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Operative Techniques in
Sports Medicine

The Diagnosis, Classification, and Treatment of SLAP Lesions

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SLAP (superior labrum, anterior and posterior) lesions have been identified as a cause of instability and pain in the shoulder. This review describes clinical features, mechanism of injury, physical examination, classification and associated lesions, normal and pathologic anatomy, as well as a treatment algorithm for SLAP lesions.
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KEYWORDS SLAP lesion, instability, SLAP classification

SLAP (superior labrum, anterior and posterior) lesions have become increasingly recognized at a source of pain and instability in the shoulder. Andrews et al[1] described lesions of the biceps tendon in high-level throwers in 1985. The mechanism of injury was described as a traction overload to the labrum by the biceps tendon during the deceleration phase of throwing. Snyder et al[2] coined the term SLAP lesion (superior labrum anterior to posterior) to describe fraying or detachment of the labral complex at the superior margin of the glenoid and classified these lesions into 4 subtypes.

Clinical Features

The clinical features of SLAP lesions have been described in several studies. The most common clinical complaint is pain, increased with overhead activity and a painful "catching" or "popping" in the shoulder.[2,3] In the throwing athlete, a SLAP lesions can present as "dead arm" syndrome.[4]

Mechanism of Injury

The mechanism of injury resulting in a SLAP lesion is varied. Repetitive throwing, hyperextension, fall on an outstretched hand, heavy lifting, and direct trauma have all been implicated.[2,3] The most common mechanism in the study by Snyder et al[2] was a fall on an outstretched arm, whereas others have reported that two thirds of patients sustained a traction injury.[5] Burkhart et al[4] have described contracture of the posterior-inferior glenohumeral ligament in throwers. The glenohumeral contact point is shifted posterosuperior, and increased shear forces are placed on the posterior-superior labrum, generating a peel-back effect and the SLAP lesion.

Physical Examination

Preoperative diagnosis of SLAP lesions is aided by physical examination. Tenderness to palpation at the rotator interval can be a helpful diagnostic sign. The most common positive physical findings are a positive anterior drawer (53%), positive apprehension at 90° of abduction and maximal external rotation (86%), and positive relocation test (86%).[3] The Speed's test and O'Brien signs are helpful for diagnosing anterior lesions, whereas Jobe's relocation test is positive most frequently with posterior lesions.[6] Speed's test and Yergason's test are not consistent predictors of a SLAP lesion.[7]

Prevalence and Associated Lesions

In 1995, a review of 2375 shoulder arthroscopies performed by Snyder et al[8] showed 140 superior labrum injuries, representing an incidence of 6% of all shoulder arthroscopies performed at their institution. In this study, 21% of lesions were Type I, 55% were Type II, 9% were Type III, and 10% were Type IV, with 5% of lesions being "complex." An isolated SLAP lesion was seen in 28% of patients, with associated lesions consisting of partial thickness rotator cuff tears in 29%, full-thickness tears in 11%, and Bankart lesions in 22%.

In patients under 40 years old who showed signs and symptoms of instability after a history of acute trauma, repetitive injury, fall on an outstretched arm, or an injury from heavy lifting, SLAP lesions were found in 52% of patients. Isolated SLAP lesions were found in 19%, an associated Bankart lesion was found in 21%, full-thickness rotator cuff tears in 3%, undersurface rotator cuff tear in 3%, Bankart and undersurface rotator cuff tear in 4%, and grade II impinge-

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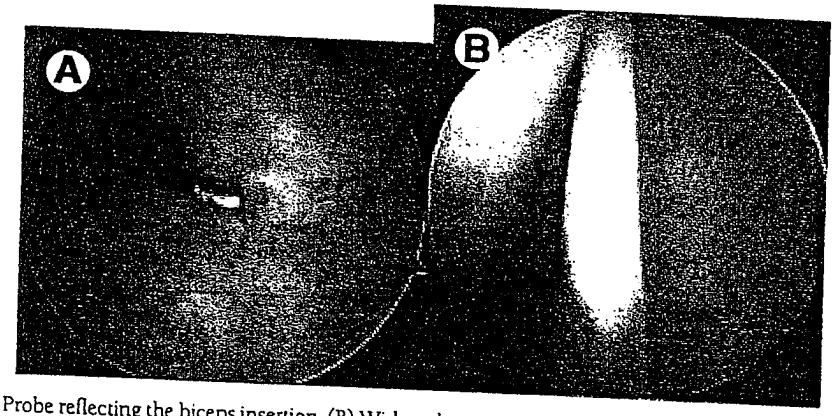

Figure 1 (A) Probe reflecting the biceps insertion. (B) Widened rotator interval, a clue to instability in the shoulder from posterior labral tear or a SLAP lesion.

ment in 4%. No patients had a Type I lesion and 93% of the SLAP lesions were Type II.[3]

More recently, Kim and coworkers[9] found SLAP lesions according to the Snyder classification system in 26% of 544 consecutive shoulder arthroscopies. Of these shoulders, 74% were Type I, 21% were Type II, 0.7% were Type III, and 4% were Type IV. Type II SLAP lesions in patients under 40 years old were associated with a Bankart lesion, whereas SLAP lesions in patients over 40 were associated with a tear of the supraspinatus tendon and osteoarthritis of the humeral head. Maffet et al[5] believed that Type I lesions, or superior labral fraying, represented normal aging and not likely to lead to shoulder dysfunction.[5]

Normal Anatomy

In identifying a SLAP lesion, it is essential to understand the normal anatomy and variation. Cooper et al[10] described the anatomy of the biceps anchor. Hyaline cartilage covers the superior rim of the glenoid. The biceps tendon inserts directly into superior labrum. There is a sublabral sulcus at the labral-bicipital junction that is normal in 73% of patients and should not be misdiagnosed as a traumatic lesion.[11] Essential to every arthroscopic examination of the shoulder is reflection of the biceps attachment at the superior glenoid (Fig. 1A). This maneuver can reveal otherwise unsuspected trauma at the attachment of the biceps to the labrum. Fissuring in the sublabral recess, cracks in the articular cartilage of the superior glenoid, and impaction fractures of the articular cartilage of the superior humeral head are all suggestive of a SLAP lesion. In addition, widening of the rotator interval (Fig. 1B) and a positive drive-through sign can be clinical features of the diagnostic arthroscopy that may suggest an associated SLAP lesion.

Important variations in the normal anatomy (Fig. 2) of the labrum have been identified. Three distinct variations occur in over 10% of patients:[12] an isolated sublabral foramen (Fig. 3), a sublabral foramen with a cord-like middle glenohumeral ligament (Fig. 4), and a cordlike middle glenohumeral ligament without tissue at the anterosuperior labrum (Fig. 5). Recognition of these normal variants can help to avoid misdiagnosing labral lesions.

Classification

Snyder et al[2] initially classified SLAP lesions into 4 categories. Type I is characterized by fraying and a degenerative appearance of the superior labrum and is an uncommon source of clinical symptoms. (Fig. 6).[13] Type II is a detachment of the superior labrum from the supraglenoid tubercle (Fig. 7) Type III is a bucket handle tear that displaced in to the joint while the biceps root remains stable (Fig. 8). Type IV is a bucket-handle tear where the tear propagates into the biceps tendon (Fig. 9). Three subtypes of Type II SLAP lesions have been identified.[6] Of 102 Type II lesions observed, 37% were ante-

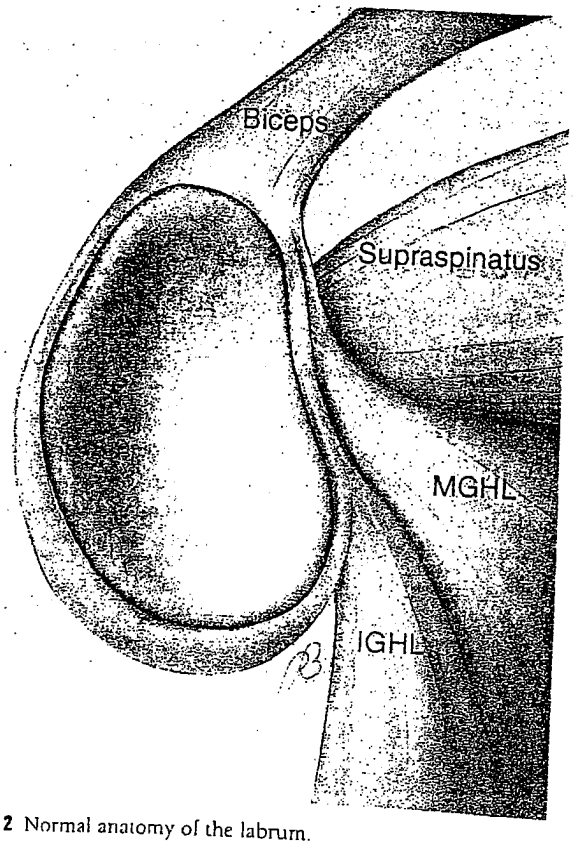

Figure 2 Normal anatomy of the labrum.

