

# Reported Technical Aspects of Type II SLAP Lesion Repairs in Athletes



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**Purpose:** To systematically review the available literature to further describe and report the available data on SLAP repair techniques and the association with outcomes. **Methods:** A systematic review of literature was performed on manuscripts describing type II SLAP repairs in athletes. Selection criteria included studies reporting exclusively type II SLAP tears without concomitant pathology, minimum 2-year postoperative follow-up, use of anchor fixation, and return to previous level of play data available. We extracted patient outcome as well as surgical construct details from each article. Average outcomes and return to play rates were calculated and substratified further by athlete type. Return to play rates were compared by repair constructs with the Student *t* test. **Results:** Initial search resulted in 107 articles. After exclusion criteria were applied, 17 articles were included in the final analysis. Overall, 84% of patients had good-to-excellent results. Of all athletes, 66% returned to previous level of play. There was significant variation in reported technique in terms of anchor number, location, material, suture type, and knotless versus knotted constructs. No significant difference was reported in outcomes in comparison of suture type (*P*-value .96) or knotted versus knotless constructs (*P*-value .91). Given the significant variability in reporting, no statistical analysis was felt able to be performed on anchor location and number. **Conclusions:** Repair of type II SLAP tears in athletes is a difficult problem to treat with overall low return to play despite a high rate of “good” outcomes when assessed by outcome measures. Significant variability exists in surgical technique, as well as reporting of surgical technique, potentially limiting the ability to define the best or most effective technique for SLAP repair. **Level of Evidence:** IV, systematic review of level III and level IV studies.

A tear in the superior labrum from anterior to posterior, or SLAP, was first reported by Andrews et al. in 1985 and further defined by Snyder et al. in

1990.<sup>1,2</sup> Type II SLAP tears, the most common type, are described as labral fraying with detachment of the superior labrum and associated biceps anchor from the glenoid (Fig 1). Overhead and contact sports are commonly described as the main risk factors for type II SLAP tears.<sup>3</sup>

Type II SLAP tears can be a significant source of pain and decreased performance in athletes, particularly those who participate in overhead activities. The superior labrum helps to restrain translation of the humerus. Loss of this restraint in a SLAP lesion may be the cause of the pain experienced in overhead athletes.<sup>4</sup> Increased attention has been placed on appropriate treatment for these injuries in athletes to optimize return to play or sport. The incidence of SLAP repair has risen recently in the United States.<sup>5,6</sup> Previous systematic reviews of SLAP repairs in athletes show an overall 83% good-to-excellent patient satisfaction, with a 73% return to previous level of play in all athletes. Unfortunately, the results in overhead athletes are not quite as favorable, with a reported return to play rate of only 63% and as low as 48% in baseball pitchers with return to previous performance quoted as low as 7% in pitchers.<sup>3,7</sup> Despite the increasing rate of SLAP

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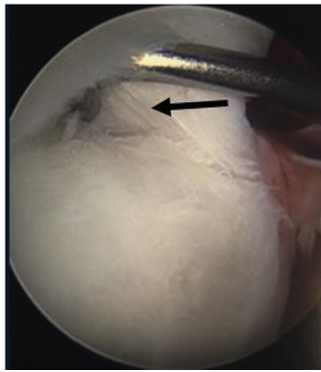
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**Fig 1.** Intraoperative arthroscopic view of right shoulder in lateral decubitus position through posterior portal showing a type IIb SLAP tear demonstrating full-thickness tearing from below the biceps anchor insertion posteriorly (black arrow).

repairs,<sup>5,6</sup> there is little in terms of consensus regarding optimal surgical technique. There is a relative paucity of literature comparing SLAP repair construct details such as number, type, and position of anchors, as well as type of suture material used in the repair. Furthermore, most of the literature is in the form of level III or level IV evidence.

