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Glenoid exposure in shoulder arthroplasty: the role of soft tissue releases

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Background: The deltopectoral approach is commonly used in shoulder arthroplasty. Various soft tissue releases can be performed to obtain adequate glenoid exposure, but their effectiveness is not known. The purpose of this study was to (1) quantify the effects of various releases on the amount of glenoid surface area exposure and (2) determine if common soft tissue releases performed about the shoulder significantly improve exposure of the glenoid.

Methods: A standard deltopectoral approach was used on cadaveric shoulders (n=8) in the beach chair position. The releases performed were as follows: long head of biceps, pectoralis major tendon, inferior capsule, and posterior capsule. Following each release, a custom-designed jig was used to mark the exposed glenoid surface. The glenoid was then digitized using a 3D surface scanner to quantify the exposed surface area with each release.

Results: The mean glenoid surface area exposure prior to any releases was 57% (SD 8%). Following release of the long head of biceps, exposure increased to 69% (SD 10%). The exposed area was increased to 83% (SD 6%) with release of the pectoralis major, and 93% (SD 2%) with inferior capsule. The entire glenoid was exposed following posterior capsule release.

Conclusions: Release of the long head of biceps, pectoralis major, and inferior and posterior capsule all independently led to significant increases in glenoid surface exposure in the deltopectoral approach. Mean surface area exposed with all 3 releases was 93%. Although posterior capsular release improved exposure, the results of this study suggest that this is rarely necessary.

The deltopectoral approach is a common exposure used to gain access to the glenohumeral joint.[5] It is used for surgical treatment of fractures of the glenoid or proximal humerus, soft tissue repair, and shoulder arthroplasty. The aim of any surgical approach is to obtain adequate exposure while both minimizing disruption of soft tissues and avoiding neurovascular damage to adjacent structures.[1] The deltopectoral approach preserves the origin of the deltoid and occurs through an interval that is internervous and intermuscular between the deltoid and pectoralis major muscles. It may also be extended distally for access to the entire humerus. However, exposure and instrumentation of the glenoid can be difficult and lead to malpositioning of the glenoid component.[4] Proper positioning and orientation of the glenoid is essential for long-term stability and survivorship of the prosthesis.[8] Malposition of the glenoid component may result in compromised fixation because of inadequate bony support and incomplete implant seating, which can result in glenoid loosening—one of the most common modes of failure for shoulder arthroplasty.[6] Adequate exposure of the glenoid is essential.

For glenoid exposure during anatomic and reverse shoulder arthroplasty, various releases are often performed to improve exposure of the glenoid, including the long head of biceps tendon, inferior capsule, pectoralis major tendon, and the posterior capsule. However, to our knowledge, whether each of these releases are beneficial to glenoid exposure, the degree of exposure improvement, or whether any benefits to the releases are additive to the exposure have not been previously studied in a systematic manner.

To provide guidance as to which approach provides the greatest exposure possible, and to avoid releases that are ineffective, the objective of this study was to quantify the exposure of the glenoid obtained with release of the (1) long head of biceps, (2) pectoralis major tendon, (3) inferior capsular, and (4) posterior capsule.

Institutional review board approval was received from the Ottawa Health Science Network Research Ethics Board (protocol no. 20160584-01H).

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Materials and methods

Four cadaveric whole bodies (8 shoulders), 3 male and 1 female, mean age 77 years (range 71-84) were used for the study. No specimens had undergone prior shoulder surgery. Specimens were stored at −20°C and thawed for 24 hours prior to dissection. All specimens had normal scapular anatomy with no pre-existing glenohumeral osteoarthritis, and the rotator cuff was intact in all specimens. The mean glenoid retroversion was within 5° of neutral in all specimens (mean 3°, range 1°-5°).

