Suprascapular nerve injury during arthroscopic superior labral repair: a prospective evaluation

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Abstract

Purpose This prospective study evaluated suprascapular nerve injury risk during arthroscopic superior labral repair in patients of average height or shorter.

Methods From 2009 to 2011, 12 patients <179 cm tall undergoing arthroscopic superior labral repair were prospectively enrolled. Portal location, tear and anchor characteristics, and surgeon impression of medial glenoid wall perforation were collected. Suprascapular nerve conduction studies were obtained postoperatively. A musculoskeletal radiologist evaluated medial glenoid wall perforation and the distance from the anchor to the suprascapular neurovascular bundle on postoperative magnetic resonance images (MRI). DASH scores were recorded preoperatively and 6 months postoperatively.

Results Medial wall perforation occurred in five (42 %) patients, with 3 patients having a single perforation and two patients having two perforations. Eight of 38 (21 %) anchors drilled into the superior half of the glenoid, and 6 of 20 (30 %) anchors inserted into the postero-superior quadrant of the glenoid, perforated the medial wall. Perforations occurred both through the portal of Wilmington and the antero-superior portal. The distance to the suprascapular neurovascular bundle from the perforating anchors ranged from 0 to 4 mm. Nerve conduction studies revealed subclinical signs of an incomplete nerve injury in one patient. DASH scores improved on average 29.3 points postoperatively (SD = 27.0, p = 0.007).

Conclusion Medial wall perforation is common in smaller patients during arthroscopic superior labral repairs; the suprascapular nerve can be injured if perforation occurs. The clinical significance of these findings is unclear. In spite of a high drill-out rate, the nerve is rarely injured; however, an anchor designed for implantation into bone that is instead lodged in the soft tissues has the potential to harm these tissues and surrounding structures.

Level of evidence Prospective cohort study, treatment study, Level III.

Keywords Suprascapular nerve · Arthroscopic repair · Medial glenoid wall perforation · Nerve injury risk

Introduction

Superior labrum anterior-posterior (SLAP) lesions have been classified into four types by Snyder et al. with the type II SLAP tear being the most common comprising more than 50 % of all labral tears in this region [10, 13]. These injuries may develop in many patients involved in overhead sports such as baseball, tennis and volleyball. Surgical management may be warranted in patients with significant pain and shoulder dysfunction who have failed conservative management. During superior labral repair, standard arthroscopic equipment is used to drill into the glenoid and insert a suture anchor. There are numerous implants available for this purpose with varying lengths and widths of drills and anchors.
Because the surgeon is unable to see beyond the articular zone, the drill and/or anchor may in fact penetrate the medial wall of the glenoid [4, 8]. The suprascapular nerve is an average of 20 mm from the glenohumeral joint in its course from the suprascapular notch to the spinoglenoid notch [1, 2, 6, 15]. In spite of this proximity, iatrogenic injury to the nerve has rarely been reported. In our previous anatomical work, we demonstrated in cadaveric specimens that medial wall perforation and injury to the suprascapular are in fact possible when drilling for superior labral repair, specifically through a supero-lateral portal of Wilmington. This risk was associated with female gender and smaller scapular size [4, 6].

The purpose of this study was to prospectively follow patients undergoing SLAP repair and evaluate the risk of medial glenoid wall perforation and suprascapular nerve injury in patients of average height or less using standard equipment and portals to determine whether perforation occurred in the clinical setting and to monitor for any nerve injuries if perforation(s) occurred. The hypothesis of this study was that the suprascapular nerve would be at high risk of injury during arthroscopic superior labral repair via the standard drilling techniques and/or suture anchor insertion.

Materials and methods

Between 2009 and 2011 patients undergoing arthroscopic SLAP repair were prospectively enrolled, all patients provided written informed consent. Preoperatively, a disability of arm, shoulder, hand (DASH) score, shoulder radiographs and MR arthrogram were performed. All patients had physical examinations to ensure no atrophy or weakness of the rotator cuff was present, suggesting a possible pre-existing suprascapular nerve injury. All patients were less than 179 cm tall, which is less than the height of the average male in North America [5].