Given poor return-to-play rates after type II SLAP repairs in athletes and lack of consensus on repair constructs and technical details, the purpose of this study sought to systematically review the available literature to further describe and report the available data on SLAP repair techniques and the association with outcomes. Specifically, we sought to compare patient satisfaction and return-to-play rates for all athletes, with emphasis on baseball athletes in isolation, based on the type of repair construct that was performed. These factors would include anchor position, number of anchors, anchor material, suture type (absorbable vs nonabsorbable), and knotted versus knotless suture anchors. We hypothesized that there would be significant variability in reported surgical techniques with no identifiable significant differences between the techniques.

## Methods

### Search Details

A systematic search of PubMed, MEDLINE, and Cochrane databases was performed. Our search focused on manuscripts describing type II SLAP repairs in athletes up to December 31, 2018. Criteria included studies reporting exclusively type II SLAP tears without concomitant pathology, minimum 2-year postoperative follow-up, use of anchor fixation, and return to previous level of play data available. Articles using staples or tacks for labral repair were not included so as not to skew our data, as these have generally fallen out of favor to anchor fixation.

### Data Extraction

After final articles were selected based on the aforementioned search criteria, data were extracted on patient outcomes as well as surgical technique and construct details. Patient outcome data included patient satisfaction based on the outcome measure used in the respective study, return to previous level of play for all athletes (and the definition of return to play they used), return to previous level of play for overhead athletes, and return to previous level of play for baseball players when available. Surgical data extracted included anchor position, number of anchors used, anchor material, suture type used, suture technique, and whether knotted or knotless constructs were used. Level of evidence of each individual study also was identified.

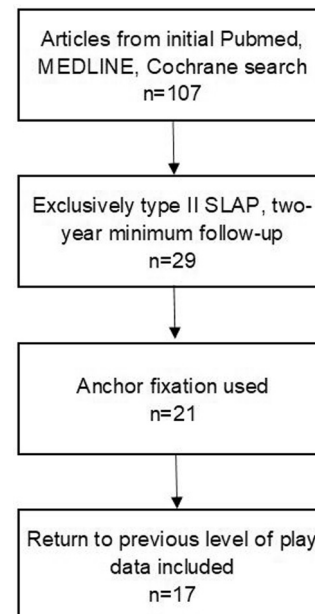
### Statistical Analysis

All outcome and surgical technique data available from the included articles were extracted. Satisfaction outcomes and percent return to play was calculated as weighted averages from the included studies. The return to play weighted averages were also substratified by overhead and baseball athletes as reported in the respective articles. A Student *t* test was performed to compare the return to play rates between knotted and knotless constructs.

## Results

### Article Selection

The initial search generated 107 articles using our search strategy. Review of these abstracts focusing on



**Fig 2.** Flowsheet of reviewed manuscripts and inclusions/exclusion criteria used for final selection of included manuscripts in review of type II SLAP repairs. As illustrated, 17 manuscripts met inclusion/exclusion criteria and were used for final review.

