

Do Knots Matter in Superior Labrum Anterior to Posterior Lesions Repair?

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Background: In general, the outcomes of arthroscopic repair for superior labrum anterior to posterior lesions (SLAP) are favorable, however, persistent pain and limitation of motion are not rare complications. One of the possible cause is a “knot-ache”. This study evaluated the results of reoperation of symptomatic recurrent SLAP lesions and asked whether the knot is associated with postoperative complications.

Methods: Between 2005 and 2015, a total of 11 patients who had undergone arthroscopic SLAP repair were reoperated for recurrent symptomatic SLAP lesion. By retrospective chart review, operative findings, the visual analogue scale for pain (pVAS), the range of motion (ROM), and functional scores were analyzed.

Results: The mean age of the study participants was 38.3 years, and the mean follow-up period was 42.5 months. In the primary operation, there were nine cases of repairs with conventional knot-tying anchors and three cases with knotless anchors. Impingement of the knots during abduction and external rotation of the shoulder was observed in the all cases with knot-tying anchors. The mean pVAS, ROM, and functional scores significantly improved with reoperation. At the final follow-up, the mean satisfaction VAS was 8.3.

Conclusions: The knots of suture anchor maybe a possible etiology of the pain, which we termed a “knot-ache”. Considering that reoperation is performed due to pain after primary repair, the use of knotless suture anchor may have benefits of eliminating one of possible cause, “knot-ache”. Therefore, authors suggest the use of knotless anchors during reoperation for recurrent or recalcitrant pain after primary SLAP repair.

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Key Words: Arthroscopy; Postoperative complications; Reoperation; Suture anchors

Introduction

A superior labrum anterior to posterior (SLAP) lesion is a tear of the superior labrum, encompassing the origin of the biceps tendon long head. This condition is associated with symptoms such as pain, clicking sound, and joint instability. It was first discovered in an overhead throwing athlete as a tear of the labrum induced by excessive biceps tension.¹⁾ Snyder et al.,²⁾ who named the condition as a SLAP lesion, also developed a classification system to categorize them. Amongst the different

categories, they found that type II SLAP lesions were the most common form of the lesion. Over the time, the classification system was further developed. For instance, Maffet et al.³⁾ added three more categories, from type V to VII, on top of the preexisting ones, furthermore, Morgan et al.⁴⁾ sub-categorized the type II SLAP lesion by site of torn labrum.

The supposed etiologies of SLAP lesion vary, but it is generally thought that exaggerated outstretching or forceful pulling of the arm, direct compression injuries, or repetitive throwing actions are mainly accountable.⁵⁾ The functional parameters after surgi-

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cal SLAP repairs have been shown to be generally favorable.⁶⁻⁸⁾ However, Cohen et al.⁹⁾ reported that, in 41 retrospectively analyzed type II SLAP repairs, the satisfaction level reached only 71% and that nocturnal pain persisted in 41% of patients. Likewise, in another retrospective study, Provencher et al.¹⁰⁾ found that, despite a functional improvement after SLAP repairs, 37% of the 179 cases failed to recover pre-injury levels of activity and 28% had required reoperation later. These findings imply that recurrent pain and restricted motion are common postoperative complications of SLAP repair. The causes of complications after SLAP repair are known to vary¹¹⁾; therefore, it is necessary to investigate the cause and treatment of complications after SLAP repair for achieve good clinical outcomes of SLAP repair.

In this study, we investigated patients who despite a primary SLAP repair presented with recurrent or recalcitrant pain. Upon reoperation, we found that a potential cause of the unresolved pain in a number of patients was the knot-tying suture anchor and specifically the knot itself. We hypothesized that during joint exercises the knot tied above the superior labrum collides with surrounding tissues and induces an inflammatory response, which in turn causes pain. To prove this hypothesis, we analyzed patients who in spite of primary operation had recurrent or recalcitrant pain and had received reoperation. We evaluated the putative and causative factors of pain; the complications associated with the knot—or knot-ache—in SLAP repair; and the outcomes of reoperation.

