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Risk of suprascapular nerve injury during glenoid baseplate fixation for reverse total shoulder arthroplasty: a cadaveric study

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Background: Reverse total shoulder arthroplasty (rTSA) is an effective treatment for patients with advanced rotator cuff arthropathy. During implantation of the glenoid baseplate, screws are inserted through the glenoid face into the scapular body to achieve adequate fixation. Placement of peripheral baseplate screws in the superior and posterior glenoid may increase the risk of injury to the suprascapular nerve (SSN). The purpose of this cadaveric study was to evaluate the risk of SSN injury with placement of baseplate screws in the superior and posterior direction.

Methods: Twelve cadaveric shoulders were implanted with glenoid baseplates. A bicortical 44-mm screw was placed in both the superior and posterior glenoid baseplate screw holes. Following implantation, the SSN was dissected and visualized through a posterior shoulder approach. The distance from the tip of the screws to the SSN and the distance from the screw's scapular exiting hole to the SSN was recorded. Average distances were calculated for each measurement.

Results: The superior screw contacted the SSN in 8 of the 12 specimens (66%). For the superior screw, the average distance from the exiting point in the scapula to the SSN was 9.2 ± 6.3 mm, with the shortest distance being 3.9 mm. The posterior screw contacted the SSN in 6 of 12 specimens (50%). For the posterior screw, the average distance from the exiting point to the SSN was 8.9 ± 3.8 mm, with the shortest distance to the nerve being 2.2 mm.

Conclusion: Placement of the superior and posterior screws in the glenoid baseplate during rTSA risks injury to the SSN. The safe zone for superior- and posterior-directed baseplate screw is <2 mm from its exiting point on the scapula. Therefore, precise measurements of screw lengths in this area is important in avoiding injury to the SSN.

Level of evidence: Anatomy Study; Cadaver Dissection

Keywords: Shoulder; reverse shoulder arthroplasty; glenoid; suprascapular nerve; shoulder arthroplasty; arthritis

Reverse total shoulder arthroplasty (rTSA) has become an effective treatment for a variety of shoulder conditions, including rotator cuff arthropathy and complex comminuted proximal humerus fractures.[1,14] This procedure is not without complications, and among those reported include aseptic loosening, postoperative fractures, glenoid notching, infection, dislocation, axillary nerve injury, and neurovascular injury to the suprascapular nerve (SSN).[3,4,19,22]

This cadaver study was exempt from institutional review board approval.

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Implantation of the glenoid component during rTSA requires placing either cortical or locking screws into the glenoid and scapular body to achieve proper fixation. Various design modifications and innovations have occurred to improve glenoid baseplate fixation. This includes eccentric glenoid baseplates, bicortical central screw fixation, and multidirectional cortical and locking peripheral screws.[10,11] Several biomechanical studies have demonstrated that the best bone within the scapular body is the base of the coracoid, the scapular spine, and the medial scapular pillar, making these 3 areas optimal for screw placement.[6,9]

However, this is not without risk to the anatomic structures in the area like the SSN. The SSN provides motor innervation to the supraspinatus and infraspinatus muscles and arises from the distal portion of the fifth and sixth cervical root as a sensorimotor nerve from the upper trunk of the brachial plexus.[19] The nerve runs parallel to the superior border of the scapula and passes through the suprascapular notch below the superior transverse scapular ligament.[5] It gives off several branches to the supraspinatus muscle before curving inferiorly just lateral to the scapular spine and through the spinoglenoid notch to reach the infraspinatus fossa, where it delivers branches to the infraspinatus and posterior capsule.[2,16] On average, the SSN is 1.8 cm from the posterior-superior glenoid rim,[2] making it vulnerable to injury from the superior and posterior screws (Fig. 1).

Case reports and postoperative electromyographs have documented injury of the SSN from superior and posterior screw placement during rTSA.[14,19] Injury to the nerve can cause postoperative posterior pain and weakness in abduction or external rotation.[14,19] Proper determination of the cause of pain in such cases may be difficult to make without a proper level of suspicion.

The goal of this cadaveric study was to evaluate the risk to the SSN from the superior and posterior peripheral baseplate screws. Specifically, we evaluated how often the nerve was contacted when placing a purposely long (44-mm) screw in either the superior and posterior hole positions and the respective distances from the exiting point in scapular cortical surface to the SSN for either screw.