Each donor body was secured in a beach chair position for dissection. A standard deltopectoral approach to the shoulder was used to expose the glenohumeral joint. The skin incision was placed lateral to the coracoid process and directed toward the deltoid insertion and parallel to the anterior aspect of the deltoid. The skin incision was standardized to 12 cm long. The cephalic vein was exposed and the deltopectoral interval developed. The subscapularis was released with a peel technique; release was carried out from the medial border of the bicipital groove and extended inferiorly and medially to include the inferior humeral neck posteriorly to the level of the teres minor. The humeral head was dislocated anteriorly and cut at 20° retroversion with an oscillating saw along the anatomic neck. The arm was placed in 30° flexion, 45° abduction, and 45° of external rotation, and the arm position was adjusted to obtain optimal exposure as is done in vivo. The anterior glenoid labrum was excised and the capsule was released from the 12-o'clock position to the 5-o'clock position. A glenoid rim retractor was placed on the anterior glenoid neck. A second glenoid rim retractor was placed on the posterior glenoid and was used to distract the humeral head posteriorly (Fig. 1). In the absence of a known ideal force, the amount of force chosen was consistent with the amount of force typically applied during shoulder exposure in vivo; force was applied until there was no further displacement of the soft tissues. This was standardized across all specimens at 5 kg or 50 N. The exposure of the glenoid obtained prior to any further release was used as a control.

The order of release was as follows: (1) biceps tendon, (2) pectoralis major tendon, (3) inferior capsule, and (4) posterior capsule. This is the standard order these approaches would be completed in vivo. All releases were performed by or under the direct supervision of the senior author (P.L.).

Technique for releases and osteotomies

The long head of biceps was released from its origin on the superior glenoid tubercle using sharp dissection. The pectoralis major tendon was released 1 cm medial to its humeral insertion. This release consisted of the superior 1 cm typically involving the pars clavicularis portion of the pectoralis insertion. The inferior glenoid labrum and capsule was released from 5 o'clock to 7 o'clock along the inferior glenoid rim in a subperiosteal fashion with sharp dissection. The long head of triceps was not released. The posterior labrum and capsule was released along the posterior aspect of the glenoid in a subperiosteal fashion with sharp dissection.

Glenoid exposure marking

A custom-designed and fabricated guide was used to determine the extent of glenoid exposure (Fig. 2). The guide was designed to allow insertion of a pin perpendicular (in both coronal and sagittal planes) to the glenoid surface based on the amount of posterior humeral subluxation. The guide was placed on the glenoid surface and the track-mounted pin carriage was pushed posteriorly until it abutted the humerus to determine the extent of glenoid exposure perpendicular to the surface. The maximal exposure, defined as the glenoid bony morphology that can be accessed with the pin in a perpendicular trajectory (in both coronal and sagittal planes) to the glenoid surface was scored at each level of exposure. A corresponding digital photograph was acquired to assist in etching identification during postprocessing. Exposure of 100% was defined as contact of the pin along the posterior glenoid rim.

Once all 5 exposures (including control) had been completed and marked, the glenoid was removed from the cadaver.

Digitization of bones and quantification of exposed area

Once the glenoid had been removed from the cadaver, the remaining soft tissue was removed. A validated laser and camera