Methods

Selection Criteria

We recruited a total of 15 patients (16 cases of reoperation)

who were hospitalized between 2004 and 2014 for an isolated SLAP lesion that had been treated using arthroscopic suture and had received reoperation between 2005 and 2015 for recurrent or recalcitrant symptoms. All patients were analyzed retrospectively. To select a homogeneous study population, we evaluated the patients' charts and the arthroscopic findings from the time of primary operation and included or excluded patients on the basis of those findings. Specifically, we noted the extent of SLAP lesion, classification of the lesion, the presence of any concomitant lesions at the primary treatment, the position of suture anchors, and whether the suture was tied with a knot or not. If descriptions of the SLAP lesion and/or the treatment method were not accurate enough or if the additive arthroscopic procedures had been also performed for a concomitant lesion, these cases were excluded. This led to an eligible recruit of 13 patients (14 cases).

In these patients, we conducted computed tomography (CT) arthrography to evaluate the healing status of primary repaired SLAP lesion and the cause of the pain. Only when the patient had received magnetic resonance imaging previously from different hospital, did we not perform a CT arthrography (Cases 8 and 10). Another inclusion criterion was a follow-up period of at least 12 months, leading to a final enrollment of 11 patients. Because one of the patients had a bilateral SLAP lesion, a total of 12 cases of reoperation were evaluated in this study (Table 1).

Analysis of Clinical Outcomes

We performed a retrospective review of the patients' medical records to analyze the patients' demographic characteristics, the suture material, whether or not the suture was tied with a knot, the operation method, and other treatment-related factors. As

Table 1. Chief Complaint before Reoperation, Diagnostic Method of Recurrence and Final Diagnosis before Reoperation by Cases

Case No. (sex/age, yr)	Chief complaint before reoperation	Diagnostic method of recurrence	Final diagnosis before reoperation
1 (male/42)*	Pain at abduction, external rotation	CT arthrogram	Recurred SLAP, type II
2 (male/35)*	Persistent night pain	CT arthrogram	Recurred SLAP, type II
3 (male/64) [†]	Recurred pain after slip down, FOOSH [‡] injury	CT arthrogram	Recurred SLAP, type II
4 (male/43)*	Persistent night pain	CT arthrogram	Recurred SLAP, type II
5 (male/19)*	Persistent night pain	CT arthrogram	Recurred SLAP, type III
6 (male/25)*	Recurred pain	CT arthrogram	Recurred SLAP, type II
7 (male/25)*	Recurred pain	CT arthrogram	Recurred SLAP, type II
8 (male/59)*	Pain at forward flexion, external rotation	MRI [§]	Knot-ache
9 (male/49) [†]	Recurred pain	CT arthrogram	Recurred SLAP, type II
10 (male/47)*	Persistent night pain	MRI [§]	Recurred SLAP, type II
11 (male/31) [†]	Pain at forward flexion	CT arthrogram	Knot-ache
12 (male/22)*	Pain at forward flexion	CT arthrogram	Knot-ache

CT: computed tomography, MRI: magnetic resonance imaging, SLAP: superior labrum anterior to posterior.

*Primary operation is performed by other surgeon, [†]primary operation is performed by senior author, [‡]fall on outstretched hand, [§]imaging taken by outside hospital.

our parameters of functional score, the American Shoulder and Elbow Surgeons (ASES) score, the Simple Shoulder Test (SST) score, the Constant score, the Korean Shoulder Scoring System (KSS), and the Shortened version of the Disabilities of the Arm, Shoulder and Hand (Quick-DASH) score were measured, both preoperatively and postoperatively at the final follow-up. Preoperative and postoperative pain was measured as the visual analogue scale for pain (pVAS). The range of motion (ROM; forward elevation and external rotation) was measured using a goniometer, whereas internal rotation was evaluated as the height of the spinous process that could be reached with the thumb.¹²⁾ To assess the patients' subjective score for satisfaction of treatment outcomes, we measured the visual analogue scale for satisfaction (sVAS), where 0 denotes least satisfaction and 10, most satisfaction. A satisfactory treatment outcome was defined as an 8-point sVAS or higher.

Treatment Method

Each patient was positioned in lateral decubitus position, and the arm was extended into operation position using the Spider Limb Positioning System (Smith & Nephew, Andover, MA, USA). We performed diagnostic arthroscopy of the previously repaired SLAP lesion, during which we also evaluated factors concerning the preexisting suture anchors, such as the position of anchor, knot-tying of the suture, suture condition, joint abrasion upon movement, and the other pathologies within intraarticular and subacromial spaces.