Materials and methods

We dissected 12 cadaveric shoulders. Of the cadavers, 7 were male, 4 were female, and for 1 the gender was unknown. Mean age of death was 65 years. Mean patient height and weight were

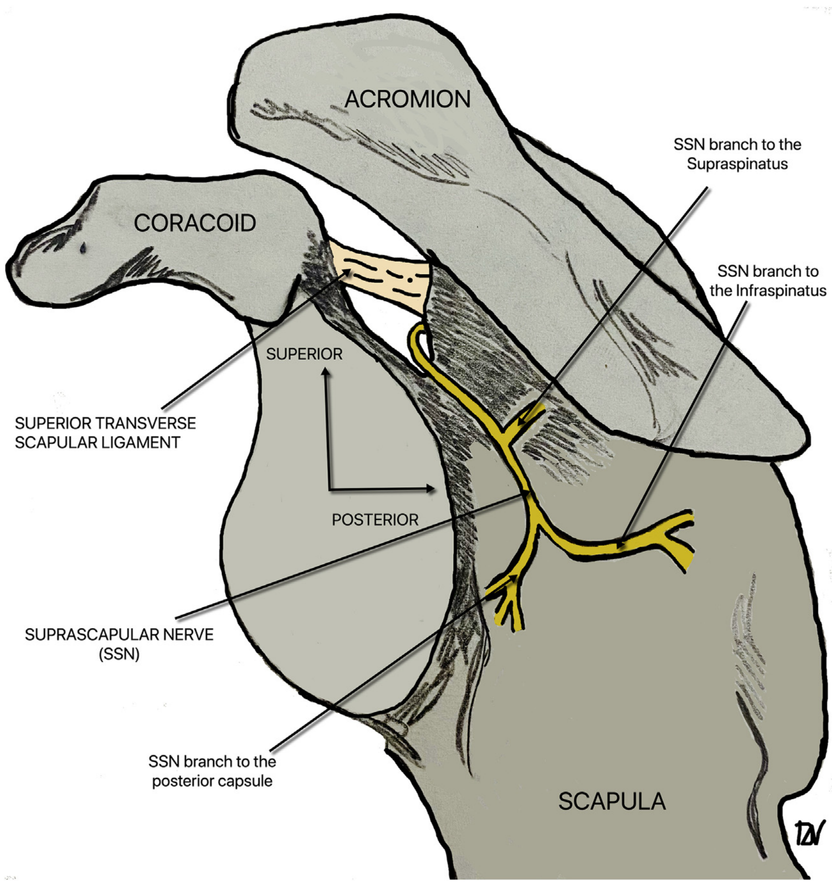

Figure 1 Labeled illustration of the scapula demonstrating the anatomic course of the suprascapular nerve.

65.3 kg (144lb), respectively. Causes of death included cancer (3), cerebrovascular disease (1), cardiovascular disease (4), and infection (1), with 3 from unknown causes. None of the cadavers had prior shoulder surgery that would affect the measurements.

Dissection

Shoulders were secured in the beach chair position. Dissection was performed using a standard deltopectoral approach. The cephalic vein was identified and dissected and retracted laterally. A deltopectoral approach was used. The clavipectoral fascia was divided, and the subscapularis tendon was exposed. A biceps tenotomy was performed along with a subscapularis peel to expose the glenohumeral joint. A surgical dislocation of the glenohumeral joint was then performed. Humeral neck cuts were made using an oscillating sagittal saw. The glenoid labrum, long head of the biceps, and capsule were excised to achieve circumferential exposure of the bony glenoid. Next, the glenoid was reamed until sufficient to achieve circumferential contact of the baseplate. A 25-mm glenoid baseplate with a splay of 7.7 mm (distance from center of baseplate to center of peripheral holes) (Wright Medical, Memphis, TN, USA) was implanted by 2 board-certified orthopedic surgeons with advanced training in shoulder arthroplasty. All baseplates were inserted using a 10° inferior tilt guide. The central screw was placed 12.5 mm superior from the inferior border of the glenoid, which allowed the baseplate to sit flush with the inferior border of the glenoid as done routinely in our practice. We positioned the baseplate such that the superior hole was aligned with the base of the coracoid. Therefore, the superior screw was at the 1-o'clock and 11-o'clock position for theleft and right shoulders, respectively. The posterior holes were at 8 o'clock and 4 o'clock for the right and left shoulders, respectively. All screws were drilled in line with the baseplate. A 44-mm screw was then inserted into the superior and posterior screw holes. This relatively long screw was chosen to ensure that the screw would protrude beyond the far cortex drill holes and make contact with the SSN if in the trajectory of the screw. Additionally, using1 screw length made the study more consistent and cost effective.