**Table 1.** Surgical Outcomes

Study	Year	All Patients			Overhead Athletes		Baseball Athletes		Outcome Measure	Study Design	Level of Evidence
		Number	% Good-to-Excellent Satisfaction	% Return to Play	Number	% Return to Play	Number	% Return to play			
Morgan et al. <sup>8</sup>	1998	102	87	n/a	53	n/a	44	84	UCLA	Retrospective case series	IV
Kim et al. <sup>9</sup>	2002	34	94	76	18	22	n/a	n/a	UCLA	Retrospective case series	IV
Ide et al. <sup>10</sup>	2005	40	90	75	40	75	19	63	Rowe	Retrospective case series	IV
Enad et al. <sup>11</sup>	2007	27	89	77	n/a	n/a	n/a	n/a	ASES, UCLA	Retrospective case series	IV
Yung et al. <sup>12</sup>	2008	16	92	94	13	n/a	n/a	n/a	UCLA	Prospective cohort	III
Brockmeier et al. <sup>13</sup>	2009	47	87	74	28	71	11	64	ASES, L'Insalata	Retrospective case series	IV
Boileau et al. <sup>14</sup>	2009	25	40	20	15	n/a	n/a	n/a	Constant-Murley	Prospective cohort	III
Friel et al. <sup>15</sup>	2010	48	76	59	13	54	7	86	UCLA (multiple others, but UCLA used for analysis)	Prospective case series	IV
Galano et al. <sup>16</sup>	2010	22	n/a	90	13	90	2	n/a	ASES, VAS, SST	Retrospective case series	IV
Neuman et al. <sup>17</sup>	2011	30	93	67	30	67	21	52	ASES, KJOC	Retrospective case series	IV
Park et al. <sup>18</sup>	2013	24	76	50	24	50	16	38	VAS, ASES	Retrospective Case series	IV
Maier et al. <sup>19</sup>	2013	12	n/a	75	9	56	n/a	n/a	Constant score, SSV	Retrospective case series	IV
Fedoriw et al. <sup>7</sup>	2014	30	n/a	43	30	43	30	43	Return to play, return to previous level of play	Retrospective case series	IV
Ek et al. <sup>20</sup>	2014	10	90	60	n/a	n/a	n/a	n/a	ASES, Satisfaction score, VAS	Retrospective cohort	IV
Gilliam et al. <sup>21</sup>	2018	133	n/a	64	133	64	133	64	WOSI, VR-12	Retrospective Case series	IV
Reinig et al. <sup>22</sup>	2018	28	n/a	33	n/a	n/a	n/a	n/a	NAS, ASOSS, SSAS	Retrospective cohort	III
**Other arm of Reinig study**		33	n/a	50	n/a	n/a	n/a	n/a	NAS, ASOSS, SSAS	Retrospective cohort	III
de Groot et al. <sup>23</sup>	2018	42	n/a	90	53	91	14	n/a	ASES, KJOC	Retrospective case series	IV
**Other arm of de Groot study**		32	n/a	93	**No distinguishing between knotted/knotless				ASES, KJOC	Retrospective case series	IV

ASOSS, American Orthopaedic Society for Sports Medicine; ASES, American Shoulder and Elbow Surgeons; KJOC, Kerlan-Jobe Orthopaedic Clinic; n/a, not available; NAS, numerical analogue scale; SSAS, shoulder sport activity scale; SST, Simple Shoulder Test; UCLA, University of California Los Angeles; VAS, visual analog scale; VR-12, Veterans RAND 12-item health survey; WOSI, Western Ontario Shoulder Instability Index.