For recurrent SLAP lesions, if we observed arthroscopically that the state of the superior labrum was fair, we performed reoperation of the SLAP lesion with knotless anchors. However, for recurrent SLAP lesions with a poor status of labral tissue and/or with a concurrent partial tear of the long head of biceps tendon, we performed biceps tenotomy or tenodesis, for which indications such as patient age, dominance, and mobility were deliberated.

For healed SLAP lesions, we decided whether or not to proceed with treating the biceps tendon, depending on the pres-

ence of concomitant lesion of the biceps tendon. Any loosened anchors were removed, and any suture materials that had loosened knots and/or knots which collided with surrounding tissue were also removed (Fig. 1).

Statistical Analysis

All statistical analyses were performed using the PASW Statistics software package ver. 18.0 (IBM Co., Armonk, NY, USA). We summarized demographic characteristics of the study population through descriptive statistics. The pain, ROM, and functional score, which were measured preoperatively and postoperatively were analyzed using the nonparametric Wilcoxon signed rank test. The subgroup analyses of reoperation outcomes were performed using the Mann-Whitney and the Kruskal-Wallis tests. All statistical analyses employed a two-sided test, for which we used type 1 error set as an alpha level of 0.05.

Results

Demographic Characteristics

The mean age of the patients at the time of reoperation was 38.3 years (range, 19–64 years). All 11 patients were male and right-handed. One patient had presented with bilateral SLAP lesion, thus, giving a total of 12 reoperations. Of the 12 cases, ten were found in the dominant, right arm, and nine had undergone primary treatment at a different hospital. The mean time lapse between the primary repair and reoperation was 33.4 months (range, 1.2–97.0 months), and the mean follow-up period was 42.5 months (range, 12.2–112.5 months) (Table 1–3). A single case (Case 3) presented with recurrent symptoms provoked by a trauma incurred after a week of primary treatment, whilst the remaining cases presented with either recalcitrant pain or trauma-free recurrent pain (Table 1).

Findings from Primary Repair and Methods of Reoperation

At the primary SLAP repair, nine cases were repaired using conventional knot-tying suture anchors and three cases were repaired using knotless anchors. Only two SLAP lesions were

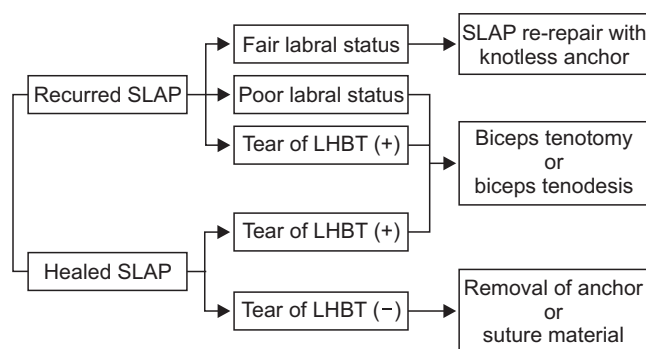


Fig. 1. Flowchart for determining treatment plan in reoperation. SLAP: superior labrum anterior to posterior, LHBT: long head of biceps tendon.

Table 2. Demographic Characteristics of the Patients Who Underwent Reoperation between 2005 and 2015

Variable	Result
Age at reoperation (yr)	38.3 (19–64)
Sex (male:female)	11:0
Hand dominance (dominant:non-dominant)	10:2
Time lapse between the primary repair and reoperations (mo)	33.4 (1.2–97.0)
Follow-up periods after reoperation (mo)	42.5 (12.2–112.5)

Values are presented as mean (range) or number only.

Table 3. Hand Dominance of Operation Site, Time Lapse between the Primary Repair and Reoperations, and Follow-up Period after Reoperation by Cases

Case No. (sex/age, yr)	Hand dominance of operation site	Time lapse between the primary repair and reoperations (mo)	Follow-up period after reoperation (mo)
1 (male/42)*	Dominant	17.3	12.2
2 (male/35)*	Dominant	14.2	112.5
3 (male/64) [†]	Non-dominant	1.2	97.5
4 (male/43)*	Dominant	19.4	71.8
5 (male/19)*	Dominant	42.1	39.2
6 (male/25)*	Dominant	74.2	42.6
7 (male/25)*	Non-dominant	78.0	34.8
8 (male/59)*	Dominant	12.7	12.2
9 (male/49) [†]	Dominant	86.9	35.8
10 (male/47)*	Dominant	20.7	12.2
11 (male/31) [†]	Dominant	16.3	12.2
12 (male/22)*	Dominant	7.2	27.5

*Primary operation is performed by other surgeon, [†]primary operation is performed by senior author.

