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Arthroscopic decompression at the suprascapular notch: a radiographic and anatomic roadmap

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Background: Arthroscopic decompression of the suprascapular nerve (SSN) at the suprascapular notch is a technically demanding procedure. Additional preoperative and intraoperative information may assist surgeons. The purpose of this study was to (1) identify which imaging modality most accurately represents the anatomic distance to the notch and (2) quantify the mean intraoperative distances from routine arthroscopic portals to the notch.

Methods: Ten matched pairs of fresh cadaveric shoulders were imaged by roentgenogram, computed tomography (CT), magnetic resonance imaging, and 3-dimensional (3D) CT, followed by arthroscopic SSN decompression at the notch and anatomic dissection. Measurements obtained included the distances from the anterolateral, posterior, and SSN portal sites to the notch in addition to the distance from the anterolateral acromion to the notch. Statistical analysis with Spearman correlation coefficients and Bland-Altman plots were used to determine the correlation and agreement between measurements.

Results: The preoperative imaging modality with the highest correlation to anatomic distances from the anterolateral acromion to the notch was 3D CT ($R_s = 0.90$, $P < .0001$). The mean intraoperative distances to the notch from the anterolateral, posterior, and SSN arthroscopic portals were 89 mm, 88 mm, and 49 mm, respectively. The mean anatomic distance from the anterolateral acromion to the notch was 64 mm.

Conclusions: Preoperative imaging with 3D CT may assist surgeons in performing arthroscopic SSN decompression. Understanding of the mean distances from the portal sites to the suprascapular notch and being cautious of arthroscopic instruments placed beyond 9 cm from laterally based portals may result in safer intraoperative medial dissection.

Level of evidence: Basic Science, Anatomy, Cadaver and Imaging Model.

Keywords: Suprascapular nerve; suprascapular notch; decompression; arthroscopy

Suprascapular neuropathy is typically caused by compression or traction of the suprascapular nerve (SSN). Compression neuropathy of the SSN at the level of the suprascapular notch was first described in 1959.[26] Many anatomic studies since then have focused on open release of

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the SSN and its anatomic relationship to vascular and intra-articular structures.[6,9,14,23,29] More recently, research has improved our understanding of the arthroscopic anatomy of the SSN and its intraoperative relationships to bony landmarks.[3,5,15] Despite the increase in the frequency of arthroscopic decompression of the SSN,[5,15,19] no studies have sought to identify which preoperative imaging modality most accurately predicts the distance to the suprascapular notch from universally identifiable landmarks. Additionally, the mean distances from traditional arthroscopic portals to the suprascapular notch have not been reported.

A number of etiologies, including anatomic variations, repetitive overhead trauma, and massive rotator cuff tears, have been implicated in SSN injury.[2,10,13,17,18,22,27,28,30] The traditional evaluation for suspected SSN pathology includes history, physical examination, roentgenograms, as well as electromyography and nerve conduction velocity studies to identify the location and extent of injury.[8,19] Magnetic resonance imaging (MRI) is commonly used to evaluate for rotator cuff tears, edema, and atrophy in addition to any space-occupying lesions, such as cysts, that may compress the nerve.[20] Computed tomography (CT) has been used to classify anatomic variations in the suprascapular notch and identify ossification of the superior transverse scapular ligament.[8,21]

Arthroscopic decompression of the SSN can be a technically challenging procedure, and the surgeon should be aware of information that may decrease the risk of erroneous or far medial dissection. Techniques for arthroscopic release at the suprascapular notch have been described, and the most frequently used portals are the posterior "soft spot," lateral, anterolateral, and SSN portals.[4,5,16] Intraoperative arthroscopic landmarks have been described to facilitate SSN release.[5,15] Additional guidance can be extracted from the preoperative workup, including the use of imaging to calculate the distances from common bony landmarks to the superior transverse scapular ligament and suprascapular notch. Despite numerous reports regarding SSN decompression and studies detailing anatomic relationships to and around the suprascapular notch,[6,12,21,25,31] to our knowledge, no previous studies have investigated the accuracy of imaging in predicting anatomic distances to the suprascapular notch, and no reports of mean distances from arthroscopic portal sites to the suprascapular notch have been published.

The current study had two purposes: first, determine which preoperative imaging modality most accurately represents the anatomic distance to the suprascapular notch; and second, to report the mean distances from routine arthroscopic portal sites to the suprascapular notch.

