Three-Dimensional Glenoid Morphology in Reverse Shoulder Arthroplasty – Classifications and Surgical Implications

1Teramoto, A; 1Luo, Z P; 1Holcomb, J; 1Chacon, A; 1Levy, J; 1Gutierrez, S; 1Pupello, D; 1Comiskey, C; +1Frankle, M A
+Florida Orthopaedic Institute, Tampa, FL

Senior author frankle@pol.net

ABSTRACT INTRODUCTION:

Reverse shoulder arthroplasty (RSA) has been increasingly used in patients who suffer from severe muscular insufficiency. This pathological entity often leads to glenoid morphology differing from that in the total shoulder arthroplasty patients. As a result, abnormal glenoid in RSA may significantly affect the final position of the glenoid component relative to the glenoid surface and ultimately, the RSA outcomes. To date, little guidance has been available about the frequency and severity of glenoid morphologic alterations in patients undergoing RSA as well as a rationale of how surgical tactics can be developed to compensate for these variations. The purpose of this study was to classify glenoid morphology in patients undergoing RSA: to define what preoperative images are necessary for the classification to be effective and, to describe how the classification can provide information for surgical placement of glenoid component fixation.

METHODS:

The morphology of 216 glenoids was examined. All patients had a primary RSA, and four of them had bilateral RSA (79 males and 133 females with a mean age of 71). The inclusion criteria were evidence of rotator cuff deficiency, along with glenohumeral subluxation, glenohumeral arthritis, or pseudo paralysis. The morphology was classified subjectively by three observers (orthopedic surgeons) into normal (essentially unaltered) and abnormal (significant articular deformity) on plain radiographs, 2D CT scans, and 3D CT models. The abnormal group was further classified according to the erosion sites on 3D models.

Six anatomic parameters were calculated and compared among the classified groups: height, width, version, inclination, distance from the coracoid base to glenoid surface (C-G), and distance from the acromion base to glenoid surface (A-G). Two surgical parameters, the center line distance (including a standard center line and a spine standard line) and the glenoid surface area/location for peripheral screw placement were determined. The screw trajectory into three scapular columns, coracoid base, spine and pillar, was also documented.

The kappa statistic was employed to estimate the reliability of measurement made by the same observer on two occasions (intraobserver reliability) or by three observers on the same occasion (interobserver reliability). The difference of each parameter among the normal and abnormal groups was evaluated by either a t-test or a one-way analysis of variance with Tukey post-hoc test. All differences were considered significant at a probability level of 95%.

RESULTS SECTION:

62.5% glenoids were normal while the distribution of eroded glenoids was 17.6% posterior, 9.3% superior, 6.5% global and 4.2% anterior erosions (Figure 1). Intraobserver and interobserver reliability for classification ranged from moderate (kappa=0.54) to almost perfect (kappa=0.97).

In the normal glenoids, the averaged height, width, version, inclination, C-G distance and A-G distance were 36.2±3.3 mm, 28.9±3.3 mm, -5.7±5.1°, 7.5±5.6°, 2.0±2.4 mm and 21.2±2.4 mm, respectively. Significant differences were identified in at least one anatomic parameter between normal and each abnormal subgroup. For example, the differences between the normal and posterior erosion were retroversion (10.8° increase, p<0.0001), C-G distance (4.0 mm decrease, p<0.0001), and A-G distance (2.0 mm decrease, p=0.0072).

The standard center line was significantly shorter in the abnormal (19.6±9.1 mm) than the normal (28.6±4.1 mm, p<0.0001). The spine center line was reduced to 34.9±17.0 mm from 42.7±19.1 mm (p=0.003). The peripheral screw placement could be placed anywhere on the surface in the normal with a total area of 790.4±141.8 mm² and decreased to 460.3±132.0 mm² in the abnormal which was largely in the inferior and anterior regions. The screw purchase was also changed from primarily dual coracoid base/spine (41.4%) and spine/pillar (51.8%) columns in the normal to spine (38.9%) and/or pillar (37.7%) columns in the abnormal which varied with the erosion site.

DISCUSSION:

Distinct morphology in RSA patients may be associated with an abnormal joint compressive force resulting from the muscular insufficiency. With or without limited compressive force, this could produce complete joint incompetence with disassociation occurring between the humeral head and the glenoid leading to pseudo paralysis. The lack of contact of the articular surfaces might in turn produce minimal alteration in joint morphology. On the other hand, extra joint compressive force from remaining dynamic structures could generate sufficient abnormal contact between glenoid and humeral head. This biomechanical overloading could induce cartilage degeneration and downstream osteolysis in subcondral bone osteone. The resultant compressive force determined the erosion sites. If it was centralized, the global erosion would occur. Otherwise, the eccentric force would lead to a shift in position of the glenohumeral articulation, resulting in abnormal wear patterns and formation of a new fulcrum.

One important finding was the three diagnostic techniques showed no difference in determining normal from abnormal glenoid morphology. As ~2/3 patients were normal, the diagnosis could be made for those patients with plain radiographs which meant savings in both time and cost. When abnormality was identified, however, 3D CT reconstruction models should be used to further define the location and severity of erosion.

The standard center line offers sufficient bone stock for central device fixation when the glenoid is normal. For abnormal glenoids, this central line has much shorter distance, indicating lack of necessary bony stock for fixation. The spine center line on the other hand may provide an alternative fixation for a central device. Similarly, the peripheral screws could be placed anywhere on the glenoid in the normal. There exist far fewer options in the abnormal not only where on the surface screws can be placed but also the trajectory of the potential screws are less available.

![Classification of glenoid morphology: (A) normal, (B) posterior erosion, (C) superior erosion, (D) global erosion and (E) anterior erosion.](image-url)