for proper and efficient knot tying. There is also variation in knot tying between surgeons, as evidenced by a wide range in both load to failure and knot height. A study performed by Hanypsiak and colleagues found that the surgical knot was the weakest portion of the suture-anchor construct, as
the knot’s load to failure was less than the pullout strength of the anchor.

There is also concern for the added height associated with traditional knotted fixation, which has been supported by case reports of knot-induced glenoid erosion after arthroscopic fixation of a SLAP tear. Hanypsiak and colleagues also found that the average knot height occupied 50% to 95% of the space between the humeral head and the acromion when the shoulder is in a neutral position, indicating that the higher profile knotted anchors may contact the undersurface of the acromion, which could affect the labral repair as well as cause rotator cuff injury. Abrasion of the rotator cuff by a prominent knot may cause pain, tearing, and disability. A recent study by Park and colleagues reported on 11 patients with knot-induced pain after type II SLAP repair. All complained of sharp pain, with 64% also complaining of clicking. Knot location did not seem to matter, as there was no difference in preoperative symptoms, with 5 of the 11 patients having knots on the glenoid side of the repair on repeat arthroscopy. Patients with knots on the labral side did, however, have humeral head cartilage damage. The knots appeared to be the cause of pain and clicking, as after arthroscopic knot removal, dramatic pain relief was seen, with Constant and UCLA scores significantly improving in all 11 patients. All patients also had positive preoperative compression-rotation testing, and at 6 weeks after surgical knot removal, all were negative.

Further, as shown by Dines and colleagues, knotless anchors may help to better restore the meniscoid anatomy of the superior labrum better than knotted suture anchors. With regards to fixation strength, Uggen and colleagues, using a cadaveric model, found no difference in initial fixation strength of knotless and traditional suture anchor repair of SLAP II tears, and both restored glenohumeral rotation without over-constraining the shoulder.

Despite the shorter operative time, lower profile, and more consistent tensioning with knotless anchors, the literature is limited with regard to evaluating patient outcomes. In a study by Yung and colleagues, 14 of the 16 patients with type II SLAP tears were treated with knotless anchors, and the authors found that 31.3% of patients had an excellent UCLA score while 43.8% had a good score. This is similar to the outcomes illustrated in studies by both Friel and colleagues and Sayde and colleagues. In a more recent study, Yang and colleagues did find some benefit in regard to ROM with knotless fixation. Their study consisted of 21 patients who underwent surgery with traditional knotted anchor fixation and 20 who underwent knotless horizontal mattress fixation. They found an average UCLA score of 37.6 and ASES score of 91.5 in patients undergoing knotless fixation, and the knotless fixation group had 5% greater total ROM, 15.6% more internal rotation at abduction, and 11.4% more external rotation at the side as compared with patients undergoing the traditional knotted technique. When compared with the current study, this study also had a significantly shorter follow-up period of 3 years. In a 2017 study, Bents and colleagues compared 44 patients who underwent knotless and 119 who underwent knotted fixation of SLAP tears. They found no statistically significant difference between knotless and knotted fixation in the ASES score, Visual Analog Scale (VAS), ASES, or Veterans RAND 12-Item Health Survey (VR-12) at 1 year postoperatively. Their outcomes were similar to those of the current study, but as in other mentioned literature, the study by Bents and colleagues included multiple surgeons with different postoperative protocols, was not limited to SLAP IIb tears, and also had a shorter follow-up of 1 year. Like Kocaoglu and colleagues, Bents and colleagues did find knotless anchors to be more efficient, as operative time was reduced by 5.3 minutes per anchor. This likely would have a significant impact on surgical cost and surgeon productivity.