Intra-operative data collection included patient position, location and size of the labral tear, number, type and location of suture anchors used, portals used, and whether the surgeon felt a perforation of the medial glenoid wall had occurred intra-operatively. If the surgeon did feel a perforation had occurred, the location of the suspected perforation was recorded. Needle electromyography (EMG) and nerve conduction studies using standard techniques were performed at approximately 6 weeks postoperatively, and a standardized non-contrast magnetic resonance image (MRI) was done between 3 and 6 months postoperatively. Although glenoid vault perforation is easily viewed with a magnetic resonance image (MRI), this does not provide researchers with information regarding the associated functional impact of any potential injury. Therefore, the present study used MRI–EMG to document the structural and functional effects of an injury to the suprascapular nerve.

A senior musculoskeletal radiologist and radiology fellow reviewed the MRIs to determine whether a medial glenoid wall perforation had occurred. If a perforation occurred, the distance from the anchor position to the suprascapular neurovascular bundle was measured in millimetres. The measurements were made independently by two MSK radiologists; in all cases, the measurements were either identical or 1-mm difference. In cases of discrepancy, the farthest measurement was chosen.

The lateral acromial offset was determined by choosing the mid-coronal image. This midline coronal image was found using the axial sequence to determine the mid-point of the glenoid face; then, the corresponding coronal slice was used to determine lateral acromial offset. Lateral acromial offset angle was measured as the angle between the lateral edge of the acromion to the superior articular surface margin and the horizontal plane. This represents a theoretical maximal angle in the coronal plane that can be used to access the superior glenoid with arthroscopic equipment (Fig. 2).

Patients underwent a standard postoperative rehabilitation protocol based on regional rehabilitation guidelines. This protocol was tailored to the major pathology treated at the time of surgery. Patients completed a postoperative DASH score at a minimum of 6 months after surgery.

Statistical analysis

Descriptive statistics were calculated for all variables, including the proportion of subjects who experienced penetration of the medial glenoid wall or suprascapular nerve injury. Paired T tests were used to compare differences between pre- and post-DASH scores. The alpha level was set at 0.05, and all analysis was performed using SPSS version 16.0 for Windows (SPSS INC., Chicago, IL).

Results

Twelve patients were enrolled by four fellowship trained shoulder surgeons (Table 1). The indication for surgery was pain or instability (Table 1). Of the instability patients, two underwent a repair of the antero-inferior labrum in addition to repair of the superior labrum, two underwent isolated SLAP repairs, and one patient had a circumferential labral repair. Of the seven patients with a primary complaint of pain, five had an isolated repair of the superior labrum, and two underwent a distal clavicle resection in addition to the repair of the superior labrum. Eleven
patients were positioned in the beach chair and one in the lateral decubitus position. No rotator cuff tears requiring surgical repair were encountered. Two patients were Workers’ Compensation patients.

Five patients (42 %) had medial wall perforation from superior labral repair visible on their postoperative MRI (Fig. 1a–d). Three patients had one perforation, and two patients had two perforations. Of the 38 anchors placed in the superior glenoid for SLAP repair, 8 (21 %) appeared to have breached the medial cortex of the glenoid on the postoperative MRI. Considering only those anchors placed posterior to the biceps in the postero-superior quadrant of the glenoid, 6 of 20 anchors (30 %) perforated the medial wall. Perforations occurred through both the portal of Wilmington and the antero-superior portal. Of those anchors that visibly perforated the medial cortex, the distance to the suprascapular neurovascular bundle varied from immediately adjacent to the neurovascular bundle with deformation of the nerve to 4 mm (Fig. 2).

The mid-glenoid coronal plane MRI of all 12 patients was evaluated to determine the lateral acromial offset angle (Table 1). In patients who experienced a perforation, the mean angle was 23°, while those without a perforation had a mean angle of 26°.

In 8 patients, surgeons subjectively felt that they drilled through the medial cortex by the change in resistance. There was no correlation between drill perforation and surgeon, anchor type or patient size. Of two different anchor systems used, they had approximately the same dimension in terms of drilled depth (20–21 mm), but anchor length varied slightly (11.6–14.5 mm).

Postoperative needle EMG and nerve conduction studies confirmed an incomplete, subclinical suprascapular nerve injury in one patient with reduced recruitment of the supraspinatus muscle. One of two anchors perforated the cortex medially, but was four millimetres away from the nerve; thus, it is surmised that the injury is the result of drill contact as opposed to contact by the anchor. The surgeon reported that a drill perforation had occurred. Repeat EMG studies confirmed the injury had not resolved.