**Table 2.** Surgical Techniques

Study	Year	Fixation Type	Anchor Construct Detail				
			Anchor Position	Anchor Type	Anchor Number	Suture Type	Knotted vs Knotless
Morgan et al. <sup>8</sup>	1998	Anchor	Anterior and/or posterior depending on tear	Metal	2	81 w/PDS, 21 w/ETHIBOND	Knotted
Kim et al. <sup>9</sup>	2002	Anchor	Biceps insertion	Metal	1 w/more "as needed"	ETHIBOND	Knotted
Ide et al. <sup>10</sup>	2005	Anchor	1 anterior, 1 posterior	Biocomposite	2 w/more "as needed"	ETHIBOND	Knotted
Enad et al. <sup>11</sup>	2007	Anchor	Anterior and/or posterior depending on tear	Biocomposite	n/a	n/a	Knotted
Yung et al. <sup>12</sup>	2008	Anchor	Anterior and/or posterior depending on tear	Biocomposite	2-4	PDS	Knotted
Brockmeier et al. <sup>13</sup>	2009	Anchor	Anterior unless tear extends too far posteriorly	n/a	1 w/more "as needed"	Nonabsorbable	Knotted
Boileau et al. <sup>14</sup>	2009	Anchor	1 anterior, 1 posterior	Biocomposite	2	n/a	Knotted
Friel et al. <sup>15</sup>	2010	Anchor	Under biceps insertion and posterior	Biocomposite	2	n/a	Knotted
Galano et al. <sup>16</sup>	2010	Anchor	Posterior	Biocomposite	1 w/more "as needed"	n/a	Knotted
Neuman et al. <sup>17</sup>	2011	Anchor	Anterior and/or posterior depending on tear	Biocomposite	1-4	n/a	Knotted
Park et al. <sup>18</sup>	2013	Anchor	1 anterior, 1 posterior with additional posterior as needed	Biocomposite	2-4	Nonabsorbable and absorbable	Knotted
Maier et al. <sup>19</sup>	2013	Anchor	Anterior and/or posterior depending on tear	Biocomposite	1-2	FiberWire	Knotted
Fedoriw et al. <sup>7</sup>	2014	Anchor	n/a	n/a	n/a	n/a	n/a
Ek et al. <sup>20</sup>	2014	Anchor	Beneath biceps insertion, or just posterior	Biocomposite	1	PDS	Knotted
Gilliam et al. <sup>21</sup>	2018	Anchor	n/a	n/a	n/a	n/a	Knotted
Reinig et al. <sup>22</sup>	2018	Anchor (knotted)	1 anterior, 1 posterior	n/a	2	Nonabsorbable	Knotted (vs knotless)
**Other arm of Reinig study**		Anchor (knotless)	1 anterior, 1 posterior	n/a	2	Nonabsorbable	Knotless (vs knotted)
de Groot et al. <sup>23</sup>	2018	Anchor (knotted)	Posterior	Biocomposite	1-4	FiberWire	Knotted (vs knotless)
**Other arm of de Groot study**		Anchor (knotless)	Posterior	Biocomposite	1-4	Labral tape/suture tape	Knotless (vs knotted)

n/a, not available; PDS, polydioxanone.

**Table 3.** Summary Table

Number of articles reviewed	107
Number of articles reviewed	17
Articles reporting number of anchors, %	82.3%
Articles reporting position of anchors, %	88.2%
Articles reporting type of anchor, %	82.3%
Articles reporting type of suture, %	58.8%

studies reporting exclusively type II SLAP tears without concomitant pathology and with minimum 2-year postoperative follow-up resulted in 29 articles. Eliminating studies that did not use suture anchors left 21 articles (1 used staple, 7 used tacks). Of these, 4 articles did not have any return-to-play data reported. This left us with a final article total of 17 for the review. A flowsheet of the article selection is illustrated in Fig 2.

### Surgical Outcomes

Surgical outcomes for all studies are included in Table 1.<sup>7-23</sup> Overall, 84% of the patient population had “good-to-excellent” results based on the postoperative outcome measures used in the respective studies. In all athletes, 66% returned to the previous level of play. Duration of return to play was not clearly defined in the included manuscripts. One article (Morgan et al.<sup>8</sup>) did not provide return to play data for all athletes, this was only reported for baseball players. In the articles that subdivided patients into overhead athletes and baseball players, 65% of all overhead athletes and 63% of baseball players were reported to return to their previous level of play. Only four articles specifically subdivided pitchers. In these articles, 65% of pitchers returned to their previous level of play.

### Surgical Techniques

As illustrated in Table 2, considerable variation existed in reported surgical techniques.<sup>7-23</sup> Reported anchor position varied from anterior and/or posterior depending on tear (5/17), 1 anchor anterior and 1 posterior (4/17), posterior (2/17), anterior unless the tear extends too far posteriorly (1/17), at the biceps insertion (1/17), at the biceps insertion or posterior (1/17), under biceps insertion and posterior (1/17), or not reported (2/17). Number of anchors varied from 2 anchors (4/17), 1 anchor with more “as needed” (3/17), 1-4 anchors (2/17), not reported (3/17), 1 anchor (1/17), 2 anchors with more “as needed” (1/17), 2-4 anchors (2/17), or 1-2 anchors (1/17). No specifics were provided as to how many patients within each study received a certain number of anchors if a range was provided in the surgical methods. In the manuscripts that included ranges of anchors, none of the articles described the exact number of patients who received each number of anchor (i.e., % of patients with 1

