Original Article With Video Illustration

Vertical Versus Horizontal Suture Configuration for the Repair of Isolated Type II SLAP Lesion Through a Single Anterior Portal: A Randomized Controlled Trial

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Purpose: To compare the clinical and functional outcomes of the repair of an isolated type II SLAP lesion by 2 different configuration techniques (vertical *v* horizontal suture) through a single anterior portal. **Methods:** We designed a prospective, double-blinded, randomized clinical trial. A junior orthopaedic surgeon, who made the initial diagnosis, used a 10-point visual analog scale for pain and subjective instability and the American Shoulder and Elbow Surgeons (ASES) scoring system and evaluated the range of motion. After a diagnostic arthroscopy that ascertained the presence of an isolated type II SLAP lesion, patients were randomized to receive either vertical suture configuration (group 1) or horizontal suture configuration (group 2), both through a single anterior portal. Thirty-two patients were included in the study. The mean follow-up time was 37 months. **Results:** The mean postoperative ASES score was 91.9 in group 1 versus 95.8 in group 2 ($P > .05$). The differences observed from preoperative ASES score for both groups to postoperative ASES score were statistically significant. The differences observed in preoperative range of motion from the contralateral healthy shoulder and the affected shoulder in both groups were all clinically and statistically significant. Comparing the overall range of motion of the affected limb postoperatively with the range of motion of the contralateral healthy shoulder and between both groups, we found no statistically significant differences in forward flexion ($P = .067$), external rotation ($P = .101$), or internal rotation ($P = .343$). **Conclusions:** The results of this study suggest that the repair of an isolated type II SLAP lesion through a single anterior portal is clinically and functionally beneficial to patients regardless of the suture configuration performed (vertical or horizontal suture) because no differences were observed between these configurations after repair of an isolated type II SLAP lesion. **Level of Evidence:** Level I, randomized controlled trial.

Note: To access the video accompanying this report, visit the December issue of Arthroscopy at www.arthroscopyjournal.org.

The superior labrum–biceps complex contributes to the stability of the glenohumeral joint.[1-4] Surgical repair is the most current treatment recommendation for unstable type II SLAP lesions. The management of the lesion has improved as arthroscopic techniques have evolved. Multiple fixation methods have been used, including transosseous sutures, staples, screws, bioabsorbable tacks, and suture anchors.[5-7] Many authors have reported successful outcomes after SLAP repair, and reattachment of the labrum to the glenoid with bioabsorbable suture anchors for the treatment of type II lesions is considered the current standard of care for such injuries.[8,9] Recently, however, the outcomes of SLAP repair have been reported as being less than ideal,[10] especially in overhead athletes.[11,12]

Traditionally, 3 portals have been used in SLAP repair, and some of these portals involve establishing a working cannula through the supraspinatus tendon.[13-17] Attention has recently been drawn to the potential rotator cuff morbidity associated with this portal, and athletes in whom SLAP lesions commonly develop have large demands on the rotator cuff and require optimal rotator cuff function. For these reasons, to minimize the morbidity to the rotator cuff, percutaneous techniques of suture anchor insertion and suture passing have been developed.[18] Nevertheless, despite concerns with regard to using portals through the cuff, some reports have indicated favorable outcomes with a trans–rotator cuff portal.[19]

The purpose of this prospective study was to compare the clinical and functional outcomes of the repair of an isolated type II SLAP lesion when 2 different configuration techniques were used (vertical *v* horizontal suture) through a single anterior portal. We hypothesized that the horizontal suture configuration for the repair of the isolated type II SLAP lesion would bring about better functional and clinical results than the vertical suture configuration after a mean follow-up of 37 months.

METHODS

We designed a prospective, double-blinded, randomized clinical trial. This study involving human subjects was performed in accordance with the Declaration of Helsinki of 1975 as revised in 2000 and was approved by the relevant institutional ethical committee. All patients were initially evaluated by a junior orthopaedic surgeon, who made the initial diagnosis and performed a comprehensive physical examination on admission, including range of motion (ROM) testing, manual muscle strength assessment, and tests for impingement syndrome, SLAP lesion, acromioclavicular joint instability, and scapular dyskinesia.