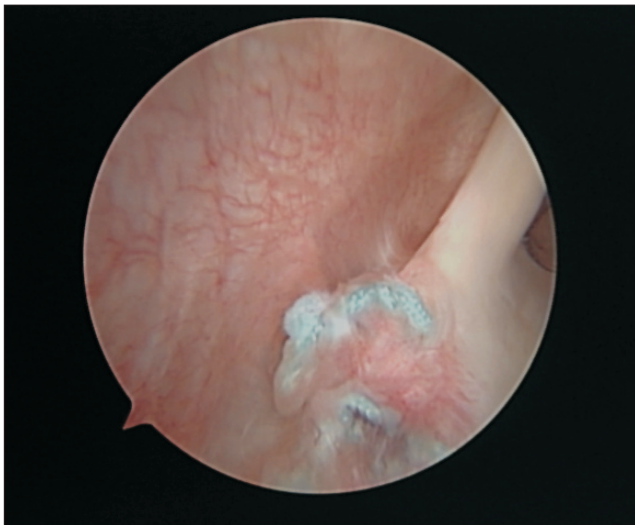


Fig. 2. When the shoulder was abducted and externally rotated under general anesthesia, impingement between suture knot and superior capsule of shoulder joint was occurred (Case 1, male/42 years).

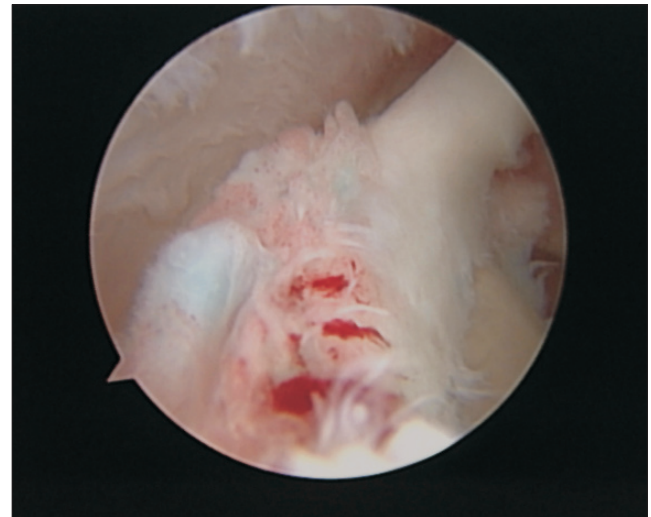


Fig. 3. Arthroscopic finding shows the reddish synovial proliferation around the knots which suggests synovitis (Case 2, male/35 years).

successfully repaired and ten were not. At the reoperation, the following methods were used: SLAP repair using knotless suture anchors (three cases); tenotomy of the biceps tendon (three cases); tenodesis of biceps tendon (five cases); and removal of anchor and suture material (one case) (Table 4, 5).

We found that all nine cases of knot-tying anchors presented with knot-induced abrasion of tissue surrounding the superior labrum during external rotation or abduction of the shoulder (Fig. 2). Amongst them, eight cases also showed signs of reddish synovial proliferation around the knot (Fig. 3). For the three cases of knotless anchors, we observed that one case had pulled-out

anchor; two (Cases 3 and 9) had a partial tear of the biceps tendon; and all three, a non-restored SLAP lesion. Unlike the cases of the knot-tying anchors, cases of knotless anchors did not present any distinctive synovitis around the anchors. Cartilage erosion of the glenoid or the humeral head because of the unfixed suture anchor was observed in two cases (Fig. 4, Table 5).

Comparative Analysis of Pre- and Postoperative Parameters of Reoperation

We found that the mean preoperative pVAS of 5.6 (range, 0–9) significantly decreased to 1.2 (range, 0–5) with reoperation ($p=0.003$). For ROMs of the shoulder, the mean forward eleva-