Materials and methods

Ten matched pairs of fresh cadaveric shoulders were obtained through a local organ center donor program. The shoulders were

Figure 1 Roentgenogram of a cadaveric shoulder demonstrates a typical Grashey view. The line indicates the measured distance from the anterolateral acromion border to the suprascapular notch.

identified as right or left, and matched pairs were marked and kept at −20°C until the time of testing. None of the shoulders had undergone previous surgical procedures. Specimens were imaged before arthroscopic decompression of the SSN and then underwent gross dissection to measure distances from bony landmarks to the suprascapular notch.

Roentgenograms were taken of the 20 shoulder specimens. The specimens then underwent dual-energy CT with 2-mm slice cuts with subsequent 3-dimensional (3D) reconstruction. MRI scans with standard axial, coronal, and sagittal reformats were completed using a 1.5-Tesla Siemens magnet (Siemens Healthcare, Erlangen, Germany).

On all imaging modalities, measurements were performed on the coronal image that most readily displayed the suprascapular notch. The measurements on the roentgenograms were made using a standardized Grashey view[11] because it best approximated the coronal view. Measurements were recorded for the distance from the anterolateral edge of the acromion to the lateral portion of the suprascapular notch (Fig. 1). The magnification effect on the measurements was minimal because the specimens were positioned close to the image receptor. All measurements were made by a board-certified musculoskeletal radiologist (M.C.L.) using the Philips iSite picture archiving and communication system (Philips Healthcare, Andover, MA, USA).

After imaging analysis was complete, each shoulder was placed in an arthroscopic shoulder station in the beach chair position. Arthroscopic evaluation of each shoulder was performed with arthroscopic dissection of the suprascapular artery and nerve as they traverse the suprascapular notch. This was accomplished using standard posterior, lateral, and anterolateral portals as described by Lafosse et al.[15] An additional suprascapular nerve portal (superomedial portal) was made in each specimen for direct

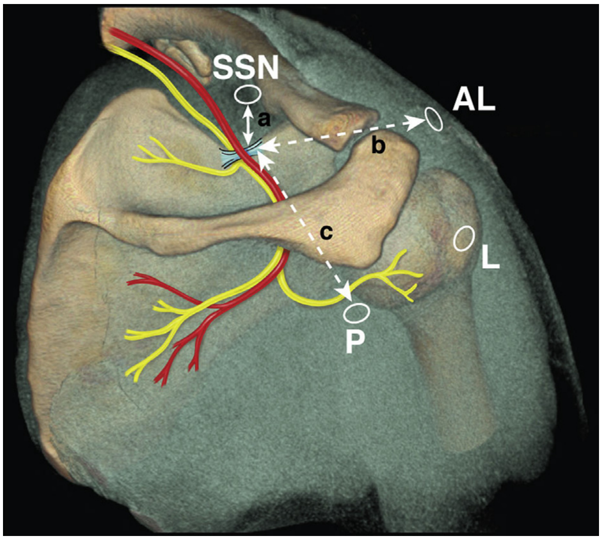

Figure 2 Suprascapular nerve (*SSN*), anterolateral (*AL*), lateral (*L*), and posterior (*P*) portals are shown, with the *double arrows* (a, b, and c) representing the measured distances to the suprascapular notch from their respective portal sites.

access to the superior transverse scapular ligament. This portal was made 1 cm medial to a standard Neviaser portal and directed anteriorly towards the suprascapular notch. Figure 2 illustrates the measured distances from the arthroscopic portals to the suprascapular notch.

The lateral portal was used for viewing while a Wissinger rod (Arthrex, Naples, FL, USA) was placed through the superomedial portal so that it rested on the lateral border of the suprascapular notch at the origin of the superior transverse scapular ligament. In each instance, the rod was marked at the level of the skin, and the distance from the skin to the end of the rod was measured. The posterior and anterolateral portal distances were measured in a similar manner. This technique allowed us to calculate the distance from each skin portal site to the origin of the superior transverse scapular ligament. This was repeated in triplicate, and the mean of each measurement set was used in the analysis.

The specimens were then denuded of skin and muscular soft tissue attachments. The supraspinatus muscle belly was carefully elevated from the supraspinatus fossa so that the orientation of the suprascapular artery and nerve was not disturbed. Measurements were then made, using a Vernier caliper (0.02-mm scale; Fowler, Boston, MA, USA), from the most anterolateral portion of the acromion to the lateral border of the suprascapular notch. Each measurement was repeated in triplicate, and the mean value was used in the analysis.