A standard universal goniometer was used for measurement with scales marked by 1° increments. Patients were positioned supine on an examining couch with the shoulder at 90° of abduction in the scapular plane (approximately 15° anterior to the coronal plane). Measurement of supine forward elevation (sagittal plane) and internal and external rotation (90° of abduction) was obtained by use of standard measurement guidelines.[20]

Examination for the SLAP lesion consisted of the Speed test, Yergason test, compression rotation test, active compression (O'Brien) test, modified Jobe apprehension and relocation test, anterior slide (Kibler) test, Whipple test, and biceps load II test. An impinge-ment test was done to confirm subacromial impingement. A self-assessment questionnaire, a 10-point visual analog scale (VAS) for pain and subjective instability, and the American Shoulder and Elbow Surgeons (ASES) scoring system were also applied. The self-assessment questionnaire is our own self-report questionnaire, which lacks scientific validity and consists of 2 questions: whether the patient agrees to the surgical treatment performed and whether the patient would not undergo the operation again by the same technique.

All patients had simple radiographs obtained and underwent special imaging studies. Standard multiplanar T1- and T2-weighted magnetic resonance imaging (MRI) were obtained for evaluation of the rotator cuff, bony edema, paralabral cysts, and nervous and vascular structures around the shoulder. However, when we suspected pathology in the labrum, we obtained a magnetic resonance arthrogram with an intra-articular injection of gadolinium. This technique has been shown to provide improved visualization of the labrum and associated pathology.[21] A musculoskeletal radiologist confirmed the imaging diagnosis of the SLAP lesion.

Labral healing, recurrence of the SLAP lesion, and presence of rotator cuff damage were postoperatively evaluated at the latest follow-up by MRI.

Initially, all patients were prescribed physical therapy for ROM exercises (3 to 6 months). All were prescribed rotator cuff strengthening and scapular stabilization exercises. When needed, intra-articular cortisone injection was given. Of the patients who were dissatisfied with conservative treatment, most had regained an acceptable ROM but continued to have pain. In these cases we proposed revision surgery, and information about the possibility of being included in a clinical trial was given. When the patient accepted, an informed consent form was signed. After a diagnostic arthroscopy assessing the status of the shoulder joint, we ascertained the presence of an isolated type II SLAP lesion. At this stage, patients were randomized into 1 of 2 groups, to receive either vertical suture configuration (group 1) or horizontal suture configuration (group 2) for the repair of the isolated type II SLAP lesion. The SLAP lesion was categorized according to the classifications of Snyder[22] and Morgan et al.[14] Exclusion criteria were patients with multidirectional or minor shoulder glenohumeral instability, previous ipsilateral shoulder surgery, and rotator cuff tears or biceps tendinopathy.

Instead of randomization, we performed minimization, which is considered a highly effective allocation method and ensures balance between intervention groups especially when the sample is not large

enough.[23] With minimization, important prognostic factors are identified before the trial starts and assignment of a new patient to a treatment group is determined to minimize the differences between the groups in terms of these factors.

From January 2005 to December 2006, 32 patients underwent arthroscopic fixation for unstable isolated type II SLAP lesions. The same surgeon performed all surgical interventions. Patients were divided into 2 groups according to the suture configuration performed for the repair of the type II SLAP lesion. In group 1 (vertical suture configuration) there were 11 men and 4 women (mean age, 29 years; range, 21 to 39 years). The dominant arm was affected in 11 patients (Table 1). The SLAP lesions were classified as type IIA in 1 patient, type IIB in 5 patients, and type IIAB in 9 patients (Table 2). In group 2 (horizontal suture configuration) there were 12 men and 5 women (mean age, 28 years; range, 21 to 39 years). The dominant arm was affected in 12 patients (Table 1). The SLAP lesions were classified as type IIA in 1 patient, type IIB in 5 patients, and type IIAB in 11 patients (Table 2). The mean follow-up period was 37 months (range, 26 to 60 months). The same single examiner who was blinded to the study prospectively checked all questionnaires for functional evaluation.

