**Optimal Screw Placement for Reverse Total Shoulder Arthroplasty**


**INTRODUCTION:**

The reverse design of the total shoulder arthroplasty has been utilized for elderly patients with severely degenerated glenohumoral joints that are rotator cuff deficient. One of the most common causes of failure in shoulder arthroplasty involves loosening or catastrophic failure of the glenoid component. Such problems can be related to suboptimal fixation due to bone loss from fractures, severe degenerative changes and from previous failed arthroplasty surgery [1]. This emphasizes the need to secure the glenoid component with sound screw purchase beyond the glenoid vault. However, such fixation can often be tenuous as scapula bone quality is heterogeneous with a wide variation across short distances [2, 3]. Moreover, it can be difficult to identify regions with the best bone stock intraoperatively. This often requires multiple passes with the drill, which leads to further bone loss and potential decreased screw purchase. Thus, it is important for the surgeon to have a firm understanding of scapular anatomy with potential screw trajectories in mind.

The purpose of this study is to determine clinically relevant screw angles to reach regions of high bone stock for securing the glenoid base plate in reverse total arthroplasty.

**METHODS:**

Computed tomography (CT) images of 12 scapulae within torsos were scanned with standard 16-row MDCT (MX8000 IDT 16, Philips) with a slice thickness of 1mm in 0.5mm increments and 0.57mm/pixel in-phase spatial resolution. The scans were imported into commercial 3D reconstruction software (Mimics 12.1, Materialise) to isolate the scapular cortical bone.

A CAD file was created of the glenoid base plate for virtual representation. The plate was superimposed on 3D reconstructions of the scapulae and oriented centrally in the anterior-posterior plane. As per recommendations from Kelly et al [4] to minimize scapular notching, the base plate was aligned with the inferior most aspect of the glenoid and rotated until the superior and inferior holes were in line with the inferior axis of the scapula.

The 3D models were imported into a commercial image analysis software (3-Matic, Materialise) to quantify cortical thickness of the scapulae. As the distance between screw threads is 1.75mm, regions were demarcated between 1, 1.5 and 2 thread distances (td). Each virtual screw was positioned with the following criteria: 1) remains intraosseous; 2) exits in thickest cortical region accessible; 3) longest screw within defined region; 4) does not encroach on other screw path; and 5) does not penetrate regions containing vital structures. The suprascapular nerve is particularly at risk during its course through the suprascapular and spinoglenoid notches [5]. Projected angles were calculated in the superior-inferior and anterior-posterior orientation. Angles were measured with respect to the center of the screw head relative to the axis parallel to the central press-fit peg of the base plate.

**RESULTS:**

There were several regions of consistent increased cortical thickness between scapulae. These include: 1) lateral aspect of the suprascapular notch; 2) base of the scapular spine; 3) the ant/ sup aspect of inferior pillar; and 4) junction of glenoid neck and scapular spine. Screw trajectories to utilize these regions are summarized in Table 1.

Table 1: Optimal screw orientation for each screw hole location on the glenoid base plate. Values represent mean +/- st. dev across all specimens for superior (+)/inferior(-) (S/I) and anterior (+)/posterior (-) (A/P) inclination angles (in degrees) relative to the base plate.

<table>
<thead>
<tr>
<th>Screw Hole (#)</th>
<th>S/I</th>
<th>A/P</th>
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<tbody>
<tr>
<td>(1) Superior</td>
<td>8 ±3</td>
<td>-3 ±7</td>
</tr>
<tr>
<td>(2) Inferior</td>
<td>-16 ±7</td>
<td>5 ±3</td>
</tr>
<tr>
<td>(3) Anterior</td>
<td>-17 ±6</td>
<td>-14 ±4</td>
</tr>
<tr>
<td>(4) Posterior</td>
<td>-29 ±8</td>
<td>3 ±7</td>
</tr>
</tbody>
</table>

(2) Inferior

(3) Anterior

(4) Posterior

(A/P) inclination angles (in degrees) relative to the base plate.

**DISCUSSION:**

Placement of implants into the scapula can be one of the more challenging areas of open shoulder surgery. It was determined that once identifying such regions, the need to preserve adjacent vital structures makes accessing them more difficult.

Classically, the superior screw has been angled into the coracoid base. Our analysis revealed that the region adjacent to the suprascapular notch does have higher values for cortical thickness in the region. However, its proximity to the suprascapular nerve makes this a less ideal target [5].

We did identify a region ~1cm inferior to the notch that also had thickness greater than 2td. The sup/inf trajectory to reach this region was consistent between samples but there was variability between the ant/post angles. We believe this reflects differences in glenoid version and can be accounted for by preoperative CT templating.

Two distinct orientations were found for the inferior screw. The inferior pillar is supported by cortices greater than 1.5td with the ant-sup aspect consistently greater than 2td. This area was the ideal target and could be achieved in 7 of the 12 samples. The remaining 5 had to be directed more posteriorly and inferiorly to remain intraosseous for the entire screw course. As there are no significant neurovascular structures along the inferior pillar, an in-out-in screw trajectory may be acceptable to achieve screw purchase in the anterior region of the pillar.

The ideal area for posterior screw fixation was at the base of the scapular spine laterally where it meets the neck. However, this region was found to be inaccessible without exiting through the spino-glenoid notch, endangering the suprascapular nerve [5]. The area between the central peg of the base plate and posterior cortex was very narrow and had limited potential. Screws could only be directed inferiorly. As such, they did not penetrate areas with high bone stock in the majority of cases. Previous studies have suggested a potential superior trajectory for this screw, but such cases had more room due to the superior screw angled into the coracoid [4]. Directing the screw inferiorly is also more favorable to the standard surgical approaches.

Directing the anterior screw inferiorly takes advantage of bone stock at the junction of the glenoid neck and inferior pillar. Similarly to the posterior screw, the potential variability in trajectories was limited.

It was found that the scapula has specific regions more favorable to screw placement. Pre-op planning with CT scans is recommended to adjust screw trajectories for patient variation in glenoid version for the superior and inferior screws. Placement of the anterior and posterior screws remains a challenge due to limited area and bone stock accessibility. There may be a potential in the future for implant redesign to alter screw trajectory to allow locking into the central peg.

**REFERENCES:**