Statistical analysis

Spearman correlation coefficients (SCCs) were used to determine the correlation between imaging distances and anatomic measurements for each imaging modality. Bland-Altman plots were constructed to evaluate the agreement between each imaging modality and anatomic measurements.

Table I Mean distances from the anterolateral edge of the acromion to the suprascapular notch for anatomic, roentgenogram, computed tomography, magnetic resonance image, and 3-dimensional computed tomography in the coronal plane

Imaging modality	Distance to notch, mm (SD)
Anatomic	64 (6.2)
Roentgenogram	64 (9.5)
CT	47 (5.3)
MRI	49 (8.9)
3D CT	64 (5.5)

3D, 3-dimensional; *CT*, computed tomography; *MRI*, magnetic resonance image; *SD*, standard deviation.

Results

The cadaveric specimens were an average age of 51 years (range, 22-65 years). The average height was 170 cm (range, 152-188 cm), and average weight was 86 kg (range, 59-118 kg). The specimens had a mean body mass index (BMI) of 30 kg/m^2.

The preoperative imaging of the 20 specimens included 18 roentgenograms, 20 CT scans, and 20 MRI studies that were of adequate quality to make measurements. The mean distance from the anterolateral acromion to the notch was 64 mm (standard deviation [SD], 9.5 mm) on roentgenogram, 47 mm (SD, 5.3 mm) on CT, 49 mm (SD, 8.9 mm) on MRI, and 64 mm (SD, 5.5 mm) on 3D CT (Table I). The mean anatomic distance measured from the anterolateral acromion to the notch was 64 mm (SD, 6.2 mm). 3D CT had the highest correlation with anatomic measurements (SCC, 0.90; $P < .001$), followed by MRI (SCC, 0.76; $P = .001$), roentgenogram (SCC, 0.45; $P = .07$), and finally, CT (SCC, 0.33; $P = .16$). Figure 3 demonstrates the correlation between the anatomic and imaging measurements obtained from the cadaveric specimens. In none of the shoulders was the superior transverse scapular ligament ossified or absent.

Bland-Altman analysis was used to evaluate the agreement between anatomic and imaging measurements for each imaging modality (Fig. 4). In addition to having the highest correlation, 3D CT most accurately represented anatomic distances. Furthermore, the analysis revealed that conventional CT and MRI consistently underestimated the anatomic measurements.

The mean intraoperative distance from the skin at the anterolateral arthroscopic portal to the suprascapular notch was 89 mm (SD, 0.9 mm), from the posterior portal was 88 mm (SD, 0.8 mm), and from the SSN portal was 49 mm (SD, 0.9 mm; Table II). Correlations between BMI and distances from the arthroscopic portal sites were not statistically significant.

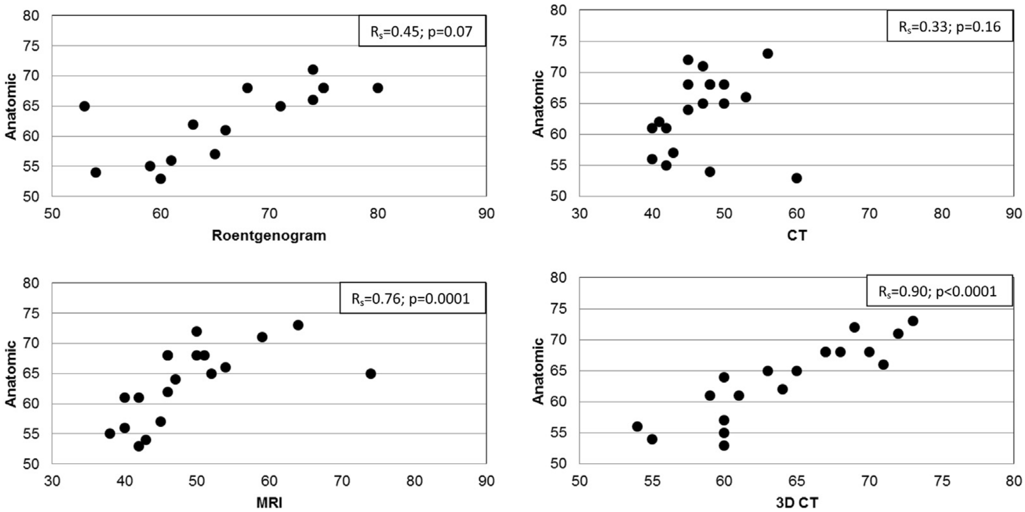

Figure 3 Spearman rank correlation coefficients (R_s) are shown for each imaging modality used to evaluate the distance (mm) from the anterolateral acromial border to the lateral suprascapular notch.