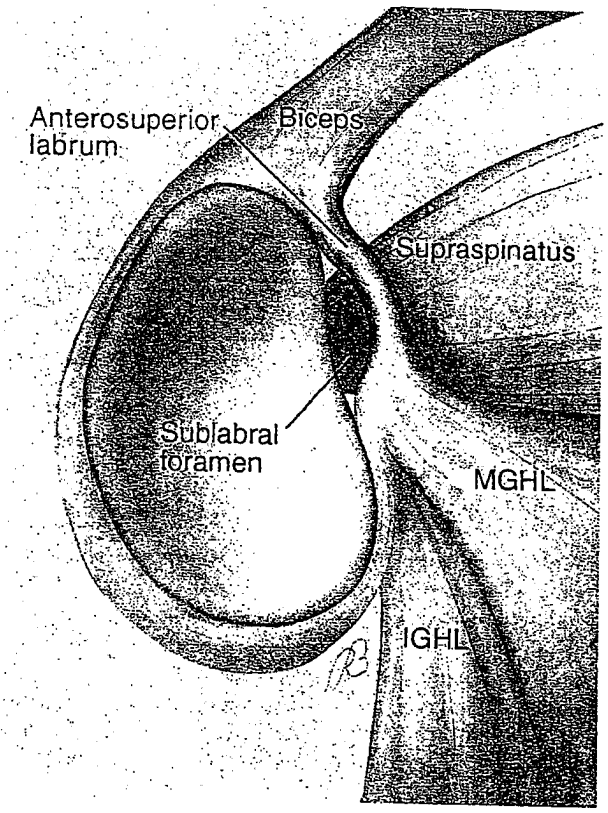

Figure 3 Isolated sublabral foramen.

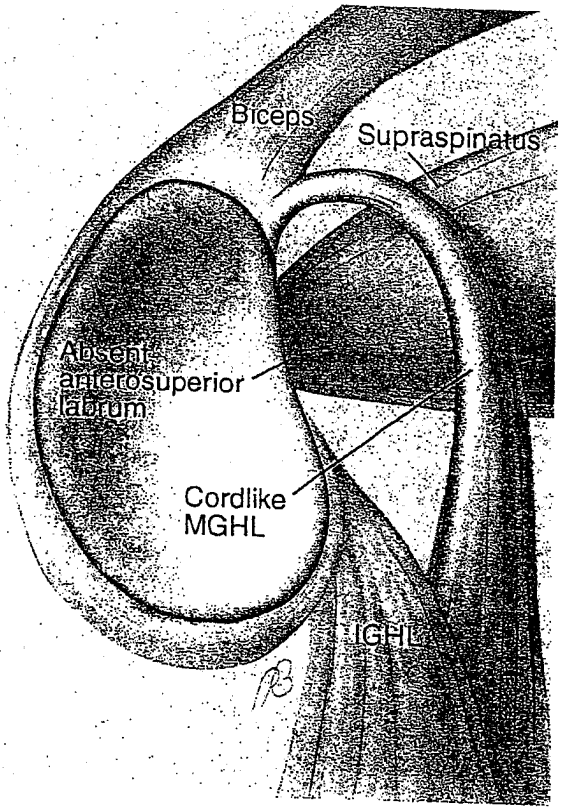

Figure 5 Cord-like middle glenohumeral ligament without tissue at the anterosuperior labrum.

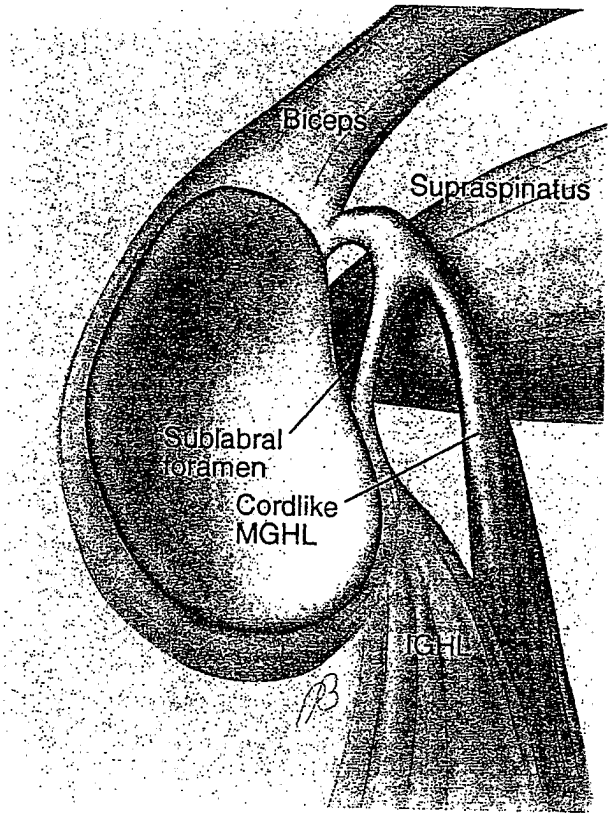

Figure 4 Sublabral foramen with a cord-like middle glenohumeral ligament.

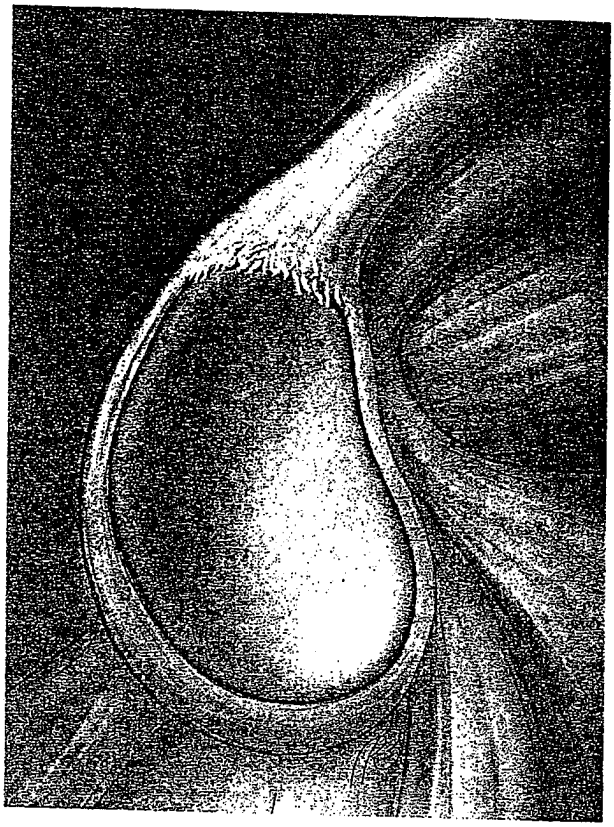

Figure 6 SLAP lesion Type I.

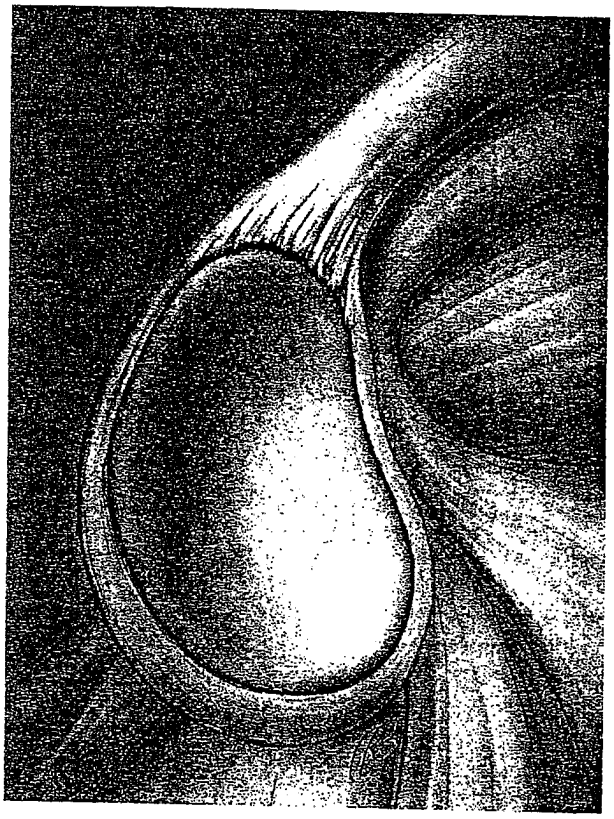

Figure 7 SLAP lesion Type II.