tion improved from 164.2° (range, 150°–180°) preoperatively to 173.3° (range, 160°–180°) postoperatively; the mean external rotation, from 63.8° (range, 40°–90°) to 79.6° (range, 45°–100°); and the mean internal rotation, from the 8.8th thoracic level (range, 4th thoracic–1st lumbar) to the 7.7th thoracic level (range, 5th thoracic–1st lumbar). All parameters of ROM showed a statistically significant increase with reoperation ($p=0.026$, 0.003, 0.040). For the functional outcome, the mean ASES score improved from 61.3 (range, 28–100) preoperatively to 91.6 (range, 58–100) postoperatively; the mean Constant score, from 71.0 (range, 39–98) to 87.4 (range, 56–100); and the mean KSS score, from 72.3 (range, 45–90) to 92.6 (range, 60–100). Again, these functional scores were associated with a statistically significant improvement with reoperation ($p=0.009$, 0.018, 0.037). Although both SST and Quick-DASH scores improved with reoperation, these improvements was not statistically significant ($p=0.085$, 0.066). We found that 10 of 12 (83.3%) reoperations

were satisfactory, and a mean sVAS of 8.3 was observed at the last follow-up (Table 6–8).

Discussion

In this study, we analyzed the cause of recurrent and/or recalcitrant pain after primary repair. The proportion of untreated SLAP lesions (83.3%, 10/12) and suture material-induced pain (41.7%, 5/12) were higher than previous study^{13,14}; however, proportion of cartilage injury was just 16.7% (2/12) (Table 9). At the time of reoperation, all nine cases of knot-tying suture anchors presented with knot-induced abrasion during external

Table 4. Type of Suture Anchor at Primary Repair and Methods of Reoperation

Variable	Case (n)
Type of suture anchor at primary repair	
Knotted	9
Knotless	3
Methods of reoperation	
SLAP repair using knotless suture anchor	3
Biceps tenotomy	3
Biceps tenodesis	5
Removal of suture anchor	1

SLAP: superior labrum anterior to posterior.

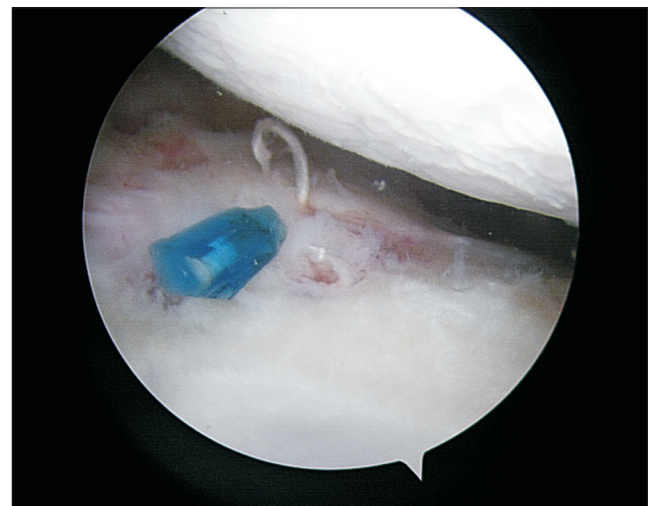


Fig. 4. Arthroscopic finding shows the broken and pulled-out suture anchor with loose suture material which induced cartilage erosion of glenoid and humeral head (Case 11, male/31 years).

Table 5. Arthroscopic Finding, Status of SLAP Lesion, Presence of Cartilage Erosion of Glenohumeral Joint, Methods of Reoperation by Cases

Case No. (sex/age, yr)	Arthroscopic finding	SLAP lesion	Cartilage erosion	Methods of reoperation
1 (male/42)*	Knot impingement	Remained	Presence	SLAP repair
2 (male/35)*	Knot impingement	Remained	Absence	SLAP repair
3 (male/64) [†]	Knotless suture anchor, Pulled-out anchor	Remained	Absence	Biceps tenotomy
4 (male/43)*	Loosen suture material	Remained	Absence	SLAP repair
5 (male/19)*	Knotless suture anchor	Remained	Absence	Biceps tenodesis
6 (male/25)*	Loosen suture material	Remained	Absence	Biceps tenodesis
7 (male/25)*	Pulled-out anchor	Remained	Absence	Biceps tenotomy
8 (male/59)*	Knot impingement	Healed	Absence	Biceps tenotomy
9 (male/49) [†]	Knotless suture anchor	Remained	Absence	Biceps tenodesis
10 (male/47)*	Knot impingement	Remained	Absence	Biceps tenodesis
11 (male/31) [†]	Pulled-out anchor, Loosen suture material	Healed	Presence	Removal of suture anchor
12 (male/22)*	Knot impingement	Remained	Absence	Biceps tenodesis

SLAP: superior labrum anterior to posterior.