Discussion

The advent of arthroscopic release of the SSN at the suprascapular notch has facilitated the frequency by which it is being performed. As the indications for SSN release continue to evolve, the need for practical preoperative and intraoperative guides increases. Of the preoperative imaging modalities investigated, 3D CT was the most accurate predictor of the anatomic relationships. In contrast, MRI consistently underestimated the true anatomic distance. Laterally based arthroscopic portal distances were relatively fixed and had mean measurements of less than 9 cm.

Numerous previous anatomic studies have looked at the SSN and its relation to surrounding bony landmarks.[6,12,24] The nerve at the suprascapular notch is typically found a mean distance of 3.0 cm medial to the supraglenoid tubercle.[6] Other described measurements have included the distances from the glenoid and the palpable posterolateral corner of the acromion to the base of the scapular spine, although this information is more valuable when evaluating the spinoglenoid notch.[12,29] Studies have found the anatomy around the suprascapular notch is highly variable; for instance, the bony morphology of the suprascapular notch has been classified into 6 types.[22] The arrangement of the vessels at the notch also varies, with the suprascapular artery passing under the superior transverse scapular ligament in 26% of shoulders whereas the vein passed inferiorly in 13%.[31]

However, these measurements do not provide arthroscopic guidance for surgeons attempting SSN release at the suprascapular notch because the glenoid and scapular spine are not described landmarks used in this procedure. Key anatomic landmarks described to facilitate arthroscopic SSN decompression include the lateral border of the acromion, the acromioclavicular joint, the coracoacromial ligament, coracoclavicular ligaments, and the base of the coracoid.[4,15,16]

Fundamental to this study was the decision to use measurements from bony landmarks. First, bony landmarks are not expected to be affected by the girth of the soft tissue envelope surrounding the shoulder. In addition, relationships to specific soft tissue structures, such as the SSN, can be affected by soft tissue derangements such as a large rotator cuff tear.[1] The anterolateral acromion was used as the reference landmark because of its familiarity to those performing shoulder arthroscopy and the ease of identification by palpation and direct arthroscopic visualization. The lateral edge of the suprascapular notch was used as the target landmark because it is the lateral origin for the superior transverse scapular ligament.

One possible explanation for the improved accuracy of 3D CT measurements, compared with conventional CT or MRI, is that the landmarks for measurement are more readily identifiable, especially because modern software allows for rotation of the 3D image on the image viewer. The conventional CT and MRI measurements consistently underestimated the anatomic distance to the suprascapular notch. When conventional CT and MRI are used to obtain measurements, the plane in which the scan is performed dictates the measurements. In this study, the coronal images for the CT and MRI were coronal obliques, aligned parallel to the long axis of the supraspinatus tendon. Thus, the measurements in both modalities may not reference the true lateral-most portion of the acromion, resulting in a shorter measured distance to the suprascapular notch.

One concern with CT imaging is the increased radiation exposure to the patient. A standard shoulder CT scan exposes a patient to an effective average dose of 2.06 mSv, which is equivalent to approximately 26 conventional chest roentgenograms.[7] However, the information obtained from 3D CT, which can be generated from conventional CT without additional radiation exposure, may help prevent