Next, the SSN was dissected using the technique described by Warner et al.[20] An incision was made from the anterior aspect of the acromion and curved posteromedially over the scapular spine and then inferomedially along the border of the scapula. The incision provided access to the posterior glenoid and SSN. The SSN and vessels were dissected from just proximal to the transverse scapular ligament and the suprascapular notch through the spinoglenoid notch to its termination into the infraspinatus. The supraspinatus and infraspinatus tendons were released if needed for further exposure (Fig. 2).

The glenosphere baseplate screw tips were identified as well and their relationship to the SSN was noted. Four separate measurements were made with a digital vernier caliper while the shoulder was in neutral rotation. First, the shortest distance from the superior screw to the SSN was measured and recorded as the superior screw to nerve distance. If the screw had contacted the SSN, this distance was recorded as 0 (Fig. 3).

The second measurement was the shortest distance from the SSN to the exiting hole made by the superior screw in the scapular cortical surface, collected as the superior hole to nerve distance. These measurements were repeated with the same method for the posterior screw using a digital vernier caliper while the shoulder was in neutral rotation (posterior screw to nerve distance). Each measurement was repeated 3 separate times using the digital vernier caliper with the mean recorded. The measurements were analyzed for number of times the screw contacted the nerve and for mean distance from screw to nerve.

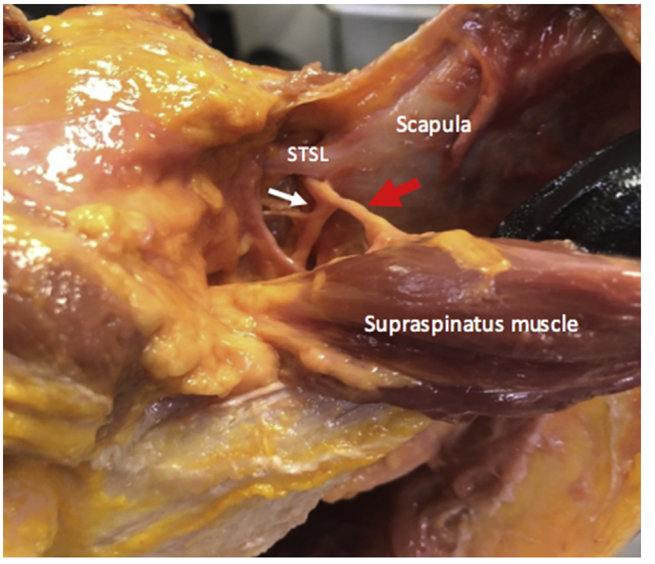

Figure 2 Dissection of the suprascapular nerve (*white arrow*) as it goes under the superior transverse scapular ligament (STSL) and gives a branch to the supraspinatus muscle ( ).

Results

Of the 12 shoulders dissected, the superior screw contacted the SSN in 8 of the 12 specimens (66%). In the 4 specimens where the screw did not contact the SSN, the superior screw

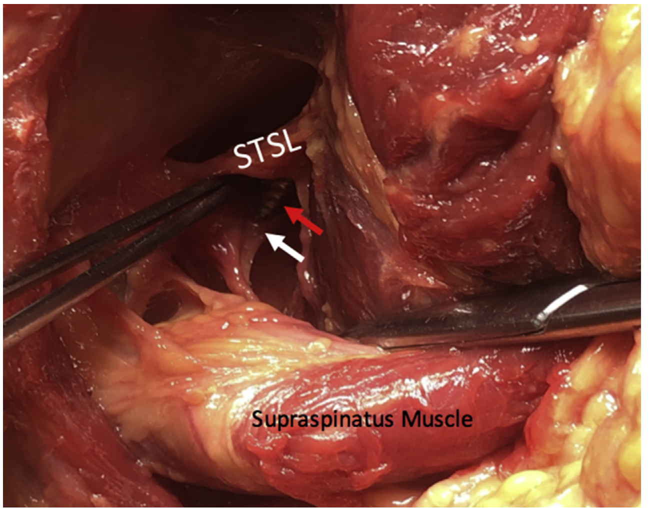

Figure 3 Dissection of SSN (*white arrow*) showing contact with the superior baseplate screw ( ) as it travels underneath the superior transverse scapular ligament (STSL).