Before the beginning of the study, a power analysis was performed. The choice of sample size was made based on the primary outcome of shoulder function scores. Assuming a β error of .05 and a power of 0.80, it was anticipated that 15 patients would be required in each group to show a 15% difference in the shoulder score between the 2 groups.

TABLE 2. *Subtype of SLAP Lesion Repaired in Each Group*

Type II SLAP Lesion	Group 1	Group 2
Subtype A	1	1
Subtype B	5	5
Subtype AB	9	11

Data were compared by use of the Mann-Whitney *U* test (independent group comparison test) through SPSS Statistics software, version 17.0 (IBM, Armonk, NY). Differences were considered significant when the *P* value was less than .05.

Surgical Technique

Patients underwent brachial plexus block associated with general anesthesia and were placed in a lateral decubitus position. The arm was suspended at approximately 45° of abduction and 20° of forward flexion. Distraction of the shoulder joint was accomplished with 4.5 to 6.5 kg of traction. A diagnostic arthroscopy was then performed to evaluate the presence of rotator cuff tear, any lesion to the biceps tendon, and other associated lesions. Through the standard posterior portal, we established the anterosuperior portal, which was situated above the superior glenohumeral ligament, as close and lateral to the biceps tendon as possible (Fig 1). This way, the anterior border of the supraspinatus tendon is then left untouched.[24] We established the lateral anterosuperior (LAS) portal with the use of the Wissinger rod technique. This

TABLE 1. *Demographic Distribution*

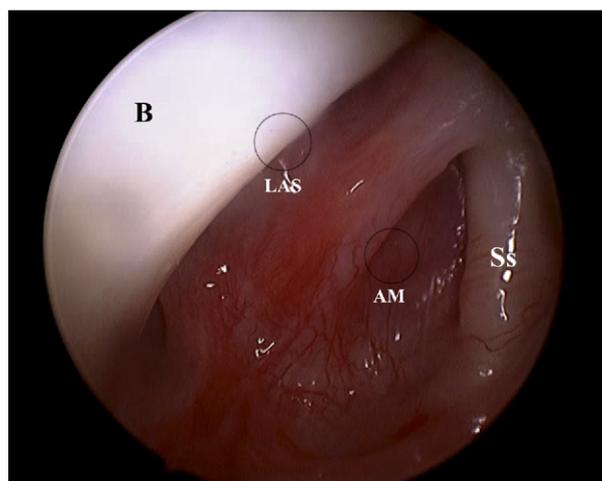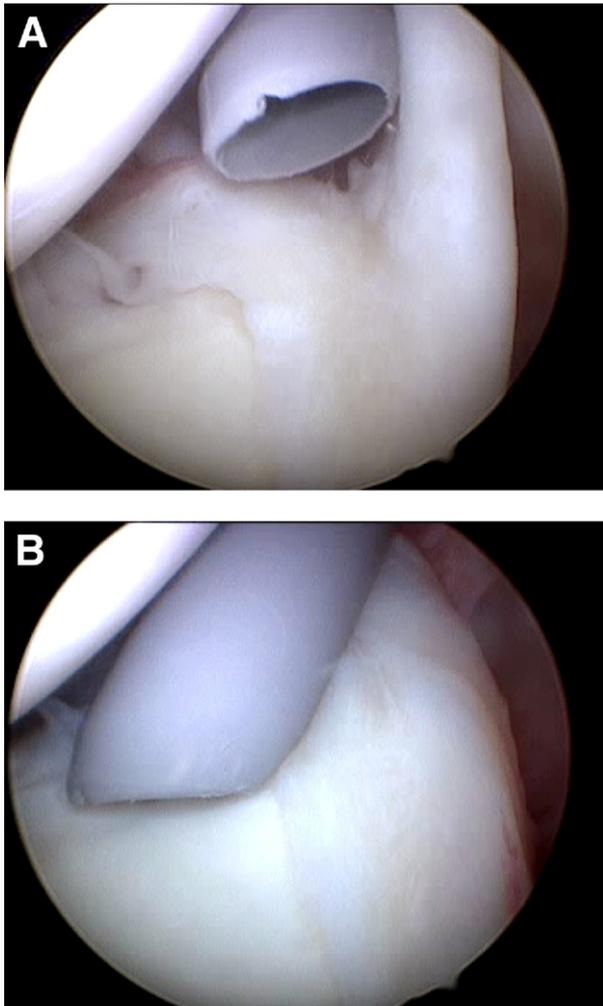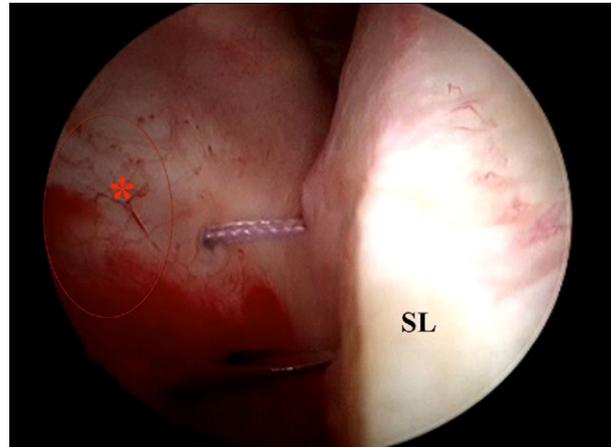|	Group 1	Group 2	*P* Value
No. of patients (N = 32)	15	17	NS
Mean age (range) (yr)	29.66 (21-39)	28.83 (21-39)	NS
Gender	11 M, 4 F	12 M, 5 F	NS
Dominant arm	11 of 15	12 of 17	NS
Work level			
Heavy manual labor	8	9	NS
Moderate labor	6	7	NS
Sedentary	1	1	NS
Sport level			
Handball, professional	2	1	
Tennis, collegiate/			
recreational	3	5	
Paddle, collegiate/			
recreational	4	3	