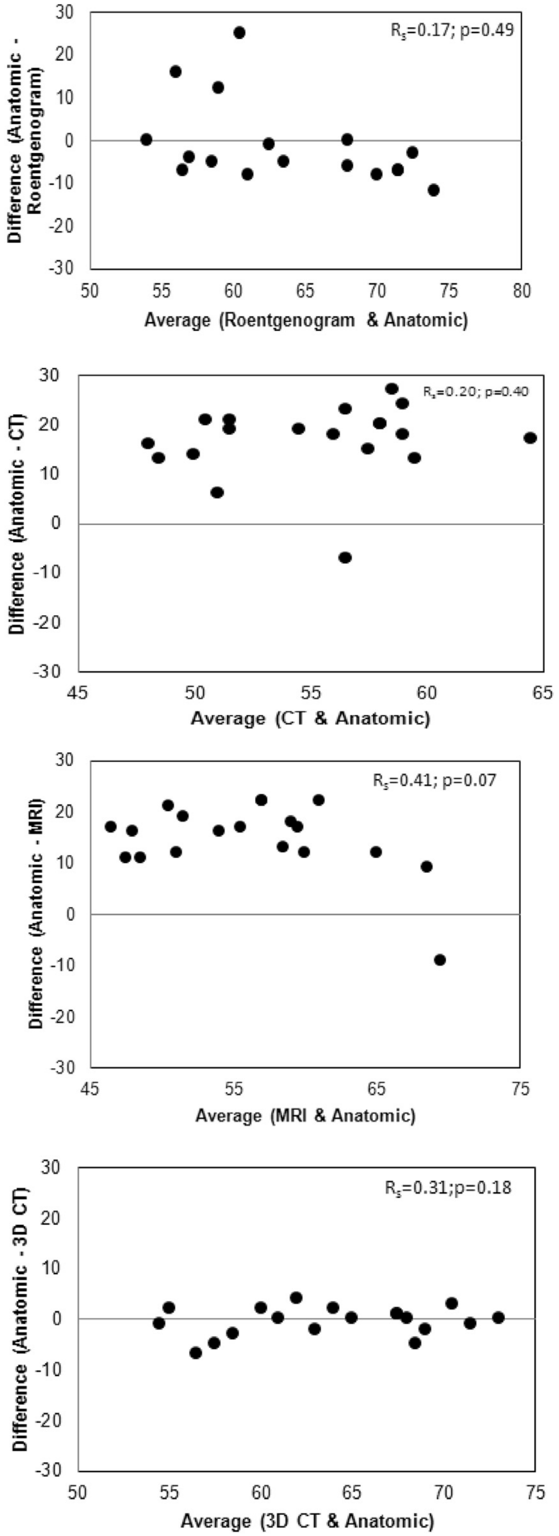

Figure 4 Bland-Altman agreement plots between anatomic and imaging measurements (mm) are shown with the Spearman rank correlation coefficient (R_s) for each imaging modality. *3D*, 3-dimensional; *CT*, computed tomography; *MRI*, magnetic resonance image.

Table II Mean distances from common arthroscopic portal sites to the suprascapular notch

Portal site	Distance to notch, mm (SD)
Anterolateral	89 (0.9)
Posterior	88 (0.8)
Suprascapular	49 (0.9)

SD, standard deviation.

unnecessary and potentially dangerous medial dissection in the suprascapular fossa. Although this preoperative imaging information may be especially useful for the arthroscopist with limited experience with SSN release, we are unable to endorse its routine use in practice because of the increased radiation exposure. Alternatively, we do recommend reformatting of conventional CT into 3D CT if the study has already been obtained. The surgeon should also be aware that relying on preoperative distance measurements from conventional CT or MRI might be inaccurate, although application of any of these measurements intraoperatively has not been examined in the clinical setting.

In attempt to assist intraoperative assessment during this challenging procedure, we also described the mean distance from arthroscopic skin portal sites to the lateral edge of the superior transverse scapular ligament. Marking a distance of 9 cm on arthroscopic instruments for the posterior and anterolateral portals and 5 cm for the SSN portal may provide a useful intraoperative guide to approximate the depth of arthroscopic dissection. General lengths of arthroscopic cameras can vary but generally measure approximately 160 mm, suggesting that if the camera is hubbed to the patient, there should be concern that dissection has been carried out too medial, risking potential iatrogenic injury. Such information may be useful for the arthroscopic surgeon who is less experienced with SSN release at the suprascapular notch. Although our portal distance measurements were relatively consistent, these measurements are only estimates and may be influenced by BMI, muscle mass, gender, and the soft tissue swelling that occurs during arthroscopy. Nonetheless, correlations between BMI and arthroscopic portal site distances were not statistically significant in our study.

Beyond the limitation of a small number of specimens likely underestimating the variability in the general population, another limitation is that no measurements were taken on the preoperative imaging studies in the sagittal plane or from an alternate palpable bony landmark such as the coracoid. Although the assumption that the accuracy of imaging in all planes can be verified by measurement of consistent landmarks is reasonable, verifying the imaging correlations in another plane would have added strength to the study. Similarly, measuring the distances to other neurovascular structures surrounding the notch would have also provided additional helpful information.

Conclusions

Although preoperative MRI provides valuable information before arthroscopic decompression of the SSN, 3D CT imaging may also provide beneficial information for this technically challenging procedure. Awareness that medial dissection from laterally based arthroscopic portals is approximately 9 cm in conjunction with knowledge of previously described visual landmarks may be useful in facilitating arthroscopic identification and safe release of the SSN at the suprascapular notch.

Disclaimer

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