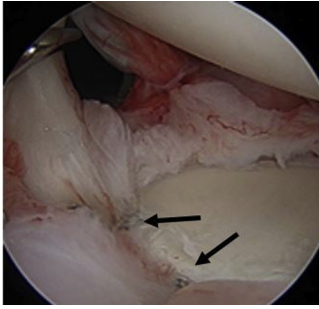
anchor, % with 2 anchors, etc.). Anchor material reported included 12 of 17 manuscripts used bio-composite anchors, 2 of 17 used metal anchors, and 3 did not report the material used or if the anchor was the biocomposite or PEEK (polyether ether ketone) version of the anchor. Suture type was not reported in 7 of 17 articles. Of the remaining, suture options included absorbable sutures such as PDS (#1) and nonabsorbable sutures such as ETHIBOND (#2), FiberWire (#2), and labral tape. Two studies reported only using absorbable sutures. Six studies reported only using nonabsorbable sutures. One study used nonabsorbable suture in 21% of patients and absorbable sutures in 79% of patients. Two studies compared knotted and knotless suture options and, therefore, had 2 separate study arms. One study did not report if they used a knotted or knotless construct. The remaining 12 studies used knotted suture construct. No studies looked at knotless sutures in isolation without directly comparing to knotted constructs. In total, 7 of 17 of the studies reported suture technique. Of these, all included simple passes. One study used horizontal mattress and simple technique depending on surgeon and tear type.<sup>19</sup> One study used lasso loop or simple sutures.<sup>11</sup> Table 3 shows a summary of reported data in the included studies.

In comparison of suture type, there was a 90% good-to-excellent satisfaction rate in the nonabsorbable population and 91% in the absorbable population ( $P$ -value .96). There was a 75% return to previous level of play rate in the nonabsorbable population and 81% in the absorbable population. This difference was not statistically significant ( $P$ -value .46). Comparing knotted versus knotless constructs, we found there were no data available in terms of patient satisfaction with the knotless constructs. However, with regards to return to previous level of play, 67% of patients with the knotted construct and 71% with the knotless construct returned to their previous level of play. This difference was also not statistically significant ( $P$ -value .91). Given the high variability in anchor number and position, no further statistical analysis could be performed on the anchor details.

### Discussion

This study provides further evidence of the overall lower return to play rates after type II SLAP repairs in this population. More importantly, this study highlights the significant variability in surgical techniques and constructs used for this operation and thus questions whether surgical technique could provide a more predictable and better chance at successful return to play. Type II SLAP tears have traditionally been difficult to treat in athletes, particularly overhead throwing athletes. The outcomes of nonoperative management in throwing athletes have been shown to be inferior to those in nonthrowing athletes.<sup>24</sup> High levels of success