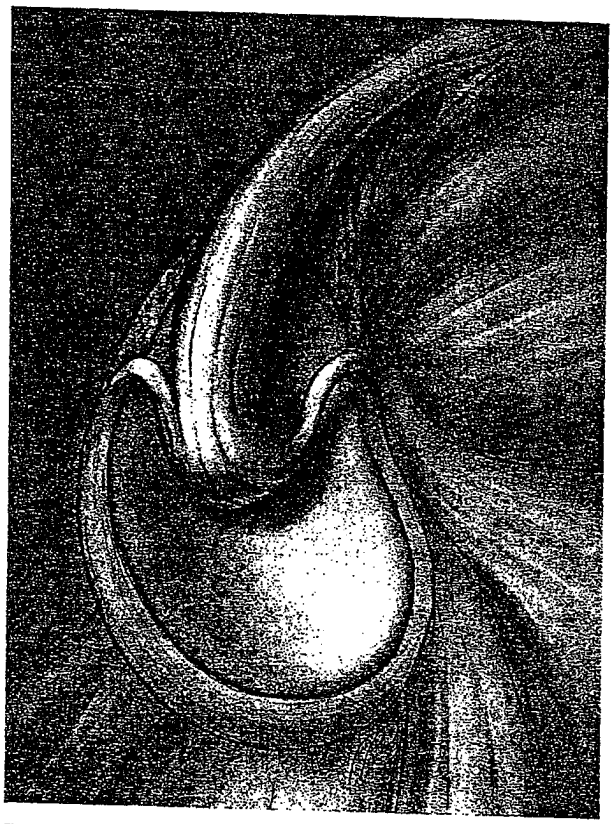

Figure 9 SLAP lesion Type IV.

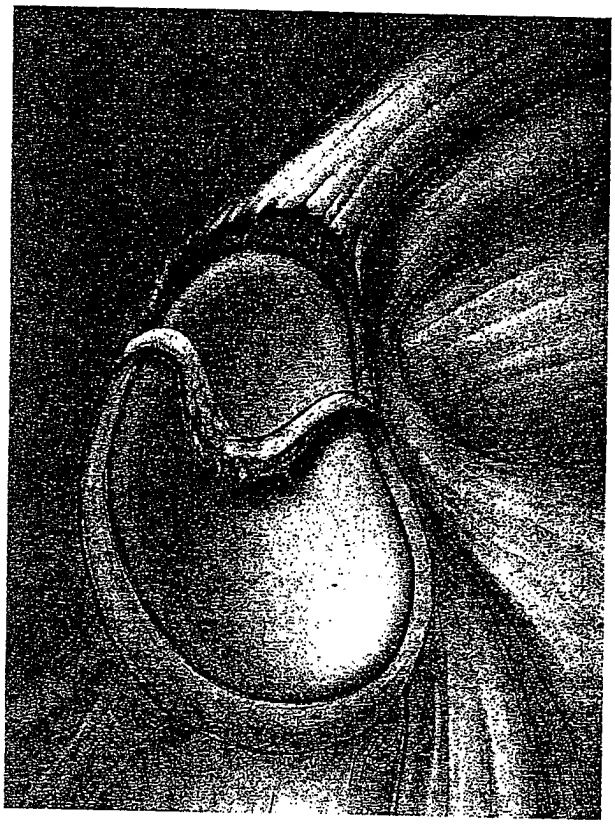

Figure 8 SLAP lesion Type III.

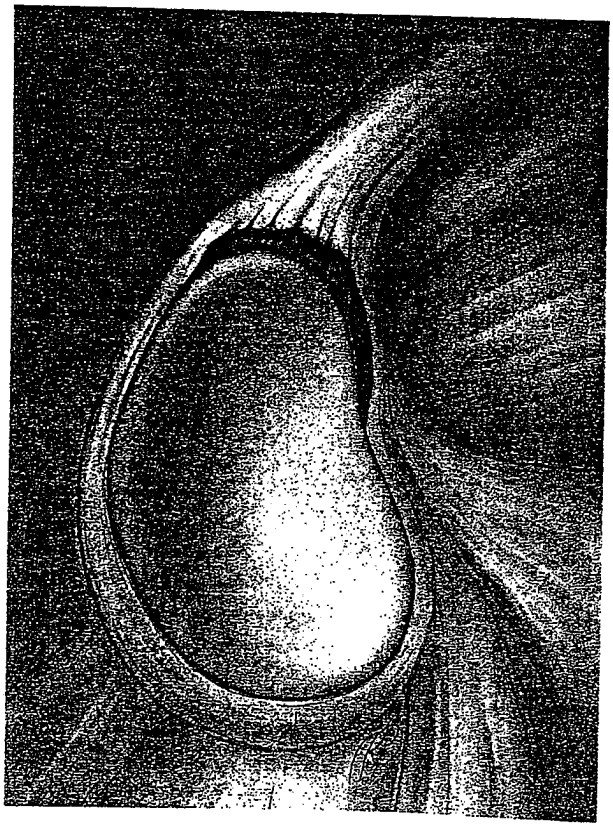

Figure 10 SLAP lesion Type II anterior subtype.

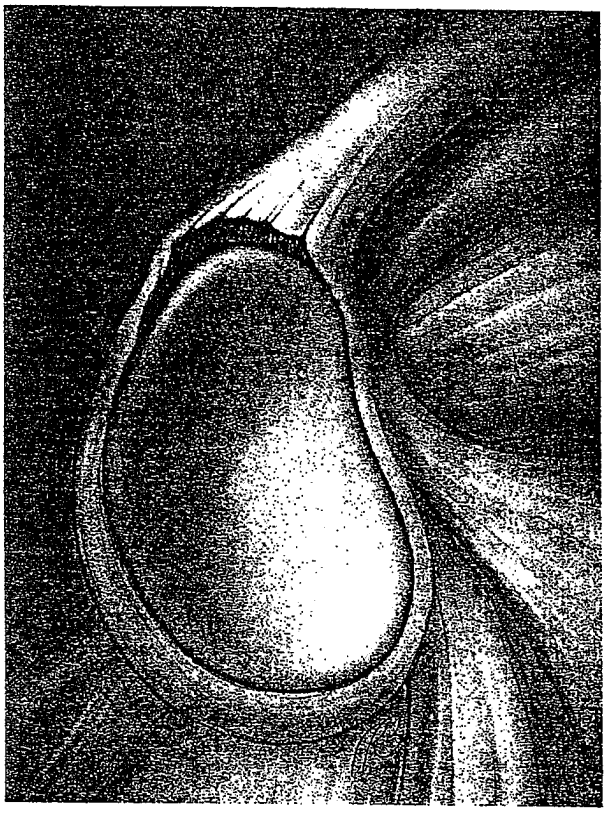

Figure 11 SLAP lesion Type II posterior subtype.

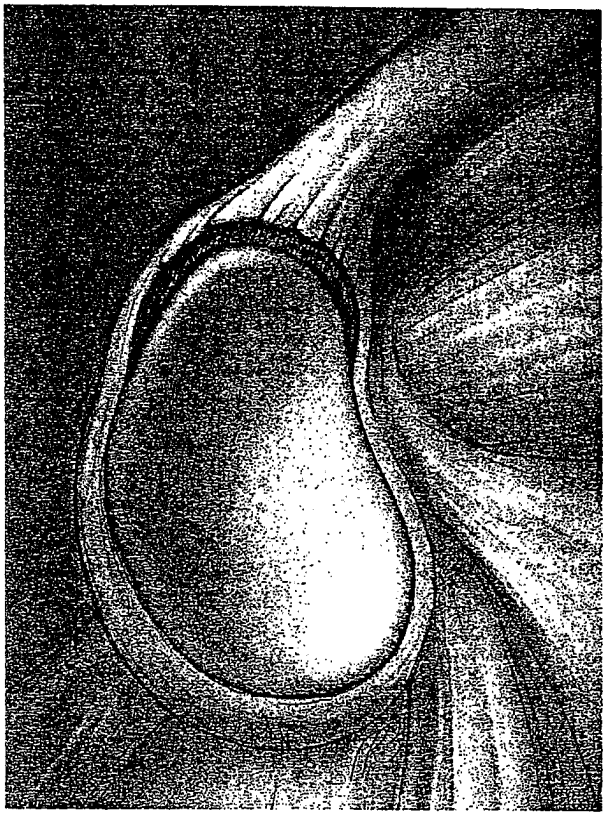

Figure 12 SLAP lesion Type II combined anterior/posterior subtype.