was 11.3 ± 8.9 mm away on average, with 1 specimen having a screw that did not exit the scapular cortical surface. After removal of the screw, the distance from the exiting hole in the scapula cortical surface to the nerve was 9.2 ± 6.3 mm on average, with the shortest distance to the nerve being 3.9 mm (Table I).

The posterior screw contacted the SSN in 6 of the 12 specimens (50%). For the 6 specimens in which this posterior screw did not contact the nerve, the posterior screw was just 6.7 ± 4.8 mm away on average. After removal of the screw, the distance from the exiting hole in the scapula cortical surface to the nerve was 8.9 ± 3.8 mm on average, with the shortest distance to the nerve being 2.2 mm.

Discussion

Iatrogenic injury to the SSN has been well described across a variety of shoulder surgeries.[7,12] Wang et al[19] described a case of SSN entrapment following rTSA in a patient who presented with unresolving postoperative posterior shoulder pain. Advanced imaging demonstrated that the tip of the superior baseplate screw had penetrated the nerve in the suprascapular fossa. The patient eventually underwent a second procedure to remove the tip of the screw and decompress the nerve.[19] Furthermore, Lopiz et al[14] evaluated the status of the SSN with electromyography following revision shoulder arthroplasty at 3 and 6 months postop. Among the 20 included shoulders, they found 5 shoulders (26.3%) to have acute injury to the SSN postoperatively, with 3/5 not having full recovery on electromyography by 6 months.[14]

Newer glenoid baseplate designs include variable angle screws, which allow better bone purchase in the scapula, whose strongest bone lies at the base of the coracoid, spine of the scapula, and medial scapular pillar.[6,9] Our current study evaluated the risk of SSN injury when placing the superior and posterior baseplate screw in a cadaveric shoulder model.

When placing a 44-mm screw, in either the superior or posterior peripheral baseplate hole, 8 of 12 superior screws (66%) contacted the SSN and 6 of 12 posterior screws (50%) contacted the SSN. Additionally, the average distance from the exiting hole in the scapula to the SSN was 9.2 ± 6.3 mm for the superior screw and 8.9 ± 3.8 mm for the posterior screw. These data demonstrate that there is a realistic risk of nerve injury when placing these screws, and close attention should be paid on screw length as long screws have a higher chance of contacting the SSN. These results are consistent with those of Molony et al,[16] who similarly evaluated the distance from the peripheral baseplate screws to the SSN in rTSA. They found the posterior screw to likely be within 5 mm of the SSN, with a 40% chance of contacting the SSN. Unlike their study, our baseplates were tilted 10° inferiorly as we commonly do in our practice. What this tilt does in relation to the risk of nerve injury was previously unknown.

In addition to postoperative posterior shoulder pain, injury to the SSN may affect postoperative shoulder function, specifically external rotation. Preservation of external rotation has been demonstrated to be important for successful rTSA.[8,16,18] Preventing injury to the posterior shoulder muscles including the infraspinatus is key to maintaining ER.[16] Therefore, avoiding injury to the SSN, which innervates the infraspinatus, may contribute to preserving ER.[13] Additionally, the increase in popularity and innovation of the rTSA has led to increasing use in patients without rotator cuff tears such as in fracture cases or management of shoulder osteoarthritis with significant glenoid retroversion or bony deficiency. These individuals often have intact posterosuperior rotator cuffs that are preserved during surgery, making the safety of the SSN even more critical.

Table I Measurement information

Case number	Superior SND (mm)	Posterior SND (mm)	Superior HND (mm)	Posterior HND (mm)	Superior screw contact	Posterior screw contact
1	0	7.36	4.05	7.36	Yes	No
2	0	15.48	5.08	15.48	Yes	No
3	0	2.24	5.29	9.24	Yes	No
4	0	0	16.6	12.68	Yes	Yes
5	0	0	7.82	5.98	Yes	Yes
6	0	4.6	4.02	11.92	Yes	No
7	23.8	0	23.8	2.24	No	Yes
8	0	0	3.94	8.2	Yes	Yes
9	0	7.73	12.76	10.94	Yes	No
10	HR	0	HR	5.75	No	Yes
11	5.68	2.96	13.84	12.28	No	No
12	4.32	0	4.32	5.13	No	Yes

SND, screw to nerve distance; *HR*, home run; *HND*, hole made by the screw in the cortical scapular surface to the suprascapular nerve.
The HR screw did not exit the scapula.