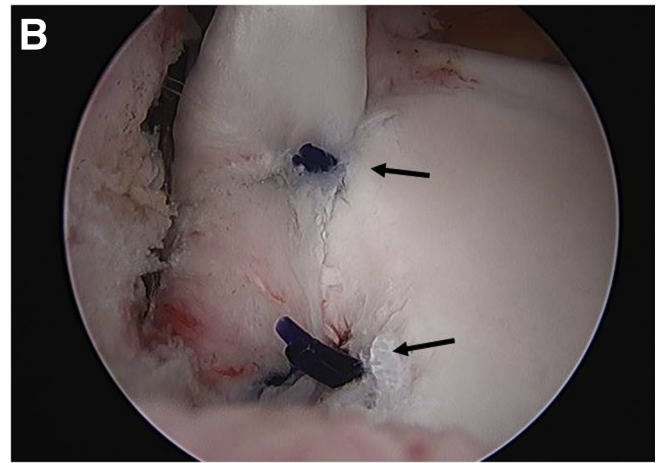
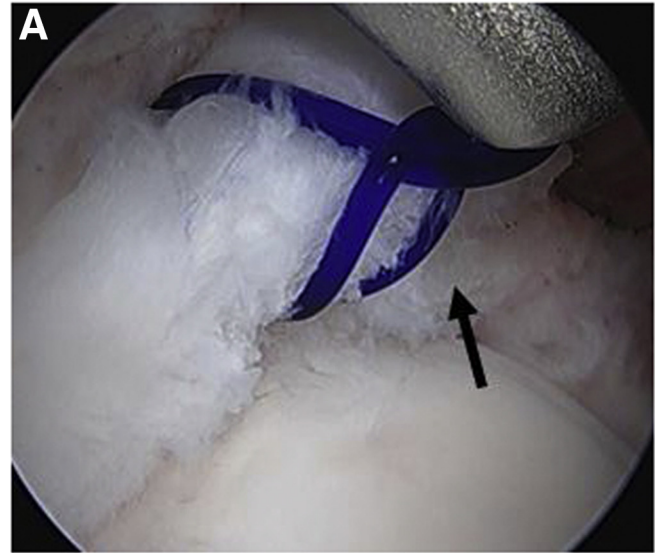




**Fig 3.** Intraoperative arthroscopic image of right shoulder in lateral decubitus position through a posterior portal during type II SLAP repair. Two knotless anchors with heavy #2 nonabsorbable suture passed in a simple fashion posterior to the biceps anchor insertion (black arrows).

for surgical treatment of type II SLAP tears were reported early in the general population, as well as military recruits, with up to 97% “good-to-excellent” results.<sup>8,11</sup> However, results for high-level athletes and overhead athletes have traditionally been less successful, which has been echoed by our review.<sup>3,25</sup>

In the studies included in our review, anchor construct detail was extremely variable. Only 7 of the 17 (41%) manuscripts gave specific descriptions of anchor position on the glenoid, as well as number of anchors used. The remainder of the articles generally provided vague descriptions of anchor placement location. Some articles provided a range of anchors; however, these articles did not generally provide rationale for number of anchors used or the location, nor did they provide a breakdown of the number of patients with different anchor number and location combinations. Although these lesions can be variable and require patient-specific approach for repair, which can lead to requirements of different anchor locations and number of anchors, there are certain well-established biomechanical principles for type II SLAP repairs. Proper anchor placement can have a significant impact on shoulder biomechanics, and could be, arguably, the most important aspect of SLAP repairs. Morgan et al.<sup>26</sup> showed in a cadaveric model that there was no biomechanical advantage to an anterior suture anchor, and argued that 2 posterior suture anchors is biomechanically preferable. McCulloch et al.<sup>27</sup> used a cadaveric throwing model to show that repair of type II SLAP tears with an anterior anchor resulted in a loss of 2.0° of external rotation. Although this could be reasoned to not be clinically significant, this loss could be extremely detrimental to an overhead throwing athlete. However, 2 degrees of loss depending on how this was measured could be in the standard deviation of error and therefore might not be of relevance. Of note, 9 of the 17 articles (53%) included in our study reported anterior anchor placement in at least a portion of their patient



**Fig 4.** (A) Intraoperative arthroscopic image of right shoulder in lateral decubitus position through a posterior portal during type II SLAP repair. #1 PDS absorbable suture has been passed in a luggage tag technique (black arrow). (B) Intraoperative arthroscopic image of right shoulder in lateral decubitus position through a posterior portal during type II SLAP repair. Two knotless anchors with #1 PDS passed in luggage tag technique and placed posterior to the biceps anchor insertion (black arrows). The elasticity of the suture could be less constraining on the labrum and luggage tag allow the labrum to position itself in a more anatomic fashion. (PDS, polydioxanone.)

population. Although current dogma believes this anterior based anchor could overconstrain a throwers ability to reach the needed external rotation to be effective, the poor rates of return of throwers with anchors only posterior to the biceps anchor may be grounds to rethink this traditionally held belief. Additionally, in our experience, it is rare that a SLAP repair would require more than 3 anchors. Four of the 17 (23.5%) included articles mentioned using up to 4 anchors in certain patients.