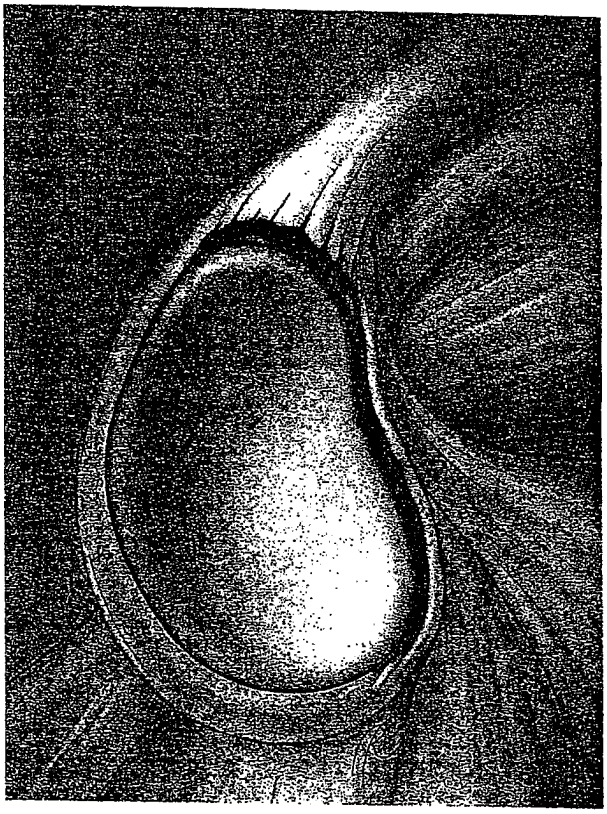

Figure 13 SLAP lesion Type V.

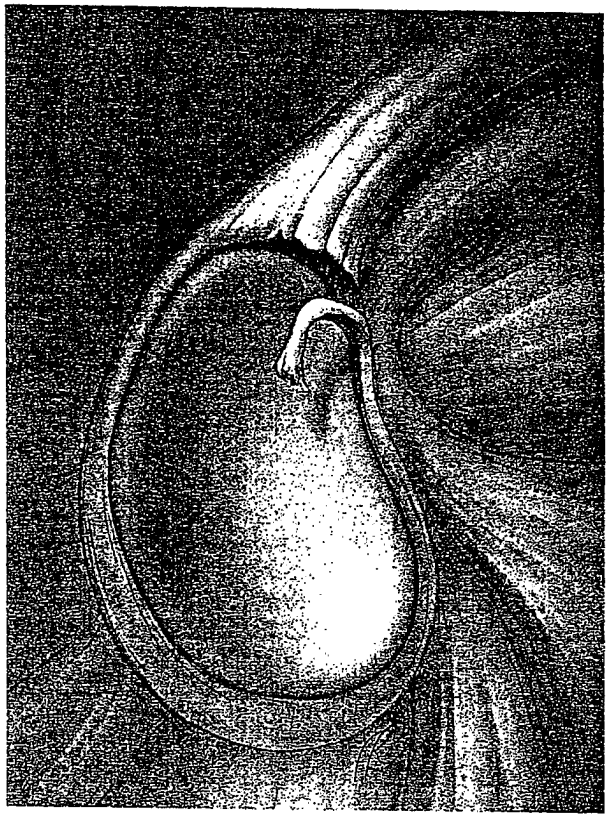

Figure 14 SLAP lesion Type VI.

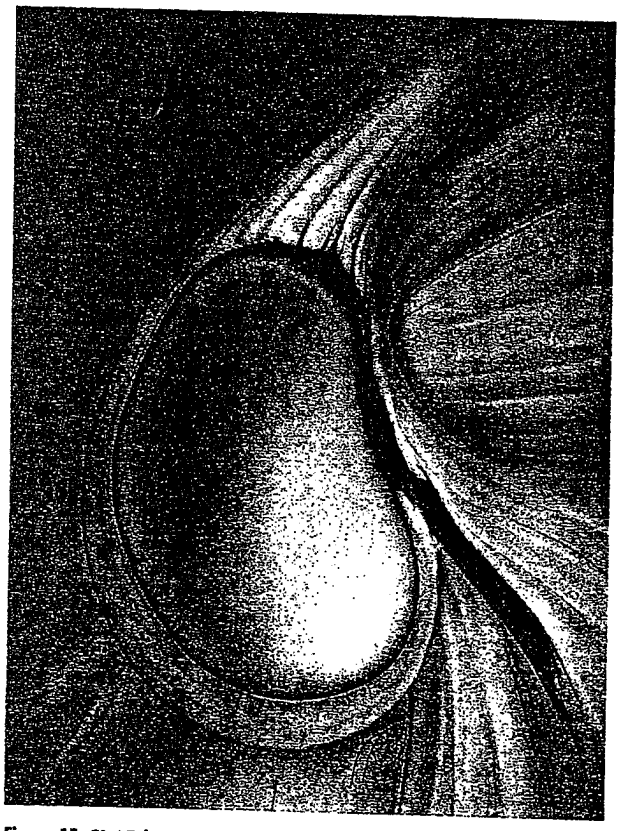

Figure 15 SLAP lesion Type VII.

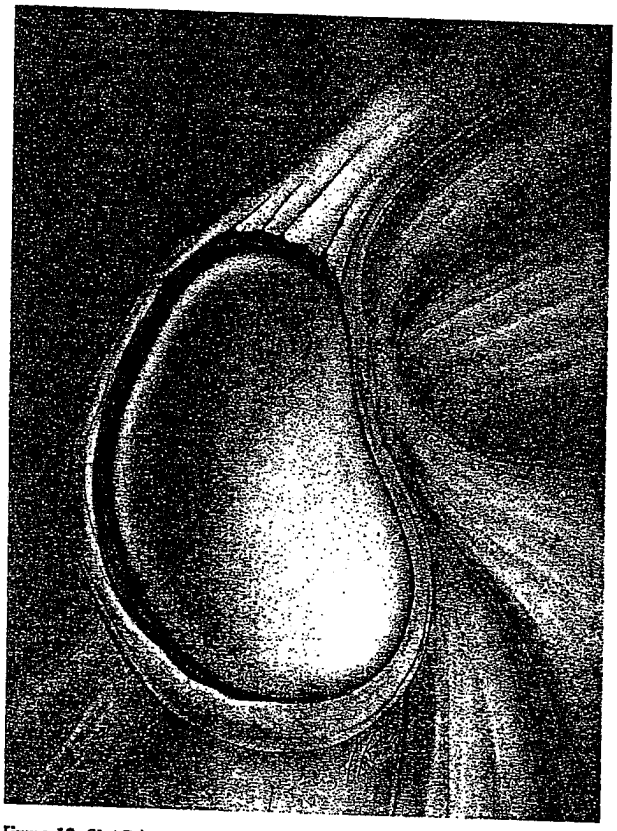

Figure 16 SLAP lesion Type VIII.

rior (Fig. 10), 31% posterior (Fig. 11), and 31% combined anterior and posterior (Fig. 12). Maffet and coworkers[5] described further types of SLAP lesions. A Type V lesion is described as an anterior-inferior Bankart lesion that propagates superiorly to the biceps tendon (Fig. 13). Type VI SLAP lesion is an unstable flap tear of the labrum with separation of the biceps anchor (Fig. 14). A Type VII lesion is a superior biceps-labral detachment that extends anteriorly beneath the middle glenohumeral ligament (Fig. 15).

Recently Nord and Ryu[14] have added several previously unclassified lesions to the schema. A Type VIII SLAP lesion is a SLAP extension along the posterior glenoid labrum as far as 6 o'clock (Fig. 16). A Type IX lesion is a pan-labral SLAP injury extending the entire circumference of the glenoid (Fig. 17). A Type X lesion is a superior labral tear associated with posterior-inferior labral tear (reverse Bankart lesion) (Fig. 18).