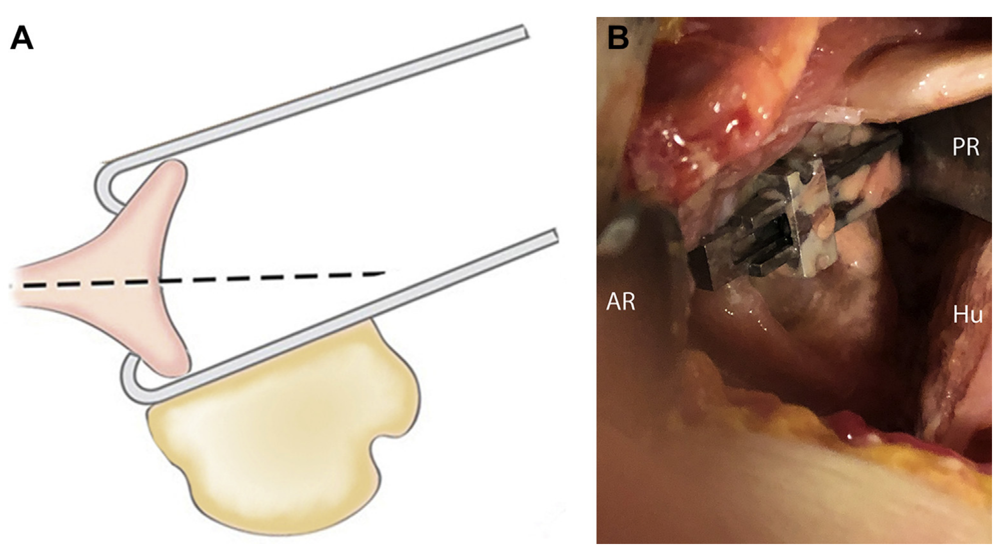

Figure 1 (**A**, **B**) Glenoid exposure of a left shoulder with position of retractors along the anterior and posterior glenoid rims prior to releases. AR, anterior glenoid retractor; PR, posterior glenoid retractor; Hu, proximal humerus. (Figure 1A adapted from Nové-Josserand and Clavert.[7])

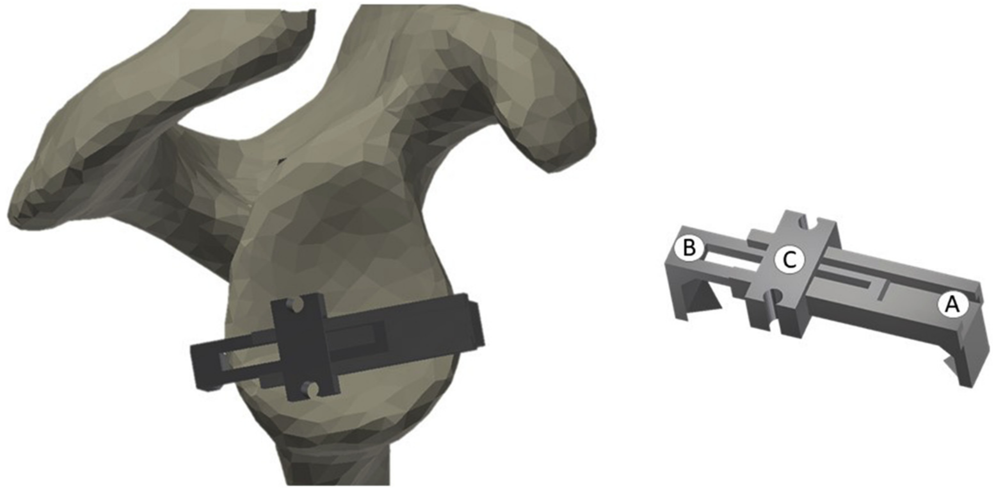

Figure 2 Custom-designed jig for glenoid marking perpendicular to the glenoid surface. *B*, posterior track; *C*, pin carriage; *A*, anterior track.

surface scanning system (DAVID Laserscanner, Palo Alto, CA, USA) as described in Desloges et al[3] was used to reconstruct digital models of the glenoid. Each glenoid was positioned within a calibration frame and scanned at multiple angles with the use of a high-intensity linear laser. Scans of each glenoid were referenced to the calibration frame and recorded with a high-resolution video camera (Nikon D5100 DSLR camera with a Nikkor 18-55-mm lens). The recordings were processed into surface maps that were merged to form a complete 3-dimensional model. This process has been previously verified to be accurate to within <0.4 mm root mean square error.[11] The pin markings made at the time of the exposure were reproduced on the 3D surface of the glenoid. The surface area exposed by each release was calculated and compared to the exposure obtained before release and to the total glenoid articular surface area.

Results

The mean surface area of the 8 glenoids was 1138 mm^2 (±153) (Table I). The mean percentage of glenoid surface area exposed following initial exposure (before soft tissue releases) was 57% (±8%) (Fig. 3). This was defined as the control. Following release of the long head of biceps, the mean glenoid surface area increased to 70% (±4%). This was further increased to 80% (±5%) following release of the pectoralis major tendon. Following release of the inferior capsule, the mean surface of the glenoid exposed increased to 93% (±4%). Once the posterior capsule was released, the entire glenoid surface was exposed in all specimens.