Besides SSN injury, an uncommon but significant complication of baseplate fixation in rTSA is scapular spine fractures. It has been postulated that glenoid baseplate position and inaccurate screw length may be causative.[15,17] Otto et al[17] reviewed 53 scapular fractures after rTSA and observed that 14 of 16 scapular spine fractures occurred at the screw tip. Although they found no significant difference in screw length or orientation, it may be that inaccurate excessively long screw especially of the superior hole increases stress on the surrounding bone, predisposing it to fracture. This potentially provides another reason why accurate screw measurements are important.

Several studies have proposed a safe zone for rTSA glenoid baseplate screws similar to the safe zone discussed in the acetabulum during total hip replacement. Hart et al[10] reported the safe zone to be anything anterior to a vertical axis that crosses the supraglenoid tubercle and the infraglenoid tubercle. Additionally, Yang et al[21] proposed the danger zone for SSN injury to be between the 2-o'clock and 8-o'clock position on the glenoid of a right shoulder. They also concluded from their study that posterior screw had a greater risk than the superior screw at injury of the SSN.[19] We found that the superior screw was at higher risk of making contact with the SSN with a proud screw as compared to the posterior screw. The strongest bone in the scapula lies in the superior and posterior direction, specifically the base of the coracoid and scapular spine, making it attractive to achieve fixation in those areas. Therefore, it is important to know the safe area within this "danger" zone. Based on our data, the safe zone for the superior screw is <2 mm from the screw's exiting point in the scapula, as in some specimens the SSN was found to be just 3 mm away from the screw's exit point. Similarly, for the posterior screw, the safe zone is again <2 mm from the exiting point of the scapula, with the SSN found to be as close as 2.2 mm in some specimens. With current locking screw technology, it may be easier to avoid long bicortical screws. It may be beneficial for manufacturers and surgeons to ensure that these screws are able to achieve good unicortical fixation. Anterior and inferior screw holes may be safer options for baseplate bicortical screw compression. Currently, most manufacturers provide baseplate screws that come in increments of 4-5 mm, individually wrapped. However, given these data, it may be most ideal to have the screws come in caddies with 2-mm increments. This would help ensure more precise screw lengths. Nevertheless, these data highlight the importance of accurate measurements when placing these screws to avoid any neurovascular injury and the impact of 10° inferior tilt of the baseplate on screw-to-SSN distances.

This study has several limitations. This is a cadaveric study, and the absence of muscle tensioning may alter the position of the nerve in some cases. Additionally, as often within a lab setting, one may achieve superior glenoid visualization compared to an actual surgical case, thus potentially altering screw placement. The relatively low number of samples make it difficult to further determine the role of the 10° inferior baseplate tilt on potential SSN injury as it is unclear how this effects superior screw orientation and cutout. Finally, clinical consequences of SSN injury are largely anecdotal and often patients who undergo rTSA have preexisting poor or nonfunctioning supraspinatus and infraspinatus muscles.

Conclusion

During placement of the superior and posterior glenoid baseplate screws in rTSA, there is increased risk to the SSN with proud screws. On average, the distances from the exiting point on the scapula to the nerve for the superior and posterior screw is only 9.2 ± 6.3 mm and 8.9 ± 3.8 mm respectively. The safe zone for both a superior- and posterior-directed peripheral baseplate screw is <2 mm from the exiting point of the scapula. Therefore, precise measurement of screw lengths in this area is important in avoiding injury to the SSN.

In all, the surgeon must carefully balance baseplate compression with risk of nerve injury. Based on these data, we recommend when placing compression screws, particularly in the superior and posterior direction, that the surgeon should remain aware of the length of the screw to ensure it is not excessively long. Placement of baseplate bicortical screws are safest in the anterior and inferior holes. We recommend locking unicortical screws in the superior and posterior baseplate holes whenever possible.

Disclaimer

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