Treatment

Isolated SLAP lesions are best treated with the patient in the lateral decubitus position. Anesthesia can be either a general anesthetic or an interscalene block. We have had success with interscalene blocks and favor it in all patients. The block is typically done in the preoperative holding area. After sedation with 2 mL midazolam (Versed; Baxter, Deerfield, IL), a nerve stimulator is used to localize the brachial plexus. Twenty milliliters of lidocaine 1% are injected first, followed by 20 mL mepivicaine (Sensorcaine; Astra-Zeneca, Wilmington, DE) 0.5% with epinephrine and bicarbonate added to increase the duration and shorten the onset of the anesthesia. A propofol (Diprivan; Astra-Zeneca) drip can be used intraoperatively to maintain sedation, or a general anesthetic can be combined with the interscalene block. In the lateral decubitus position, the patient is stabilized with a bean bag and kidney rests. A pillow is placed between the legs and a second pillow beneath the leg on the table just distal to the fibular head to avoid injury to the peroneal nerve. The shoulder traction device is placed on the ipsilateral side of the involved extremity at 30° of abduction and 0° to 20° of forward flexion, depending on the location of the lesion. A sterile bump can achieve further abduction as needed. The extremity is placed in balanced suspension with 10 lb of traction.

The procedure begins with palpation of the bony landmarks about the shoulder. The posterolateral corner of the acromion is identified and the tip of the coracoid and anterolateral corner of the acromion anteriorly. A standard posterior incision is made 2 cm inferior and 1 cm medial to the posterolateral corner of the acromion. With a finger palpating the coracoid tip, the obturator and cannula are directed anterior and superior toward the tip of the coracoid. The elastic resistance of the posterior capsule is felt at the tip of the obturator and overcome with manual pressure, yielding a pop as the tissue is penetrated.

A thorough examination of the glenohumeral joint is undertaken with attention to a widened rotator interval and positive drive-through sign, tears of the subscapularis, biceps tendon subluxation, Bankart lesions, impaction fractures of

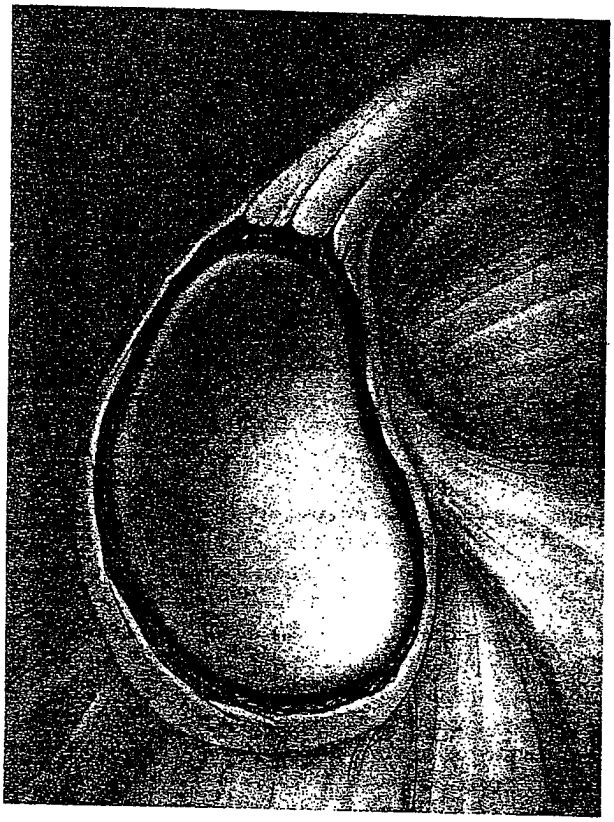

Figure 17 SLAP lesion Type IX.

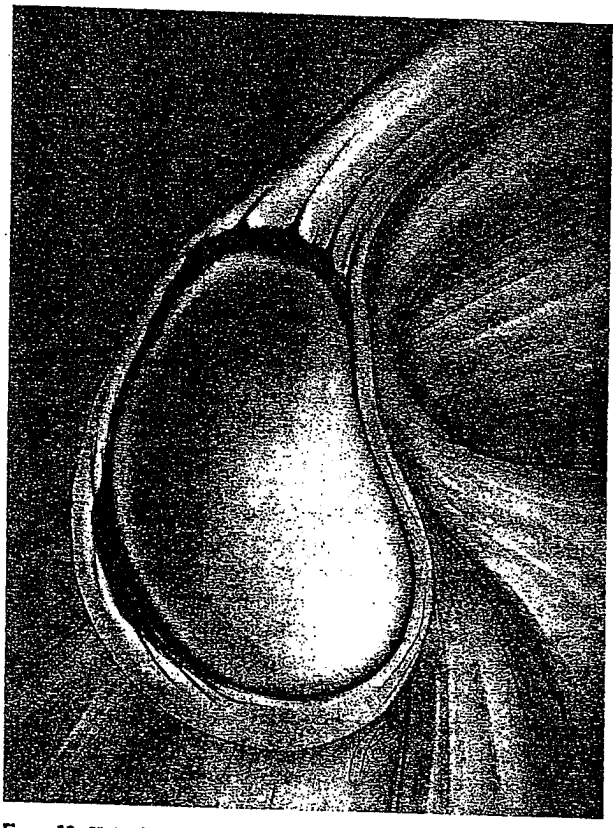

Figure 18 SLAP lesion Type X.

the cartilage of the humeral head, and posterior Bankart lesions. Care is taken to externally rotate the extremity to examine for partial-thickness undersurface rotator cuff tears and full-thickness tears. In evaluation for a SLAP lesion, it is essential to probe the biceps tendon anchor to examine for laxity, fissuring, and separation of the tendon from the superior rim of the glenoid. Pathology to the biceps anchor can easily be missed without probing the tendon. An 18-G spinal needle is placed outside in from a point 1 cm medial to the anterolateral edge of the acromion at an angle of 45° to the glenoid. The needle enters the glenohumeral joint through the rotator interval and is used to identify anterior superior cannula placement. The cannula and obturator can be used to lift the biceps tendon superior from its anchor on the supraglenoid tubercle (Fig. 19A,B). Fissuring of the articular cartilage adjacent to the biceps-labral complex, fraying of the undersurface of the attachment, and frank traumatic avulsion of the root can be revealed by this simple maneuver to what appears to be a normal biceps attachment.

After anterior portal placement, the obturator is replaced into the arthroscope cannula posteriorly, and the arthroscope is placed through the anterior portal to view posterior capsulolabral structures to complete the examination.

Portal placement for treatment of a SLAP lesion is dictated by the pathology discovered in the glenohumeral joint. For the most common SLAP lesion, the Type II lesion, 3 portals are commonly used. The standard posterior viewing portal is initially established. A high rotator interval portal is created with an outside in technique using an 18-G spinal needle beginning 1 cm medial to the anterolateral corner of the acromion, through the rotator interval tissue adjacent to the biceps' exit to the intertubercular groove. From this high angle, excellent purchase of a suture anchor into bone can be achieved. If the angle to the glenoid is too low, the anchor can either skive off bone or enter the glenoid in the osteochondral junction resulting in poor purchase of the anchor and delayed fragmentation of the cartilage.

The third portal for the isolated Type II SLAP lesion is a midlateral portal,[18] a transrotator cuff portal,[19] or a posterolateral portal (Port of Wilmington). The Port of Wilmington portal is created with an outside-in technique using an 18-G spinal needle. The needle enters the skin just off the lateral edge of the acromion at the midpoint of its anterior posterior dimension at a 45° angle to the acromion. The needle passes through the musculotendinous junction of the supraspinatus or infraspinatus and into the glenohumeral joint just posterior to the biceps root. As the needle enters the joint visualized from the posterior viewing portal, it is important to be certain the needle enters the joint as close as possible to the humeral head. This allows the cannula to be placed at a distance from the tissue that is being repaired and out of the way of the viewing portal. Nord et al[16] have described the use of the Neviaser portal for SLAP repair. The portal is a superior medial portal bordered by the acromioclavicular joint, the clavicle, and the spine of the scapula and can be used to access the superior biceps-labral tissue by introducing a penetrating suture grasper to perforate the superior labrum at a 90° angle and pass the suture from the anchor through the labrum. The suture is then retrieved out the superior medial cannula and then tied.

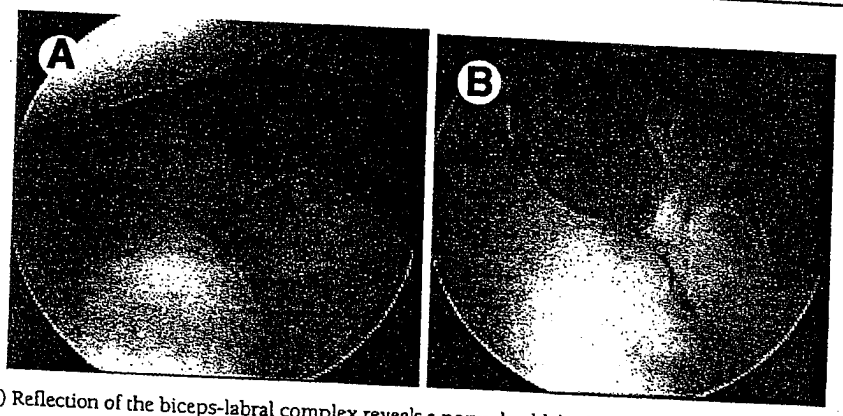

Figure 19 (A) Reflection of the biceps-labral complex reveals a normal sublabral sulcus. (B) Reflection reveals chondral injury and an unstable biceps-labral complex.