*Primary operation is performed by other surgeon, [†]primary operation is performed by senior author.

Table 6. Pre- and Postoperatively Comparison of pVAS, Functional Score, ROM, and sVAS

Variable	Preoperative	Postoperative	Significance
pVAS	5.6 (0–9)	1.2 (0–5)	0.003*
ASES score	61.3 (28–100)	91.6 (58–100)	0.009*
SST score	7.6 (3–12)	10.4 (6–12)	0.085
Constant score	71.0 (39–98)	87.4 (56–100)	0.018*
KSS	72.3 (45–90)	92.6 (60–100)	0.037*
Quick-DASH	17.5 (0–55)	4.4 (0–25)	0.066
ROM			
Forward elevation (°)	164.2 (150–180)	173.3 (160–180)	0.026*
External rotation (°)	63.8 (40–90)	79.6 (45–100)	0.003*
Internal rotation	T 8.8 (T 4–L 1)	T 7.7 (T 5–L 1)	0.040*
sVAS		8.3 (83.3)	

Values are presented as mean (range) or mean (%).

pVAS: visual analogue scale (VAS) for pain, ROM: range of motion, sVAS: VAS for satisfaction, ASES: The American Shoulder and Elbow Surgeons score, SST: Simple Shoulder Test, KSS: Korean Shoulder Scoring System, Quick-DASH: Shortened version of the Disabilities of the Arm, Shoulder and Hand Score, T: thoracic, L: lumbar.

*Statistically significant.

Table 7. Pre- and Postoperatively Comparison of pVAS and ROM by Cases

Case No. (sex/age, yr)	pVAS		Forward elevation		External rotation		Internal rotation	
	PreOp	PostOp	PreOp (°)	PostOp (°)	PreOp (°)	PostOp (°)	PreOp	PostOp
1 (male/42)	5	3	170	170	50	70	T 10	T 9
2 (male/35)	5	2	180	170	90	90	T 7	T 5
3 (male/64)	6	4	150	160	50	60	L 1	T 12
4 (male/43)	7	0	180	180	85	90	T 8	T 7
5 (male/19)	8	0	180	180	80	90	T 10	T 9
6 (male/25)	0	0	160	170	40	60	T 4	T 3
7 (male/25)	2	0	165	170	40	45	T 5	T 4
8 (male/59)	9	0	155	180	50	80	T 10	T 9
9 (male/49)	7	0	150	180	70	90	T 8	T 7
10 (male/47)	6	0	150	170	70	90	T 11	T 10
11 (male/31)	7	5	160	170	80	90	T 8	T 7
12 (male/22)	5	0	170	180	60	100	T 12	T 11

pVAS: visual analogue scale for pain, ROM: range of motion, PreOp: preoperative period, PostOp: postoperative period, T: thoracic, L: lumbar.

rotation or abduction of the shoulder, and eight cases presented with combined synovitis around the knot. In contrast, all three cases of knotless anchors did not show signs of synovitis despite the fixation loss of suture anchors. These findings seem to support our hypothesis that the knot induces abrasion of the surrounding tissues during joint motion and thereby the inflammatory response. There were four cases who complained pain during shoulder exercise after primary repair (Cases 1, 8, 11, and 12); interestingly, all four cases were treated using knot-tying suture anchors in primary repair, and half had restored SLAP

lesions whilst the other half had not. This indicates that even when knot-tying anchors give successful SLAP repairs, recurrent or recalcitrant pain may be induced by inflammatory responses provoked by knot-induced abrasion.

In terms of ROM, we found that forward elevation, external rotation, and internal rotation significantly improved with re-treatment. Likewise, pVAS and functional scores improved post-operatively. At the final follow-up, we found that the mean sVAS was 8.3 and the proportion of patients who were satisfied with the clinical outcomes was 83.3%, which were higher than the