Table 1 Preoperative characteristics

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<tr>
<th>Demographics</th>
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<tr>
<td>Mean age in [years (SD)]</td>
<td>32.9 (10.2)</td>
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<td>Males [n (%)]</td>
<td>6 (50)</td>
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<tr>
<td>Mean height in [centimetres (SD)]</td>
<td>169.7 (7.6)</td>
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<td>Mean preoperative DASH score (SD)</td>
<td>45.2 (15.7)</td>
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<tr>
<td>Indication for surgery</td>
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<tr>
<td>Pain [n (%)]</td>
<td>7 (58.3)</td>
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<td>Instability [n (%)]</td>
<td>5 (41.7)</td>
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<tr>
<td>Mean lateral acromial offset in degrees (SD)</td>
<td>24.8 (7.3)</td>
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Fig. 1  a–d MRI scan showing anchors penetrating the medial glenoid wall (arrows). Note Fig. 1c in which the anchor is in contact with the suprascapular neurovascular bundle. Also note asymmetric shape and small bony area for anchor insertion on superior glenoid (a–c)

6 months postoperatively. There was no evidence on the preoperative MRI of a pre-existing nerve injury as indicated by an absence of denervation atrophy or a paralabral cyst.

Ten (83 %) patients completed a 6-month postoperative DASH score. DASH scores improved on average of 29.3
points (SD = 27.0, p = 0.007) 6 months postoperatively (Table 2); however, two of the seven patients with isolated SLAP repairs had worse DASH scores postoperatively. All patients with concomitant pathology improved, especially when the SLAP repair was performed in the setting of glenohumeral instability.

Discussion
The most important finding of the present study was the fact that the medial wall of the glenoid is often perforated with a drill and suture anchor during arthroscopic superior labral repair through both the portal of Wilmington and the antero-superior portal, confirming our cadaveric findings [4]. However, in spite of a high drill perforation rate, the suprascapular nerve appears to be uncommonly injured and there was a mean improvement of almost 30 points in DASH scores postoperatively. Only one patient demonstrated a subclinical suprascapular nerve injury with mild weakness of the supra- and infraspinatus muscles and vague, ill-defined, posteriorly based shoulder discomfort.

In the remaining patients, no clinical or electrophysiological evidence of a permanent nerve injury occurred despite the proximity of the suture anchors to the nerve. In two cases, the anchors appeared to be touching the suprascapular neurovascular bundle. Surgeons were commonly able to detect when the drill was penetrating the medial wall of the glenoid.

Very little information appears to be published on this topic. In our original cadaveric study, we identified medial wall perforation in 38 % of drill tracts and actual nerve contact in 28 % of tracts [4]. Koh et al.[8], and in similar recent cadaveric studies placed one suture anchor at a 12:30–11:30–11 (R/L) position on the glenoid through an antero-superior portal using a 21-mm drill and 14.5-mm anchor. In all 12 cases, the drill breached the medial wall. In 33 % (4/12) of cases, the nerve was contacted by the anchor. However, they did not show a correlation between perforation and scapular size. Gumina et al. measured 500 dry scapula and determined a safe zone of 2.1 cm to the nerve from the supraglenoid tubercle to the suprascapular notch, and a smaller 1.1 cm safe zone posteriorly at the base of the scapular spine [6] with differences noted between males and females [6].

Despite these worrisome cadaveric results, to our knowledge, there have been only two iatrogenic suprascapular nerve injuries reported after superior labral repair. Kim et al. [7] presented a case report of medial glenoid wall perforation by a suture anchor, and Yoo et al. [16] identified an iatrogenic injury with a suture anchor below the level of the spinoglenoid notch.

Drill perforation can potentially occur due to both modifiable (drill angle, portal position, and type of anchor) and non-modifiable (patient size and anatomy, and the location of the tear) factors. Burkhart et al. and Rames et al. recommend an anchor insertion angle of 45 degrees relative to the articular surface, while Lehtinen et al. suggested an optimal angle of 30 degrees [3, 9, 11]. During superior labral repair, accessory portals such as the portal of Wilmington can also be used to access the torn labrum [14]. We suggest that the surgeon must attempt to make any accessory portal close to the lateral acromial border and as high as possible, to allow for a more vertical approach to the superior glenoid (assuming the beach chair position). We noted drill perforation through both the portal of Wilmington and the antero-superior portal, but medializing the portal decreased the risk of drill perforation due to an increased drill angle in the coronal plane. Alternatively, a modified Neviaser portal could theoretically reduce the risk of drill out as it affords a very steep insertion angle in the coronal plane.