The surface area of the glenoid exposed increased approximately 10% after each sequential soft tissue release, beginning with long head of biceps, pectoralis major tendon, inferior capsule, and finally the posterior capsule. All releases increased exposure, with the entire glenoid surface accessible following release of the posterior capsule.

Discussion

Surgical exposure of the glenoid can be technically difficult. Good visualization of the glenoid is necessary in both anatomic and reverse shoulder arthroplasty in order to ensure proper positioning of the glenoid component. Although various soft tissue releases have been devised to maximize visualization, the efficacy or relative contribution of each is not well understood. The rationale for the current study was to determine whether commonly performed soft tissue releases are justified by studying their relative contributions to glenoid exposure. We found that following initial exposure, the mean glenoid exposure was 57% of the total glenoid surface. This exposure increased to 70% following release of the biceps, 80% following pectoralis major release, 93% following inferior capsular release, and 100% following posterior capsular release. Thus, each subsequent soft tissue release increased glenoid exposure by approximately 10% of the total surface area. Following release of the long head of biceps, pectoralis major tendon, and inferior and posterior capsule, 100% access was obtained with an instrument perpendicular to the glenoid face in all specimens. This suggests that further releases may not be required.

There were some limitations to this study inherent to the cadaveric model used. First, tissue compliance and muscle tone may differ from the in vivo situation although fresh-frozen specimens were used (not embalmed) in this study. However, shoulder

Table I
Glenoid exposure by soft tissue release

Specimen	Total surface area, mm^2	Control, %	Long head of biceps, %	Pectoralis major tendon, %	Inferior capsule, %	Posterior capsule, %
A	1084.1	65	75	88	93	100
B	1098.2	55	67	82	95	100
C	1269.2	63	75	82	100	100
D	1339.6	68	73	80	85	100
E	1134.4	60	71	79	91	100
F	887.5	50	67	83	95	100
G	1334.6	49	69	79	89	100
H	1088.0	46	65	71	95	100
Mean (SD)	1138.1 (153.1)	57 (8)	70 (4)	80 (5)	93 (4)	100

SD, standard deviation.

