Accuracy Of Pre-operative Glenoid Correction In Reverse Shoulder Arthroplasty: Comparison Of 3d-interactive And Traditional Methods

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Introduction:
Reverse shoulder arthroplasty (RSA) is a popular option for treating patients suffering from cuff tear arthropathy, complex proximal humerus fractures, and failure of primary shoulder prostheses (2). Clinical and biomechanical studies have shown the benefits of RSA in pain relief and functional recovery (2, 3). However, RSA procedure remains technically challenging for the surgeon and exhibits many complications like scapular notching, glenoid component failure and prosthetic instability. Biomechanical and clinical studies have showed that RSA glenoid placement is important for clinical outcomes. The management of pathologic glenoid with bone deformities and defects makes it difficult to identify reliable anatomical landmarks, and consequently accurately position the glenoid component with a good primary bony fixation. Glenoid component placement during reverse shoulder arthroplasty on an arthritic eroded glenoid remains challenging for orthopaedic surgeons and clinical results have shown that glenoid version and tilt should be corrected to anatomical values after the joint replacement. In this study we investigate whether surgeons can achieve glenoid version and tilt correction during standard RSA procedure and how it compares with a pre-operative interactive planning.

Methods:
This study included CT data from 24 pre-operative pathologic shoulders with highly eroded glenoids. All 3D-CT scapula reconstruction were created using Mimics®, Materialize. Glenoid version and tilt was defined by a single operator according to the recommendations of Friedman et al.,(1992). RSA virtual surgery was performed in all shoulders using a virtual 3D model of the Biomet Comprehensive® Reverse Total Shoulder prosthesis (size: 28mm diameter glenoid baseplate; 36mm diameter standard glenosphere without offset; size 4 humeral stem; 44mm diameter standard onlay humeral tray; 44-36mm diameter standard humeral bearing.). The focus of this study was the placement of the glenoid baseplate which was performed with two different techniques/methods:

i) In the first method the 3D geometry of the scapula was fully visible and the operator could interactively choose the placement of the baseplate in 3D and in 2D CT planes (named ‘interactive method’, Figure 1a).

ii) In the second method two surgeons with RSA experience performed the virtual surgery but they were asked to place the baseplate while only the glenoid, acromion and coracoid were exposed (named ‘blind method’, Figure 1b).
The objective in both methods was to position the glenoid baseplate as inferiorly as possible but to also correct the version and tilt of the eroded glenoid to anatomical values. The accuracy in glenoid component alignment was determined by the correction of the pre-operative glenoid version and tilt. Also the position of the glenoid plate placement (in mm) was measured in both methods and accuracy was assessed as the difference between the ‘interactive’ and ‘blind’ methods. Repeated measures ANOVA with post hoc analysis was used to determine the differences on glenoid correction (version and tilt) and placement between pre and post-operative methods (interactive vs blind).

**Results:**
The average pre-operative glenoid version and tilt were 8.4° (SD: 7.7°) and 9.8° (SD: 9.5°), respectively. The average version and tilt after the surgery with the ‘interactive method’ were 0.5° (SD: 0.7°) and 0.4° (SD: 0.4°). The two surgeons that used the ‘blind method’ (they could not see the orientation of the scapula) averaged 6.1° (SD: 6.0°) version and 12.4° (SD: 7.8°) tilt. Results showed that the two surgeons were not different (p>0.05) from each other and did not significantly correct the pre-operative glenoid version and tilt (p>0.05). During the ‘blind method’ the two surgeons placed the base plate in a position that violated the glenoid vault in 11 out of the 24 scapulae (Figure 3). The positioning of the glenoid plate showed that in average the two surgeons (that used the ‘blind method’) chosen almost the same inferior position as the operator of the ‘interactive’ method (Figure 2).

**Discussion:**
The results of this study suggest that surgeons cannot correct the post-operative version and tilt in highly eroded osteoarthritic glenoids. In addition they run the risk of violating the glenoid vault by excessive or misaligned reaming. A pre-operative plan using 3D geometry and 2D CT scans can help accuracy in glenoid placement and alignment for better fixation. Misalignment of the glenoid baseplate in reverse total shoulder arthroplasty can affect load transfer and result in loosening. Despite the post-operative glenoid misalignment in the ‘blind method’, there was no significant difference on the positional placement of the baseplate. That was probably because this study did not simulate the soft tissue that surrounds the glenoid or the narrow window that surgeons usually operate during shoulder replacement.

**Significance:**
The study suggests that pre-operative planning with surgical navigation or specific tools/guides should be used to achieve accurate glenoid placement and maximize post-operative functional outcomes.
In 11 out of the 24 scapulae, glenoid violation was observed (baseplate central peg extrudes out of the glenoid vault bone) after the placement of the baseplate was performed by the two surgeons using the ‘blind method’.

Figure 2: Accuracy of glenoid baseplate.

Each point shows where each surgeon has placed the glenoid baseplate during the ‘blind method’ in respect to the ‘interactive method’.
(A) Picture of the 3D-CT reconstructed scapula. In the ‘interactive method’ virtual surgery was performed with the 3D scapula model fully visible from all planes.
(B) Picture of the 3D-CT reconstructed scapula hidden by a mask. During the ‘blind method’ virtual surgery was performed by two experienced surgeons, but the mask was hiding most of the scapula’s landmarks. Only the acromion and coracoid processes was visible.

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