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Influence of scapular tilt on radiographic assessment of the glenoid component after total shoulder arthroplasty: which radiographic landmarks are reliable?

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Background: Total shoulder arthroplasty has been shown to improve function and to reduce pain in cases of osteoarthritis. To assess loosening of the glenoid component, serial evaluation of frontal plane radiographs of the scapula has been established as the "gold standard." The aim of this study was to evaluate the reliability of different bone landmarks when the scapula is tilted compared with the ideal view.
Methods: Glenoid components were implanted into 6 human cadaveric scapulae. Radiographs were taken exactly anterior-posterior in the frontal plane as well as craniocaudal tilted (±15° and ±30°) and mediolateral tilted (±10° and ±20°). The following landmarks were evaluated: lateral margin of the scapula, medial margin of the scapula, floor of the fossa supraspinatus line, spine of the scapula line, glenoid fossa line, and coracoid base line.
Results: In evaluating the inclination of the glenoid component, the medial margin of the scapula had the best intraobserver and interobserver reliability with a variance for each of 2° ± 1° ($P < .0001$), whereas the lateral margin of the scapula had an acceptable intraobserver and interobserver reliability with a variance of 4° ± 1° and 3° ± 1°. In measuring medial migration, the glenoid fossa line had a significantly lower intraobserver and interobserver reliability than the coracoid base line (each 1 ± 0 mm vs. 3 ± 1 mm and 3 ± 2 mm; $P < .0001$).
Conclusion: To assess the inclination of the glenoid component, the medial margin of the scapula has proven best, and the lateral margin of the scapula has acceptable reliability. For measuring medial migration, the coracoid base line has proven acceptable reliability, whereas the glenoid fossa line would be subject to change when osteolysis occurs at the glenoid.

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Osteoarthritis of the shoulder is common among older patients and has substantial impact on function and well-being.[10,17,23] If nonoperative treatment fails, total shoulder arthroplasty (TSA) has been shown to improve function and to reduce pain.[17] The number of TSAs is growing faster than ever, with 27,000 performed in the United States in 2008.[12]

In a typical TSA, an all-polyethylene pegged or keeled glenoid component is cemented into the glenoid.[4] However, the glenoid component is frequently subject to loosening and osteolysis,[21,22] especially if the TSA is performed before the age of 55 years.[3] This can cause pain and loss of function.[21] To assess this loosening process, the clinical standard is to compare the anterior-posterior (AP) radiographs of the glenohumeral joint assessed directly post-operatively with radiographs obtained during the follow-up process.[6] The first stage is a progressive radiolucent line on serial radiographs that indicates loosening.[3] Several bone landmarks exist to evaluate loosening and change of the position of the glenoid component. Our clinical experience has taught us that most radiographs are not taken in an exact AP view. Because radiographs are 2 dimensional, variation in the technique may significantly influence the evaluation of the glenoid component in relation to the bone landmarks. Besides the variations in positioning of the patient for the radiograph, anatomic variation and degeneration influence the position of the glenoid.[19] Glenoid inclination, for example, has been shown to vary inter-individually by up to 20°.[2]

Therefore, the aim of this study was to evaluate radiographically available scapula landmarks with regard to resistance against mediolateral and craniocaudal tilting to determine the most reliable and clinically relevant landmarks for clinical follow-up examination of TSA.

Materials and methods

Study design

The study was designed as an experimental cadaveric study. Glenoid components (Aequalis glenoid component, size medium; Tornier, Burscheid, Germany) of TSA were cemented to a total of 6 human scapulae from adult deceased donors (International Institute for the Advancement of Medicine, Jessup, PA, USA). Radiographs were taken under fluoroscopy exactly AP as well as craniocaudal tilted (±15° and ±30° [+ means spine of the scapula closer to the anode of the x-ray device]) and mediolateral tilted (±10° and ±20° [+ means margo lateralis of the scapula closer to the anode of the x-ray device]). Angles or distances of the bone landmarks were measured by 3 blinded, independent and radiologically experienced observers. Data were statistically analyzed to evaluate reliability of the landmarks.

Surgical technique

A standardized surgical technique[1] was used to implant the convex keeled glenoid components into 6 (3 on the left side and 3 on the right side) human glenoids from adult deceased donors. Preparation of the glenoids was performed as we described previously.[20] Briefly, all implantations were done by the same surgeon (P.R.) using the Aequalis shoulder system (Tornier). After the glenoid center was located and the center hole drilled, the glenoid surface was reamed with spherical reamers of increasing size as recommended by the manufacturer. The medium-sized implants fitted in all specimens. A 2-hole drill jig was positioned using the center drill hole for stable fixation. The cranial and caudal drill holes were prepared, and then the keel slot was shaped using a high-speed burr to connect the cranial, central, and caudal holes. An impactor was used to pack the cancellous bone into the glenoid. Low-viscosity, 2-component bone cement (Palacos; Heraeus, Wehrheim, Germany) was used with a vacuum mixing system. The mixing time of the bone cement was 30 seconds as recommended by the manufacturer. After mixing of the components, the cement was filled into a 5-mL syringe. After 4 minutes, the cement was placed into the keel slot. Subsequently, 1 mL of cement was placed on the posterior surface of the components. The glenoid components were pressed manually into the prepared scapulae with an impactor after exactly 5 minutes. Constant pressure was applied. Finally, samples were embedded into paraffin in a neutral position.

Definition of landmarks, angles, and distances

Figure 1 shows landmarks used for analysis. The implanted glenoid component contains 2 metal pins at the base of the keel. The line going through these metal pins is the reference for the position of the glenoid component and is named the glenoid component line. All angles and distances are measured in reference to this line.

Line *a*, lateral margin of the scapula, was placed on the cortical border of the lateral margin of the scapula medial to the neck of the glenoid. The angle between the glenoid component line and the lateral margin of the scapula was defined as α.

Line *b*, medial margin of the scapula, was placed on the cortical border of the medial margin of the scapula. The angle between the glenoid component line and the medial margin of the scapula was defined as β.