It has been hypothesized that, in type II SLAP repairs, knotted anchors are bulkier and can abrade the rotator cuff or internally impinge which may lead to postoperative or ongoing pain. There are also concerns regarding the consistency of tensioning during knot tying with these constructs.<sup>23,28</sup> Some recent studies have attempted to directly compare knotted and knotless suture anchors.<sup>22,23</sup> Neither of these studies reported significant differences in return to sport between the knotted and knotless anchors. However, Reinig et al.<sup>22</sup> did report significantly improved range of motion postoperatively in the knotless group. Given the low population size in each of these studies, it is possible that a difference would be seen in return to play rates with a larger population given the improved range of motion in the knotless group, but this requires further study. Dines et al.<sup>29</sup> showed that a knotless anchor technique can help recreate the normal anatomy of the superior labrum. They hypothesized that this may be beneficial to overhead throwing athletes by recreating the normal glenohumeral space and preventing potential discomfort caused by a bulky knot. In a biomechanical model, Uggen et al.<sup>30</sup> showed no difference in yield load or load to failure in knotless vs. knotted anchors. A question that deserves answering is the type of suture used. An absorbable suture such as a polydioxanone has more elasticity than a #2 nonabsorbable anchor and potentially could allow healing in a more anatomical or biologically friendly manner without the concern for knot impingement. However, broader sutures such as labral tape may have the benefit of increased strength while restoring labral height and allowing for a broader surface of compression, thus limiting “cut-through” on the labrum.<sup>31</sup> Furthermore, the technique or type of suture passage could be important and not often reported upon (Figs 3 and 4 A and B).

Future directions in the study of type II SLAP tears should be focused on both continued biomechanical studies, as well as direct clinical comparisons between these different techniques. Quality randomized controlled trials comparing different surgical techniques would be the most optimal form of study but may be difficult, given the number of variables and relatively small overall population affected by this pathology. Nonetheless, improved consistency and thoroughness in reporting clinical results would be beneficial for quality reviews of the effectiveness of differing surgical techniques. Other surgical details such as anchor position, suture passage technique, and postoperative rehabilitation protocols should be included, as they also may contribute to surgical outcomes. Furthermore, increased focus on repair strategies for subtypes of type II SLAP tears (type II-A, II-B, II-C), as well as type IX SLAP tears is important. The included manuscripts did not delineate exact subtype of SLAP tear. However,

these details may additionally be important as the amount of posterior extension of the tear and treatment strategies of repair while avoiding inhibiting a thrower’s ability to get to the late-cocking position of the throwing motion and limiting athletes’ ability to return to their prior level of play is of the utmost importance.

### Limitations

This study was not without limitations. Significant variability in reported techniques in the included studies prevented any meaningful statistical comparisons between different surgical techniques. The studies included also spanned approximately 20 years, which can result in variable indications for surgery and surgical tools and techniques available at the time of each respective study. In addition, different outcome measures were used in these studies to define “good-to-excellent” results. Given that most studies included involved a low number of patients, it is possible that our study is underpowered to find statistical differences in surgical techniques. It should be noted that general shoulder outcome scores such as American Shoulder and Elbow Surgeons, Constant, etc., are not as reliable for the overhead athlete. Only 2 of the included articles used the Kerlan-Jobe Orthopaedic Clinic, which more specifically is tailored for overhead athletes.<sup>32</sup>

### Conclusions

Repair of type II SLAP tears in athletes is a difficult problem to treat with overall low return to play despite a high rate of “good” outcomes when assessed by outcome measures. Significant variability exists in surgical technique, as well as reporting of surgical technique potentially limiting the ability to define the best or most effective technique for SLAP repair.

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