Abbreviation: NS, not significant.

FIGURE 1. Posterior view of LAS portal from right shoulder. (AM, anteromedial portal; B, biceps tendon; Ss, subscapular tendon.)

portal allows us to place the drill hole at the angle required to introduce the suture anchor for the repair of the labrum lesion (Fig 2). A 6-mm working cannula was introduced in the LAS portal, and after evaluation and classification of the SLAP lesion, the suture (No. 1 polydioxanone [PDS] suture; Ethicon, Somerville, NJ) was passed through a spinal needle from the superior access (lateral to the Neviaser portal), thus avoiding rotator cuff damage (Fig 3). At this point, it is important to remain medial to the rotator cuff "cable."[25]

Group 1: We used a bioabsorbable double-loaded suture anchor to perform the vertical suture configuration.

FIGURE 3. Posterior view of superior access for suture passing from right shoulder. (asterisk, rotator cuff cable; SL, superior labrum.)

In the first stitch, the labrum was pierced posterior to the biceps tendon from the superior access. Once the PDS was inserted into the joint, it was retrieved through the anterior portal. A bioabsorbable double-loaded suture anchor with a No. 2 nonabsorbable suture was then inserted (Video 1, available at www.arthroscopyjournal.org). The most posterior suture from the suture anchor was retrieved through the anterior portal. The PDS suture was tied to the limb part of the suture anchor, and it was then used to pull the limb through the biceps anchor from inferior to superior (Fig 4). A sliding knot (SMC or Nicky knot) was placed on top of the posterior biceps root, thus
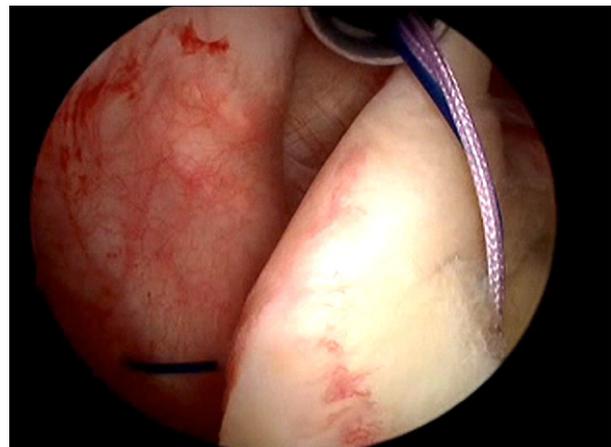