A variety of implants exist for labral repairs, but in general, drills range in length from 15 to 23 mm, and anchors from 6 to 15 mm in length. A shorter implant may

Table 2 Operative and postoperative findings

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<td>Portals used</td>
<td>Wilmington [n (%)] 9 (75)</td>
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<td>a Anchors were single-loaded PLLA or bio-composite material</td>
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reduce the risk of drill perforation; however, this hypothesis remains untested. The shortest distance between the glenoid rim and the suprascapular nerve is at the base of the scapular spine and averaged $18 \pm 2$ mm [6, 12]. This puts the nerve at considerable risk with many of the available drills, especially if seated too deeply (theoretically easier when drill perforation of the medial wall of the glenoid has occurred). Special attention should be made to drill and anchor choice for labral repairs in this region. Hypothetically, it is the drill that more often contacts the nerve and as such great care should be taken during the drilling process. If drill perforation occurs unknowingly or the anchor is inadvertently inserted too deeply, the nerve is at high risk for contact and potential injury, especially in female and smaller patients.

Smaller patient size was clearly associated with drill perforation in our cadaveric work [4]. We purposely selected patients under 179 cm height, and our clinical results support that smaller patients appear to have a higher risk for drill perforation and the potential for nerve injury.

A horizontal drill angle in the coronal plane is the essential reason why drill perforation occurs (Fig. 3) [4]. This angle occurs due to the lateral and posterior overhang of the acromion in the coronal and sagittal plane, respectively (Fig. 4), shrouding the postero-superior glenoid and preventing attainment of the desired insertion angle of $30^\circ$–$45^\circ$ [9, 11]. Kim et al. [7] and Koh et al. [8] were only able to achieve an insertion angle of $12^\circ$ and drilled out in 100% of specimens [3, 7]. In this series, we identified an average acromial offset angle of $25^\circ$; only two patients were greater than $30^\circ$. Further, from an axial view, the glenoid is shaped like an asymmetric trumpet with the thinnest portion being postero-superiorly (Fig. 1a–c) [9] giving the surgeon a very narrow target (Fig. 5).

To our knowledge, this work represents the first study to evaluate this problem in a prospective clinical series to corroborate the previous cadaveric work. Although a small cohort, we selected a high-risk population and followed over 90% to 6 months postoperatively. All subjects had MRI and EMG studies, and a validated outcome measure completed. As a single suprascapular nerve injury represents a significant complication of a superior labral repair, statistical significance is not necessary to demonstrate that medial glenoid wall perforation is a clinically important finding. This is particularly relevant in that the drills and...
implants used for this repair could be shortened to prevent medial wall perforation.

The major study limitation is the lack of preoperative EMG studies. Potentially, the one subclinical nerve injury identified postoperatively could have been present preoperatively and missed due to the lack of an objective preoperative measure of nerve function. However, this patient did not describe a specific traumatic episode and had no evidence of a paralabral cyst or denervation atrophy of the infraspinatus muscle on a preoperative MRI. Further, needle EMG findings showed acute denervation changes rather than changes compatible with a subacute or chronic nerve injury.

The clinical significance of these findings is unclear. Despite of a high drill-out rate, the nerve is rarely injured, but the implications of an anchor designed for implantation into bone that is inadvertently lodged in the soft tissues are potentially quite profound. Theoretically, as the anchor degrades, it may incite an inflammatory response that may irritate nearby nerves, or tissue. In addition, when both cortices are breached, there is a potential path for joint fluid extravasation into the soft tissues. Thus, it would appear that avoiding drill out during a SLAP repair is beneficial for the patient.

Conclusion

This study confirms the finding of frequent medial glenoid wall perforation by drills and suture anchors during arthroscopic SLAP repair using standard arthroscopic equipment in small patients. Despite the high incidence of drill perforation, iatrogenic suprascapular nerve injury was uncommon, but still possible, when a medial glenoid wall perforation occurred. To reduce the risk of medial wall drill perforation and subsequent nerve injury, the shortest possible drill and suture anchor combination, as well as making portals as medial as possible, should be used when superior labral repair is performed.

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Conflict of interest None of the authors or their family members has any financial interest or conflict of interest with this work.

References