Table 8. Pre- and Postoperatively Comparison of Functional Score by Cases

Case No. (sex/age, yr)	ASES score		SST score		Constant score		KSS		Quick-DASH score		sVAS
	PreOp	PostOp	PreOp	PostOp	PreOp	PostOp	PreOp	PostOp	PreOp	PostOp	
1 (male/42)	59	83	5	7	70	85	81	91	18.2	4.5	7*
2 (male/35)	65	100	11	10	58	68			8.3	3.3	10
3 (male/64)	66	68	3	8	61	56	80	60	30.0	13.6	8
4 (male/43)	56	100	8	12	83	100	80	100	13.6	0	10
5 (male/19)	45	100	8	12	76	100	73	100	13.6	0	9
6 (male/25)	100	100	12	12	98	98	90	98	0	0	10
7 (male/25)	90	100	12	12	93	98	85	98	0	0	10
8 (male/59)	28	98	6	11	39	95	45	98	54.6	0	8.5
9 (male/49)	52	100	3	12	73	74	69	89	18.2	2.3	9
10 (male/47)		100		12		93		89		2.3	9
11 (male/31)	62	58	12	6		77		60	0	25	0*
12 (male/22)	53	100	4	12	59	100	48	99	36.4	0	9

ASES: The American Shoulder and Elbow Surgeons, SST: Simple Shoulder Test, KSS: Korean Shoulder Scoring System, Quick-DASH: Shortened version of the Disabilities of the Arm, Shoulder and Hand, sVAS: visual analogue scale for satisfaction, PreOp: preoperative period, PostOp: postoperative period.

*Unsatisfied patients.

Table 9. Causes of Recurrent Pain after Primary Repair

Variable	Unhealed SLAP lesion	Cartilage erosion	Decreased range of motion	Suture anchor and/or suture material
Weber ¹³⁾	7/24 (29.2)	14/24 (58.3)	10/24 (41.7)	9/24 (37.5)
Katz et al. ¹⁴⁾	5/21 (23.8)		30/40 (75.0)	4/21 (19.0)
Current study	10/12 (83.3)	2/12 (16.7)	8/12 (66.7)	5/12 (41.7)

Values are presented as number/total number (%).

SLAP: superior labrum anterior to posterior.

corresponding values reported in previous studies (a mean sVAS of 6.4 reported by Park and Glousman,¹⁵⁾ and a proportion of 62% reported by Katz et al.¹⁴⁾). Our results suggest that when patients are dissatisfied with outcomes of primary SLAP repair and their symptoms do not resolve despite conservative treatment, surgical treatment should then be recommended.

Ilesanya and Scheibel¹⁶⁾ reported the case of granuloma after SLAP repair using knot-tying suture, which caused a rotator cuff collision during abduction and external rotation of the shoulder. In another study, Rhee and Ha¹⁷⁾ reported a case of articular cartilage injury caused by a loosened knot in a SLAP repair. In their cadaveric study, Kim et al.¹⁸⁾ artificially created Bankart lesions and repaired them using three sutures anchors and then performed passive pendulum movements to investigated the movement of knot before and after exercise. They found that the knot of the suture anchor that had been fixed at the labral side before exercise and had shifted towards the glenoid side by more than 1 mm after exercise. Furthermore, they observed that the direction of the knot had altered and some knots were untied. With this, they suggested that the displacement of the

knot during shoulder exercise to a more intra-articular position may cause damage to the cartilage of the glenohumeral joint. In this study, we found that the two cases (Cases 1 and 11) with a low postoperative satisfaction VAS associated with reoperation had both presented with loosen suture anchors and anchor-induced cartilage erosion of the glenoid and humeral head after the primary SLAP repair (Table 8). Comparing them to cases with high sVAS scores, we found that the corresponding values for pain, ROM, and functional scores did not significantly differ between the two groups preoperatively. At the final follow-up, although mean ROMs did not significantly differ between the two, the mean pVAS (4.0 vs. 0.6; $p=0.021$) and the functional scores were significantly poorer in the cartilage injury cases (the mean functional ASES score [70.8 vs. 96.7], $p=0.021$; the mean functional SST score [6.5 vs. 11.3], $p=0.017$; and the mean functional Quick-DASH [14.8 vs. 2.2], $p=0.039$). These results suggest that when knot-tying suture anchors are used, possible complications such as damage to the glenohumeral cartilage and poor prognosis should be taken to account.

In their study that analyzed 60 SLAP repairs using knot-tying

suture anchors, Oh et al.¹⁹ suggested that complications arising from knotted sutures may be avoided by using knotless suture anchors. Comparing clinical outcomes between SLAP repairs with knotted anchors and those with knotless anchors, Yang et al.²⁰ reported, at the final follow-up, that the functional scores did not significantly differ between the groups but that the latter group had generally more improved ROM of the shoulder, in particular the external rotation and internal rotation. They also reported that the pain at the 2nd postoperative month was less in patients of the latter group, which suggests that knotless anchors give better ROMs than knot-tying anchors and reduce early-postoperative pain. Although there is no evidence that conclusively supports the superiority of knotless anchors over knot-tying anchors in SLAP repair, given that knots can potentially induce postoperative complications and thus lead to secondary treatments, it is important to discuss and evaluate their benefits.