FIGURE 2. Posterior view of LAS portal from left shoulder. (A) Cannula anterior to biceps insertion. (B) Cannula posterior to biceps insertion.

FIGURE 4. Posterior view from right shoulder. Through the anterior portal, the PDS suture is tied to the limb part of the suture anchor, and it is then used to pull the limb through the biceps anchor from inferior to superior.

pressing this area of soft tissue firmly onto the bone (Fig 5).

For the second stitch, the labrum was pierced anterior to the biceps tendon by use of the same procedure described previously (Video 1), with a simple knot being tied on top of the anterior-superior labrum (Fig 5).

Group 2: We used a bioabsorbable simple loaded suture anchor to perform the horizontal suture configuration, which was tied over the top of the biceps anchor.

As described previously, a spinal needle was used to penetrate the posterior-superior labrum. A No. 1 PDS suture was passed through the spinal needle and was retrieved through the anterior portal (Video 1). The most posterior limb of the suture anchor was retrieved through the anterior portal. Then, the PDS suture was tied to the limb of the suture anchor, and it was used to pull the limb through the biceps anchor from inferior to superior. The same procedure was repeated for the second "anterior" suture limb, passing it through the biceps anchor 1 mm anterior to the anterior border of the tendon (Fig 6). The 2 sutures were then tied over the top of the biceps anchor, completing the horizontal suture configuration with standard arthroscopic knots (SMC or Nicky knots) under direct arthroscopic visualization. The superior labrum was tested for stability and security after fixation. This technique allows anatomic attachment of the superior labrum–biceps complex, avoiding de-

FIGURE 6. Posterior view of horizontal suture configuration from right shoulder.

pressing and over-tensioning the superior labrum–biceps complex, thus maintaining rotator cuff intact.

Postoperative Care

Postoperative management was the same for both groups. The arm was supported with a sling with an abduction pillow for 6 weeks. Active elbow flexion and extension were allowed, but terminal extension was restricted. Passive external rotation was started from the first day after surgery and maintained within a comfortable range. At 6 weeks, the sling was removed, and overhead stretching with a rope and pulley was started. Isoinertial strengthening and rehabilitation of the rotator cuff, deltoid, and scapular stabilizers were initiated at 10 or 12 weeks after the operation. Rehabilitation was continued for 6 months. Patients returned to work at a mean of 16 weeks (range, 14 to 19 weeks) after the operation.

RESULTS

At a mean follow-up of 37 months (range, 26 to 60 months), all patients completed questionnaires and physical examinations.

Clinical Outcome

The mean postoperative ASES score was 91.9 in group 1 and 95.8 in group 2 ($P > .05$) (Table 3). The differences observed from preoperative ASES score for both groups to postoperative ASES score were statistically significant ($P < .05$) (Table 3). According to the VAS for pain, preoperatively, the mean pain score was 7.7 in group 1 and 7.5 in group 2 ($P > .05$).

FIGURE 5. Posterior view of vertical suture configuration from right shoulder. The posterior suture of the anchor (blue) is tied posterior to the biceps anchor, and the anterior suture (purple) is retrieved through the anterior portal.