Mobilization of the biceps-labral tissue is essential for achieving a stable repair. The Type II SLAP lesion must often be completed with liberators to free the biceps from scar tissue from initial injury or from an incomplete avulsion secondary to microtrauma (Fig. 20A,B).

Preparation of the bony bed is achieved with a shaver followed by a rasp (Fig. 20C). Some authors use a burr to remove the leading edge of the articular cartilage, whereas others prefer a basket or biter to expose the bony edge of the superior glenoid (Fig. 21A). A bed of bleeding bone is essential to creating a stable repair.

Burkhart et al[4] have emphasized the need to place anchors at the corner of the glenoid at the articular cartilage interface to restore the normal configuration of the biceps anchor (Fig. 21B,C).

Suture-anchor techniques vary according to author. Biodegradable anchors or metal anchors may be selected. The anchor may be placed first followed by passage of a limb of suture, or the suture may be passed first and then threaded through the anchor and the anchor placed second. Nam and Snyder[13] have advocated a single-anchor, double-suture technique for SLAP repair. One anchor is placed at the root of

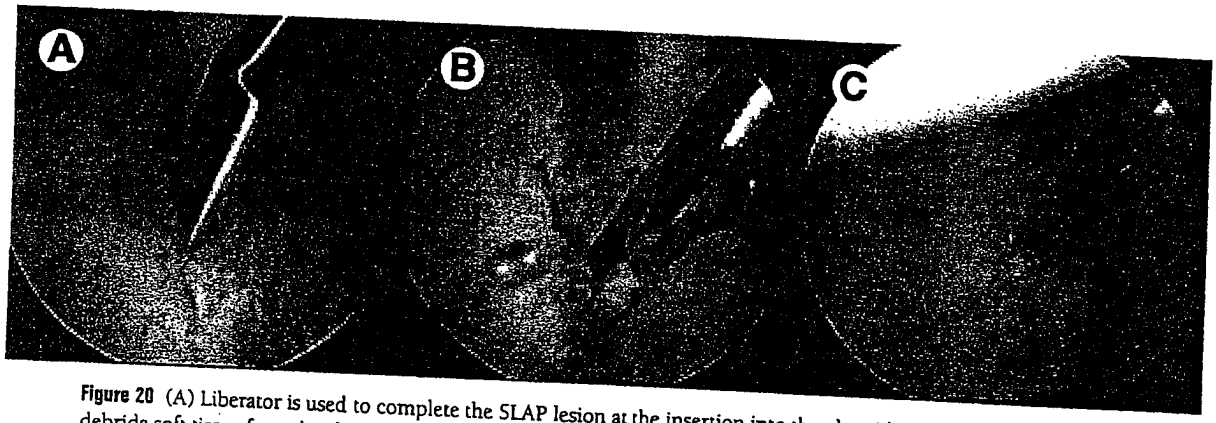

Figure 20 (A) Liberator is used to complete the SLAP lesion at the insertion into the glenoid rim. (B) Shaver is used to debride soft tissue from the glenoid rim. (C) Rasp is used to roughen the edge of the glenoid down to a bed of bleeding bone.

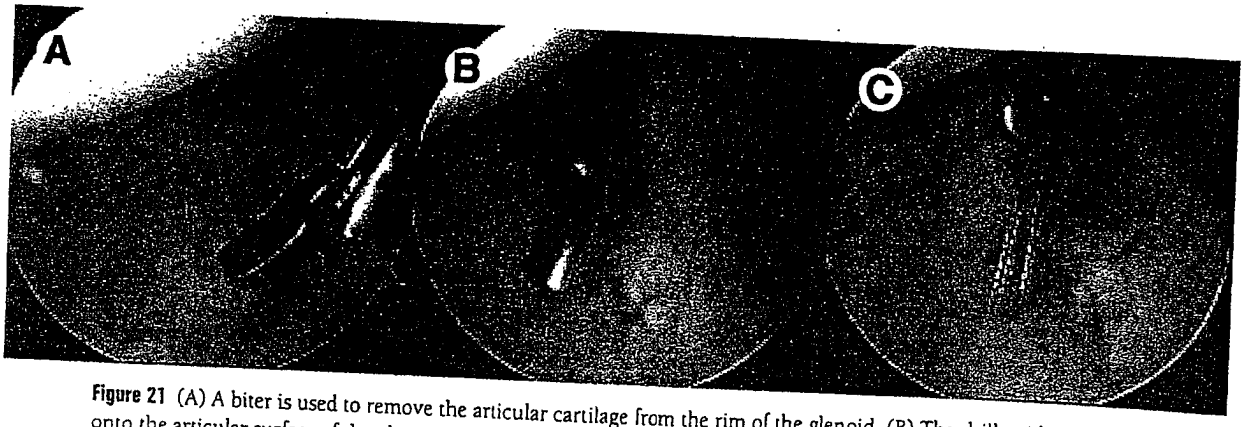

Figure 21 (A) A biter is used to remove the articular cartilage from the rim of the glenoid. (B) The drill guide is placed onto the articular surface of the glenoid. (C) Anchor in place with sutures exiting the anterior cannula.

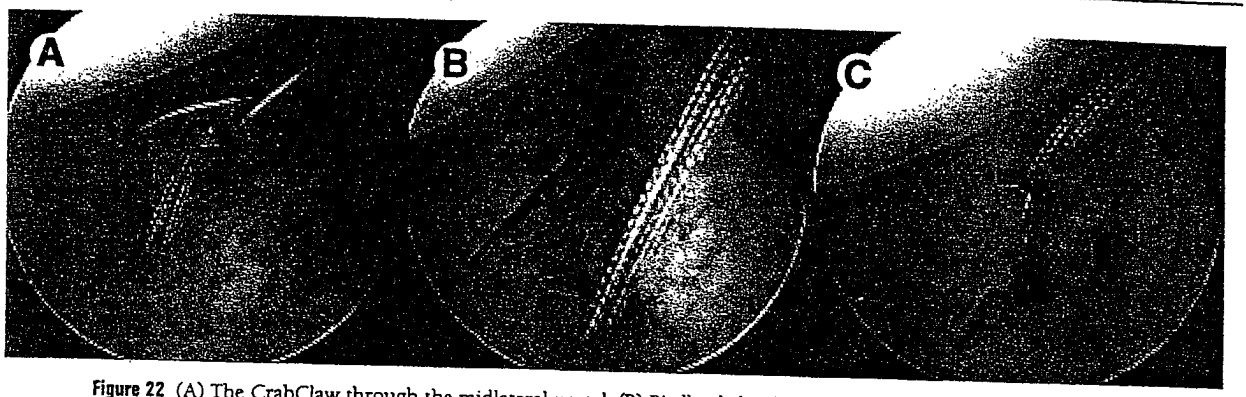

Figure 22 (A) The CrabClaw through the midlateral portal. (B) Birdbeak (22°) brought in through the anterior portal. (C) Birdbeak passed through anterior labral tissue and suture grasped.

the biceps into bone with a suture passed posterior and a second one anteriorly over the biceps root.

The authors prefer a 2-anchor technique using the Arthrex (Naples, FL) Bio-FASTak or biodegradable tap-in anchors, the Arthrex BioSutureTak. The guide is a modest 3.5 mm in diameter that can accommodate a 3.0-mm anchor. The guide is placed through the anterior portal and onto the prepared glenoid. Anchors are placed at a 45° dead man's angle to the articular surface for best mechanical fixation.[14] The guide is held in position and the drill hole made with the appropriate drill bit equipped with a stop to assure accurate depth for anchor fixation. While holding the guide in position over the drill hole, the drill is removed and the anchor placed through the guide into the drill hole. Depending on which anchor is used, the device is either screwed or tapped into bone with a mallet. Gentle traction tests the purchase of the anchor. A suture retriever or CrabClaw (Arthrex) is placed through the midlateral portal and the sutures captured and passed out of the midlateral portal (Fig. 22A). Next, a 22° Birdbeak (Arthrex) is passed through the anterior portal, through the anterior biceps-labral tissue, and opened to capture the most superior limb of the suture (Fig. 22B,C).