One limitation of the current study was that despite the inclusion of >70 patients, the study was still significantly underpowered. It was determined that >300 patients in each group would be required to detect a significant difference in the revision rate between the 2 anchor types. Also, due to the retrospective nature of this study, no preoperative scores were collected. The inclusion of objective clinical measurements and follow-up imaging evaluating the rotator cuff and other anatomy would also be of interest.
Although statistical significance was not achieved, there was a trend toward knotless fixation requiring less revision surgery and having higher RTP, ASES, and KJOC scores when compared with traditional knotted fixation at 6.5-year follow-up. Larger studies with longer follow-up periods are necessary to determine the effects of knotted and knotless anchors on rotator cuff tears, patient reported outcomes, and RTP. These complications have been shown in the literature, mostly in case reports, and typically develop over a longer period.\textsuperscript{23} Despite this, other advantages of knotless fixation, such as its lower profile, the ability to better provide consistent tensioning, and decreased surgical time are important to consider.

**Key Info**

**Figures/Tables**

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<td><strong>Table 1. Patient Demographics</strong></td>
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<td><strong>Athletes (N)</strong></td>
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<td><strong>Age (yr)</strong></td>
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<td><strong>Knotless anchors</strong></td>
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<td><strong>Overhead athletes</strong></td>
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<td><strong>Throwing athletes</strong></td>
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<td><strong>Follow-up (yr)</strong></td>
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| **Table 2. Primary Sport at Time of SLAP IIb Injury** |
| **Primary Sport** | n (%) |
| Baseball | 14 (19.7%) |
| Softball | 8 (11.3%) |
| Volleyball | 6 (8.5%) |
| Basketball | 5 (7.0%) |
| Golf | 5 (7.0%) |
| Other Sport | 33 (46.5%) |
| No Primary Sport | 3 (4.1%) |

Abbreviation: SLAP, superior labrum anterior to posterior.

<p>| <strong>Table 3. Comparison of Anchor Type in Surgical Fixation of SLAP IIb Tears</strong> |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| | RTP | RTP Same Level | ASES | KJOC | Revision Rate |
| Knotless anchors (n = 32) | 93.5% | 58.1% | 86.3 + 10.5 | 66.1 + 29.6 | 9% |
| Traditional anchors (n = 42) | 90.2% | 53.7% | 85.3 + 15.6 | 65.6 + 27.2 | 17% |</p>
<table>
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<tr>
<th>P-value</th>
<th>.94</th>
<th>.81</th>
<th>.79</th>
<th>.61</th>
<th>.50</th>
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Abbreviations: ASES, American Shoulder and Elbow Surgeons; KJOC, Kerlan-Jobe Orthopaedic Clinic; RTP: return to play.

### Table 4. Overhead vs Non-Overhead Athletes After Surgical Fixation of SLAP IIb Tears

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<th>RTP</th>
<th>RTP Same Level</th>
<th>ASES</th>
<th>ASES Good-Excellent</th>
<th>KJOC</th>
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<tr>
<td>Overhead</td>
<td>90.6%</td>
<td>52.3%</td>
<td>91.7 + 14.1</td>
<td>98.1%</td>
<td>64.6 + 25.7</td>
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<tr>
<td>Non-Overhead</td>
<td>95.5%</td>
<td>72.7%</td>
<td>86.7 + 12.7</td>
<td>100%</td>
<td>88.5 + 29.6</td>
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<tr>
<td>P value</td>
<td>0.1</td>
<td>0.29</td>
<td>0.76</td>
<td>0.50</td>
<td>0.49</td>
</tr>
</tbody>
</table>

Abbreviations: ASES, American Shoulder and Elbow Surgeons; KJOC, Kerlan-Jobe Orthopaedic Clinic; RTP: return to play.

### References

References


**Multimedia**

**Product Guide**

**Product Guide**

- STRATAFIX™ Symmetric PDS™ Plus Knotless Tissue Control Device
- STRATAFIX™ Spiral Knotless Tissue Control Device
- BioComposite SwiveLock Anchor
- BioComposite SwiveLock C, with White/Black TigerTape™ Loop

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**Citation**