In this retrospective study, we enrolled patients who after receiving primary repair for an isolated SLAP lesion presented with recurrent or recalcitrant pain, for which they received reoperation. Limitations of this study include selection bias that may have risen during the process of patient enrollment and the small study population relative to the long recruitment period (only 11 patients were recruited across a 10-year recruitment period), which restricts the statistical power of this study. Yet, the recruitment of a very small number of patients of our hospital, which is a tertiary medical hospital in which most patients are referred from primary and secondary hospitals, is also an implicit indicator that recurrence of symptoms after SLAP repairs is extremely rare. Findings of our study also indicate that knot-tying sutures may be held accountable to unresolved pain after SLAP repairs in the absence of preexisting factors which causes pain.

Almost all cases (excluding Cases 3, 9, and 11) had received primary repair for SLAP lesion at an external institution, meaning that most of these treatments were performed by different surgeons. Although this makes knowing the clinical situations and understanding the arthroscopic findings of each case at the primary repair difficult, we obtained medical charts and arthroscopic findings from each primary institution so that a better assessment of the patients' conditions could be made. If however either the charts or the arthroscopic findings obtained gave an obscure account of the surgical methods or of the lesion at the time of primary repair, these cases were excluded from the analysis so that a more reliable set of data could be generated.

The method of reoperation were determined based on the arthroscopic findings at the time of reoperation and were not controlled to increase statistical power. However, the reoperation method was selected based on the treatment policy which depends on objective criteria in order to reduce the bias caused by subjective prejudice on the operation method and all reoperations were performed by a single surgeon in a single institution. These can compensate the limitations due to various methods of

reoperation.

In our study population, we observed arthroscopically that 10 of 12 cases had a non-repaired SLAP lesion at the time of reoperation, indicating that recalcitrant or recurrent pain may not only be attributed to knot-tying anchors but also recalcitrant SLAP lesions. Further, we cannot rule out the possibility that the causes of postoperative pain are multifactorial, not unifactorial. However, we observed that all cases of knot-tying suture anchors presented evidence of knot-induced abrasion during shoulder motion and that the vast majority of cases (8 of 9) presented with synovitis around the knot. In comparison, in the three cases of knotless suture anchor, there was no synovitis around the knot despite fixation loss. In addition, there was a patient who has a pain during shoulder exercise despite the complete healing of the SLAP lesion after primary repair. Taking these findings together, we propose that recurrent or recalcitrant pain after SLAP repair in the absence of any other pathological lesions could be caused by the abrasion between the knot of the suture with its surrounding tissues and by the resulting inflammatory response.

In this study, we observed inflammation around the knot of the suture anchor in patients who had undergone a primary SLAP repair. We also found that the prognosis of reoperation was poor in the patients with cartilage injury induced by suture anchors and/or suture material. However, because not all patients who had knot-tying sutures presented with these complications, further studies are required to investigate the association between pain and knot-tying suture anchors. Findings of our study suggest that reoperation should be recommended for patients in whom recurrent or recalcitrant pain does not resolve even with conservative treatment. We also present the knot of the suture anchor or a so-called knot-ache as a cause of recurrent or recalcitrant pain in the absence of any concomitant pathological lesions. Thus, using knotless suture anchors during reoperation for recurrent or recalcitrant pain in patients with no other pathological lesions can be useful because it eliminates one potential risk factor (knot-ache) of postoperative pain.

Conclusion

Recurrent or recalcitrant pain after arthroscopic repair of SLAP lesion infrequently occurs, and its etiology varies. The knots of suture anchor may be a possible etiology of the pain, which we termed a "knot-ache". In such instances of recurrent or recalcitrant pain after primary repair is not relieved by conservative treatment, reoperation may be a desirable treatment method. Considering that reoperation is performed due to pain after primary repair, the use of knotless suture anchor may have benefits of eliminating one of possible cause of pain, "knot-ache". Therefore, authors suggest the use of knotless anchors during reoperation for recurrent or recalcitrant pain after primary SLAP repair.

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