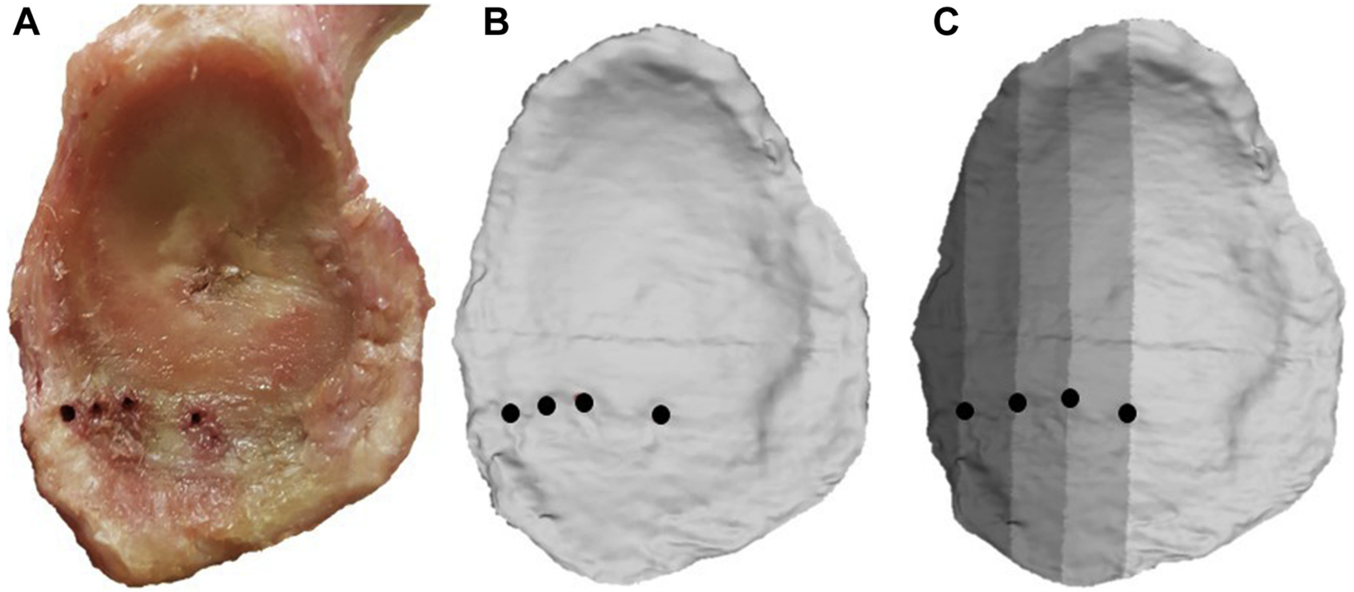

Figure 3 Example specimen (**A**) following removal of soft tissue; (**B**) 3D surface reconstruction; (**C**) surface area exposure following each release (from right to left): control, long head of biceps, pectoralis major, inferior capsule, and posterior capsule.

arthroplasty is typically performed either under general anesthesia or regional block, which typically results in a relaxed muscular state. Furthermore, the amount of glenoid exposed with initial placement of glenoid retractors and application of posterior force on the humerus was similar to the amount of exposure that occurs in vivo. A second limitation lies in the fact that the cumulative effect of each subsequent release was determined rather than the independent effect of each release. The releases were performed in a manner consistent with the order of releases in vivo as we felt it would be unrealistic to release the posterior capsule before release of the pectoralis major tendon. Shoulder arthritis is typically characterized by soft tissue contractures, changes to the glenoid contour, glenoid retroversion, and often posterior humeral head subfluxation. The fact that exposure increased following each release in our model demonstrates their efficacy; translation of this approach to the arthritic shoulder in vivo may affect the absolute magnitude of the area of glenoid exposed by each release. Other factors such as the degree of humeral rotation during glenoid exposure or osteotomy of the lesser tuberosity[2] may also affect the magnitude of the area of glenoid exposed.

Williams[10] described "10 Tips for glenoid exposure," which included making an accurate humeral cut, excising the anteroinferior capsule from the glenoid, and releasing the posteroinferior capsule from the glenoid. Szerlip et al[9] described release of the superior one-third of the pectoralis major to improve exposure and mobility of the humerus. They also noted that adequate capsular release is essential for both glenoid exposure and optimal postoperative range of motion. They describe extending the capsular release from the 3-o'clock anterior to the 9-o'clock position posteriorly. Our study findings are consistent with these recommendations and demonstrates the benefit of doing each of these soft tissue releases.

Nové-Josserand and Clavert described the optimal exposure of the glenoid consisting of a "facing" view of the glenoid.[7] To achieve this view, they recommended circumferential capsulotomy and inferior glenohumeral capsulectomy down to the humerus. Our study demonstrated this quantitatively, with 100% of the glenoid face being exposed (facing view) after biceps release, superior pectoralis major release, and complete capsulotomy.

This study demonstrated that release of the long head of biceps, pectoralis major, and inferior and posterior capsule all independently led to significant increases in glenoid surface exposure in the deltopectoral approach. Glenoid exposure increased by approximately 10% following each release. The combination of all these soft tissue releases resulted in complete (perpendicular) glenoid exposure in all specimens.

Conclusions

Release of the long head of biceps, pectoralis major, and inferior and posterior capsule all independently led to significant increases in glenoid surface exposure in the deltopectoral approach. In 10%, increase in mean surface area was observed following each release. Although posterior capsular release improved exposure, the results of this study suggest that this may rarely be necessary. Although we have demonstrated the relative efficacy of the described soft tissue releases, further studies should focus on the absolute magnitude of glenoid exposure in the arthritic shoulder in vivo.

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