TABLE 3. *Preoperative and Postoperative Results on Subjective Shoulder Surveys*

	Group 1	Group 2	*P* Value
VAS			
Preoperative	7.7 ± 1.5	7.5 ± 1.3	NS
Postoperative	3.8 ± 1.2	2.9 ± 1.2	NS
P value	*P* < .05	*P* < .05	
ASES			
Preoperative	68 ± 12	65 ± 13	NS
Postoperative	91.9 ± 14	95.8 ± 12	NS
P value	*P* < .05	*P* < .05	

Abbreviation: NS, not significant.

The pain was reduced at the last follow-up to a mean of 3.8 in group 1 and 2.9 in group 2 ($P < .05$). The differences observed postoperatively between groups were not statistically significant ($P > .05$) (Table 3). Bicipital tenderness, Speed test, Yergason test, impingement, compression-rotation test, O'Brien test, and supine flexion resistance test were positive in 2 patients from group 1 and in 1 patient from group 2. There were no patients who were dissatisfied with the procedure or who required a second operation.

Range of Motion

The mean overall preoperative ROM (Table 4) in the affected limb for patients in group 1 was 136° of forward flexion (range, 55° to 180°), 57° of external

rotation (range, 45° to 80°), and internal rotation to T12 (range, T4 to L3). Group 2 preoperative motion was 139° of forward flexion (range, 95° to 180°), 61° of external rotation (range, 45° to 90°), and internal rotation to T11 (range, T5 to L4). Group 1 postoperative ROM improved to 163° of forward flexion (range, 120° to 180°) ($P = .0014$), 75° of external rotation (range, 55° to 90°) ($P = .001$), and internal rotation to T8 (range, T5 to L3) ($P = .006$). Group 2 postoperative motion improved to 174° of forward flexion (range, 100° to 180°) ($P = .005$), 74° of external rotation (range, 50° to 90°) ($P = .005$), and internal rotation to T10 (range, T5 to L1) ($P = .008$). The differences observed in preoperative ROM from the contralateral healthy shoulder and the affected shoulder in both groups are all clinically and statistically significant. These differences disappear after the repair of isolated type II SLAP lesions at a mean follow-up of 37 months (Table 4). Comparing the overall ROM of the affected limb postoperatively with the ROM of the contralateral healthy shoulder and between both groups, we found no statistically significant differences in forward flexion ($P = .067$), external rotation ($P = .101$), or internal rotation ($P = .343$) (Table 4). Satisfaction was reported as good to excellent by 13 patients in group 1 (86.67%) and 16 patients in group 2 (94.12%). In addition, 13 patients in group 1 and 16 patients in group 2 returned to their preinjury level of working activities.

TABLE 4. *Bilateral ROM Before and After Arthroscopic Repair of Isolated Type II SLAP Lesion in Both Groups*

	Group 1	Group 2	*P* Value
Preoperative			
Affected shoulder			
FF	136° (55°-180°)	139° (95°-180°)	NS
ER	57° (45°-80°)	61° (45°-90°)	NS
IR	T12 (T4-L3)	T11 (T5-L4)	NS
Contralateral shoulder			
FF	175° (168°-182°) (*P* < .05)	178° (167°-181°) (*P* < .05)	NS
ER	87° (79°-91°) (*P* < .05)	85° (80°-90°) (*P* < .05)	NS
IR	T7 (T10-T5) (*P* < .05)	T8 (T11-T5) (*P* < .05)	NS
Postoperative			
Affected shoulder			
FF	163° (120°-180°)	174° (100°-180°)	NS
ER	75° (55°-90°)	74° (50°-90°)	NS
IR	T8 (T5-L3)	T8 (T5-L1)	NS
Contralateral shoulder			
FF	176° (167°-180°) (*P* > .05)	175° (170°-180°) (*P* > .05)	NS
ER	86° (80°-90°) (*P* > .05)	84° (80°-92°) (*P* > .05)	NS
IR	T8 (T9-T5) (*P* > .05)	T10 (T11-T6) (*P* > .05)	NS