As the grasper is backed out of the cannula, it is important to hold the opposite limb of the suture at the midlateral portal to avoid unthreading the anchor (Fig. 23A,B).

The GrabClaw is brought through the anterior portal to capture the second suture limb from the midlateral portal and brought out the anterior portal (Fig. 23C). With 1 limb of suture passing over the tissue and 1 limb through the tissue, an arthroscopic knot is ready to be tied. If a mattress stitch configuration is desirable, the suture retriever is simply passed a second time through the labrum to capture the second suture limb, retrograding the limb through the labrum as well. One author (SEP) prefers to tie with the 6th Finger Knot Pusher (Arthrex) (Fig. 24). This device keeps the knot tensioned during knot tying while alternating half hitches. This permits expedited knot tying because the need to change posts is obviated and the posts can be alternated by simply applying traction to "flip" the half hitch. This knot-tying device also allows efficient past pointing when tying sutures, thereby maximizing knot security.

The posterior SLAP repair is a variation of the anterior repair. The anchor is place through a midlateral portal or posterolateral Port of Wilmington portal (Fig. 25A). A higher-angled Birdbeak is used through the midlateral portal and placed through the labrum to capture the suture (Fig. 26A,B). Knot tying is then accomplished as previously described.

Alternatively, the Penetrator (Arthrex) can be used through the Neviaser portal for passing suture posterior or anterior to the biceps [16] (Fig. 27A-C).

Type III lesions can be treated with a simple debridement of the bucket handle portion of the biceps anchor and superior labrum. In some cases, if the labrum is not too badly frayed, the bucket-handle lesion can be repaired to the biceps

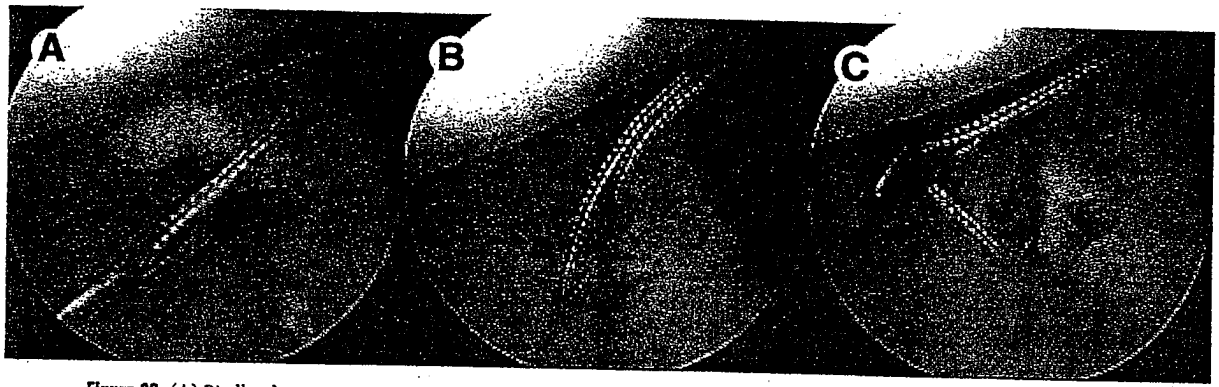

Figure 23 (A) Birdbeak grasping one limb of the suture. (B) Care is taken to watch the correct limb of the suture pulled through the tissue to avoid unthreading the suture from of the eyelet. (C) CrabClaw grasps the suture over the labrum and out the anterior cannula.

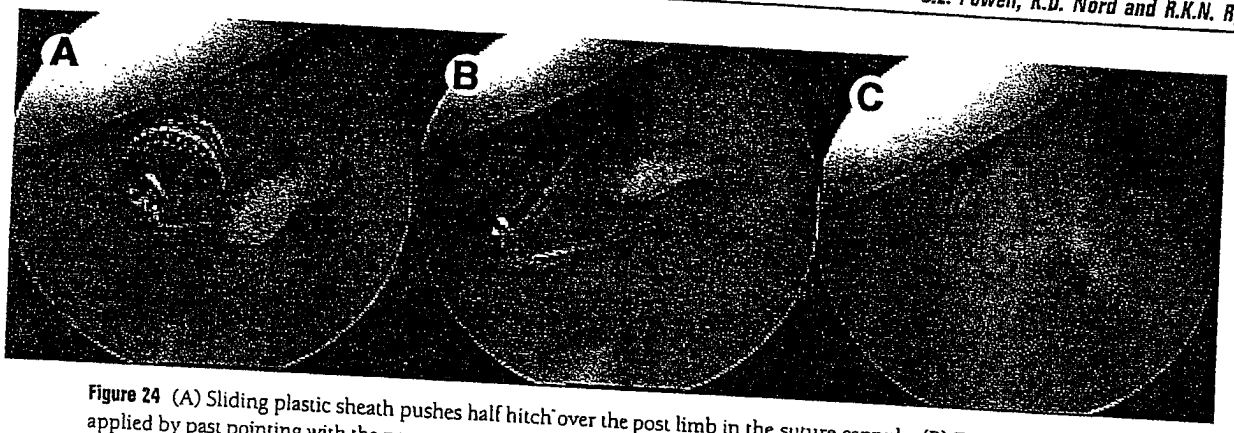

Figure 24 (A) Sliding plastic sheath pushes half hitch over the post limb in the suture cannula. (B) Tension on the post applied by past pointing with the postsuture cannula. (C) Knot securing labral tissue to the superior rim of the glenoid.

anchor much like a meniscal repair. Type IV lesions are most commonly treated with debridement of the bucket handle portion of the tissue and repair of the biceps anchor as needed. If the bucket-handle component is viable, a repair of the bucket-handle segment can accompany the reattachment of the biceps anchor. If the tear extending into the substance of the biceps involves greater than 50% of the diameter of the tendon, biceps tenodesis or tenotomy is recommended.[18] Repair of Type V SLAP lesions include fixation of the biceps root, as in a Type II lesion, and continuing with anchors to incorporate the Bankart lesion. Type VI lesions are best treated with debridement of the flap tear and fixation as in a Type II lesion. Type VII lesions include fixation of the superior labrum as in a Type II lesion and suturing of the middle glenohumeral ligament (MGHL) through the anterior rotator interval portal. Type VIII lesions are treated as a Type II SLAP lesion with fixation of the posterior reverse Bankart lesion. An accessory posterolateral portal, 1 cm lateral to the standard posterior portal, can facilitate posterior anchor placement. The guide is placed initially with a blunt trochar to the posterior capsule and exchanged for a sharp trochar to pierce the posterior capsule. The Type IX lesion, or panlabral lesion, is treated with anchors anterior, posterior, and superior with a capsular shift. Type X lesions are treated as Type VIII lesions.

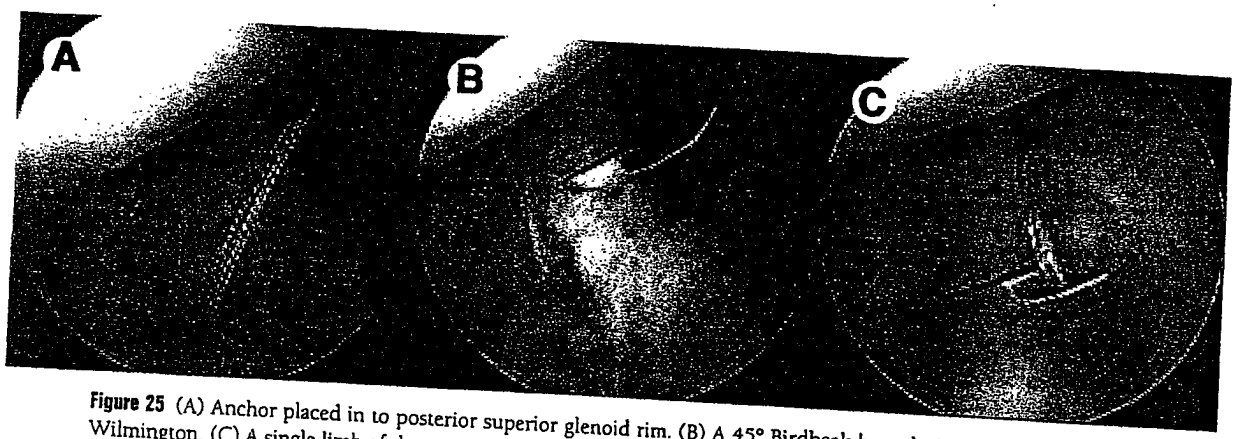

Figure 25 (A) Anchor placed in to posterior superior glenoid rim. (B) A 45° Birdbeak brought in through the Port of Wilmington. (C) A single limb of the posterior suture captured by the Birdbeak.