Abbreviations: FF, forward flexion; ER, external rotation; IR, internal rotation.
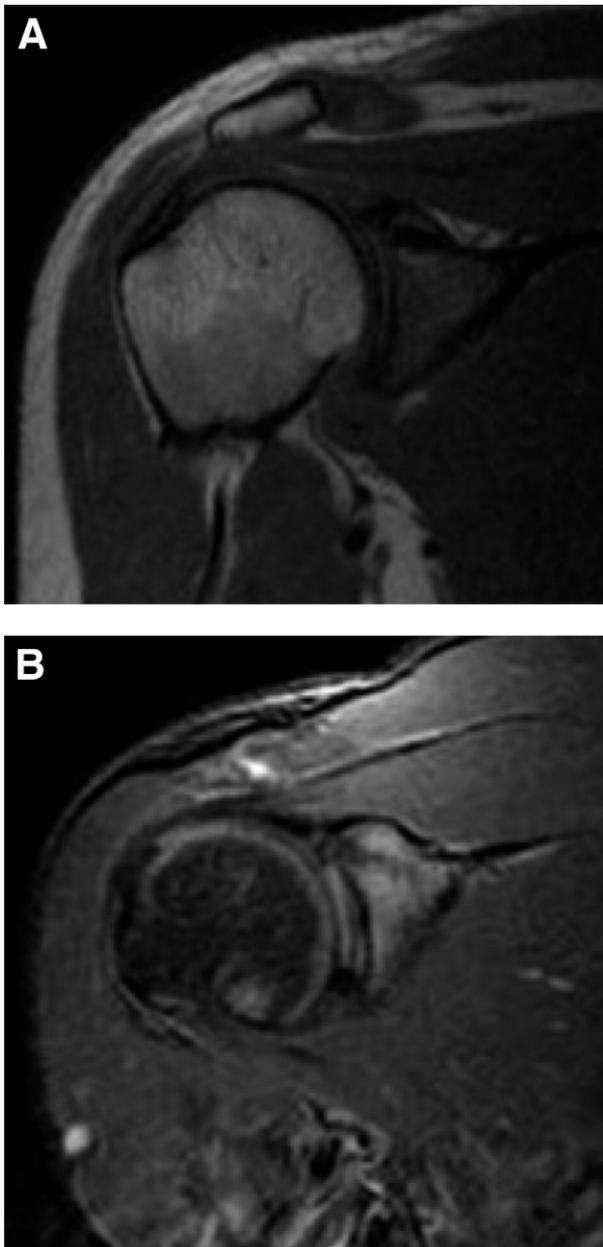
FIGURE 7. Postoperative MRI scans. (A) Vertical suture configuration (group 1). (B) Horizontal suture configuration (group 2).

Radiographic Outcome

Postoperative MRI was performed in 12 patients in group 1 (Fig 7A) and 14 in group 2 (Fig 7B). On postoperative MRI at the latest follow-up, appropriate labral healing to the glenoid bone had been achieved in all patients. Radiologic evidence of the recurrence of the SLAP lesion was not identified. No rotator cuff damage was observed.

DISCUSSION

Our discussion concerning this study involves 2 main issues: surgical approaches and SLAP repair techniques. The literature is not clear with respect to these, and major prospective comparative studies are still required. This study was designed in an attempt to look for answers concerning SLAP repair techniques and to describe the standard technique we performed for the repair of SLAP lesions.

After a mean follow-up of 37 months, we can affirm that the horizontal suture configuration for the repair of an isolated type II SLAP lesion is no more clinically advantageous than the vertical suture configuration. The horizontal suture configuration allows the knot to be placed over the biceps tendon, avoiding compression and decreasing the labrum over-tensioning that is produced when the sutures are placed in a vertical configuration. This fact could be responsible for persistent pain in overhead activities after the operation. We compared both techniques (vertical *v* horizontal suture configuration) through the assessment of preoperative and postoperative ROM, VAS scores, and ASES scores in both groups, and no differences were observed. Regarding the results obtained, we consider that further investigation should be performed to ascertain the anatomic aspects of the different configuration techniques for SLAP repair.