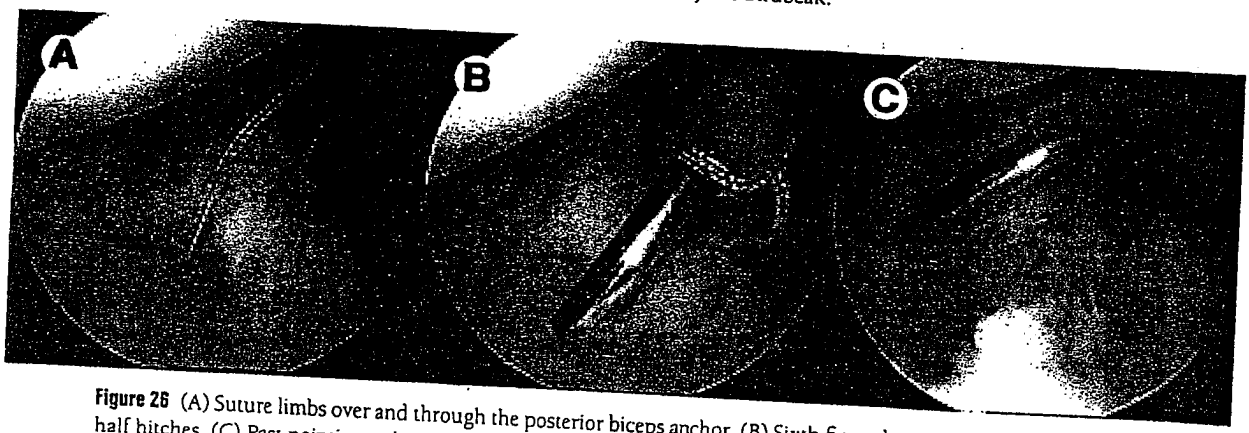

Figure 26 (A) Suture limbs over and through the posterior biceps anchor. (B) Sixth finger knot pusher tying alternating half hitches. (C) Past pointing to keep the knot tensioned during tying.

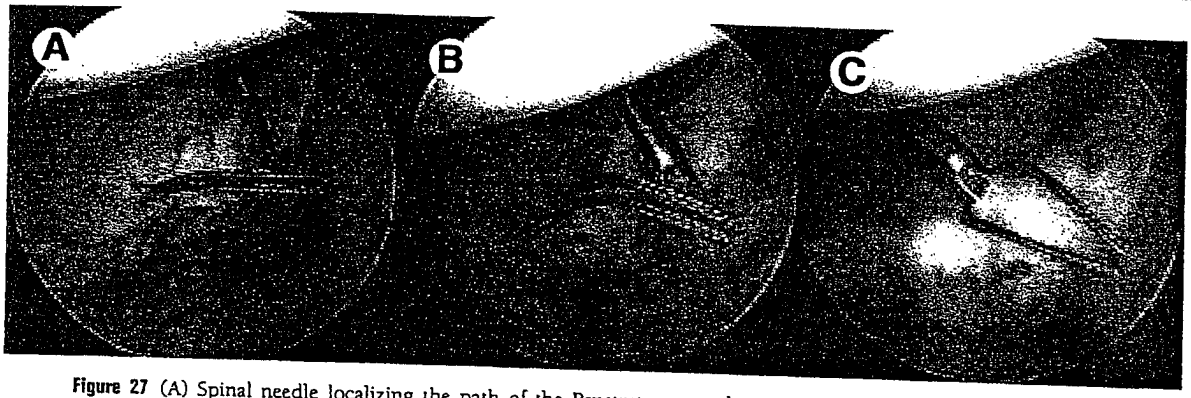

Figure 27 (A) Spinal needle localizing the path of the Penetrator over the posterior superior labrum. (B) Straight Penetrator through the Neviaser portal. (C) Penetrator grasping a limb of suture.

In the setting in which glenohumeral internal rotation deficit is the primary cause of the SLAP lesion and a preoperative posterior-inferior capsular stretching program has not improved internal rotation, a posterior capsular release in conjunction with a Type II SLAP lesion repair is indicated.

Accessory Portals for SLAP Repair

As SLAP tears progress further posteriorly as seen in Types VIII and IX, the Port of Wilmington is effective from 12 to 2 o'clock on a left shoulder or 10 to 12 o'clock position on a right shoulder (Fig. 28). For posterior-superior SLAP lesions that extend from the 2 o'clock to 5 o'clock (left) position posteriorly, or 10 to 7 o'clock (right), an accessory posterior portal is necessary. This can sometimes be accomplished without a cannula by using a 2-mm incision 1 cm lateral to the standard posterior portal and introducing a FASTak Spear (Arthrex) after locating the proper angle with a spinal needle (lateral accessory portal). After the FASTak is inserted, the suture can be passed through the labrum using a Penetrator through a separate 2-mm incision 1 cm medial to the posterior portal (medial accessory portal). The angle of retrieval prevents tension on the labrum while the suture is retrieved. Both ends of the suture are then retrieved through the anterosuperior portal and the knot is tied using the standard knot-tying device. A mattress suture can be placed by passing the Penetrator a second time through the medial accessory posterior portal. If visualization is compromised, the camera can be switched to an anterior portal and a clear plastic cannula placed through the posterior portal will allow use of the Birdbeak or similar retrieving device. At the most inferior extent of a Type VIII, IX (pan-labral tear) or X SLAP lesion, a cannula through the lateral accessory posterior portal can facilitate access to this difficult to reach region.

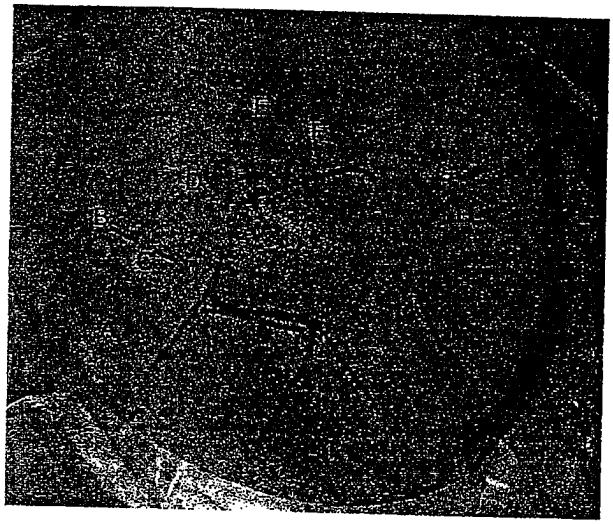

Figure 28 Initial and accessory portals for arthroscopic treatment of SLAP lesions. A, anteromedial portal; B, low anterior portal; C, high rotator interval portal; D, anterolateral portal; E, midlateral portal; F, Port of Wilmington portal; G, standard posterior viewing portal; H, medial accessory portal; I, Neviaser portal.

Rehabilitation Protocol

Surgery is performed on an outpatient basis. Postoperatively, the shoulder joint is injected with 20 mL 0.5% Marcaine if an interscalene block is not used. The patient is placed in a DonJoy Ultrasling II (Vista, CA) immobilizer for the first 3 weeks. During the first 4 weeks after surgery, the patient begins passive forward elevation, and full elbow range of motion is permitted. Abduction and external rotation is avoided. Passive and active range of motion to 90° of flexion is the goal during weeks 4 through 6. Active forward flexion beyond 90° and forceful active biceps contraction should be avoided for approximately 6 weeks postoperatively. If a posterior-inferior capsulotomy is performed, sleeper stretches are started immediately postop to stretch the posterior capsule.

After the sixth week, full range of motion and gradual strengthening is performed. Posterior rotator cuff strengthening should be emphasized. Overhead activities or strenuous biceps activity should be avoided for 12 weeks. At 12 to 16 weeks, physical therapy is discontinued and the patient may return to normal activities. Gentle interval throwing is resumed at 4 to 5 months. Full-velocity throwing is allowed at 6 months on a level surface and from a mound at 7 months. Return to unrestricted overhead sports is permitted at 8 to 9 months postoperatively.

Conclusion

SLAP lesions are becoming identified more commonly as a source of pain and instability in the shoulder. Before the

advent of arthroscopy and with it the ability to evaluate the biceps anchor, it is likely that these lesions went untreated. Now, with a careful arthroscopic examination, well-planned portals, and meticulous surgical technique, SLAP lesions can be safely and effectively treated with the reasonable expectation of returning to normal activities, including high-demand throwing.

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