Our technique uses only 1 working anterior portal, whereas the majority of surgical techniques describe 2 or more portals.[5,13,26] The use of the LAS portal, situated at the superior aspect of the rotator interval, avoids injury to the rotator cuff and allows the drill hole to be placed at the angle required to introduce the suture anchor for the repair of the type II SLAP lesion, thus making the creation of an additional portal unnecessary.

As Selby et al.[27] reported, superior access (lateral to the Neviaser portal) used for suture passage avoids rotator cuff damage, a fact that we evaluated by postoperative MRI. It also has the advantage of making it possible to place the drill hole at the angle required to introduce the suture anchor for the repair of the type II SLAP lesion, and it is a reproducible technique. Stanish and Peterson[28] described the potential risk of injury to the suprascapular nerve when establishing a Neviaser portal. However, acromial fractures and injury to the deltoid ligament are potential complications of the use of a transacromial portal.[29] Warner et al.[30] described the anterior-lateral portal to access the more posterior region of the superior labrum, but the creation of this portal requires performing an incision

in the rotator cuff tendon. More recently, in a retrospective clinical follow-up study of 31 patients treated arthroscopically by establishing a trans–rotator cuff portal, O'Brien et al.[13] observed that after a mean follow-up of 3.7 years, none of the 31 patients had symptoms suggestive of rotator cuff pathology. Furthermore, they firmly state that this approach does not compromise the function of the rotator cuff.[13] The main concern involved in the use of a trans–rotator cuff portal is the potential risk of rotator cuff injury, which evidently can be minimized by not using a cannula. Theoretically, the trans–rotator cuff portal represents a relatively small split in the musculotendinous junction, which should not adversely affect cuff function.[13]

The findings associated with type II lesions differ according to the patient's age: type II lesions in patients aged 40 years or younger are commonly associated only with a Bankart lesion, whereas those in patients aged older than 40 years are associated with a supraspinatus tear and osteoarthritis of the humeral head.[31] Andrews et al.[1] noted an association between overhead athletic activity and superior labral lesions. Isolated SLAP lesions with no associated pathologic findings are uncommon, and care must be taken when ascribing symptoms to a SLAP lesion when other lesions are present. Because the main characteristic of this technique is that no damage to the rotator cuff occurs, it is especially indicated in cases of isolated type II SLAP lesions.

The advantages of this study are that we only compare patients affected by isolated type II SLAP lesions, and all patients were treated by a single surgeon who performed the same standard technique. Moreover, it is a randomized (minimization) study where both groups are comparable (gender, age, work activity, and so on), and finally, the follow-up was performed by the same independent observer after a mean period of 37 months.

Both procedures (vertical and horizontal suture configurations) allowed 90% of patients to return to their previous working activities (86.67% of group 1 and 94.12% of group 2) with a high rate of satisfaction and maintenance of good shoulder ROM. The results of this study suggest that the repair of the isolated type II SLAP lesion through a single anterior portal is clinically and functionally beneficial to patients after a mean follow-up of 37 months, regardless of the suture configuration (vertical or horizontal) performed, because no differences were observed between these 2 suture configuration techniques for the repair of the isolated type II SLAP lesion.

The technique described has many benefits for the repair of type II SLAP lesions: the use of an anterior portal allows the drill hole to be placed at the angle required to introduce the suture anchor, the superior access used for suture passage offers an excellent angle of approach and allows the anatomic attachment of the superior labrum–biceps complex to the labrum, this technique avoids injury to the rotator cuff, and finally, the procedure is easy reproducible.

The limitations of this study include the number of patients (although a power study was performed), which is a result of careful patient selection because an isolated type II SLAP lesion is not a common entity. In addition, we only performed a single outcome score assessment (ASES), and we did not include professional athletes, in whom outcomes are generally worse regarding their previous level of activities.

CONCLUSIONS

The results of this study suggest that the repair of an isolated type II SLAP lesion through a single anterior portal is clinically and functionally beneficial to patients regardless of the suture configuration performed (vertical or horizontal suture) because no differences were observed between these configurations after repair of an isolated type II SLAP lesion.

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