



# Quantification of the exposure of the glenohumeral joint from the minimally invasive to more invasive subscapularis approach to the anterior shoulder: a cadaveric study

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**Background:** There are multiple techniques to approach the glenohumeral joint. Our purpose was to quantify the average area of the glenohumeral joint exposed with 3 subscapularis approaches and determine the least invasive approach for placement of shoulder resurfacing and total shoulder arthroplasty instruments.

**Methods:** Ten forequarter cadaveric specimens were used. Subscapularis approaches were performed sequentially from split, partial tenotomy, and full tenotomy through the deltopectoral approach. Glenohumeral joint digital photographs were analyzed in Image J software (National Institutes of Health, Bethesda, MD, USA). Shoulder resurfacing and total shoulder arthroplasty instruments were placed on the humeral head, and anatomic landmarks were identified.

**Results:** The average area of humeral head visible, from the least to the most invasive approach, was 3.2, 8.1, and 11.0 cm<sup>2</sup>, respectively. The average area of humeral head visible differed significantly according to the approach. Humeral head area increased 157% when the subscapularis split approach was compared with the partial tenotomy approach and 35% when the partial approach was compared with the full tenotomy approach. The average area of glenoid exposed from least to most invasive approach was 2.0, 2.3, and 2.5 cm<sup>2</sup>, respectively. No significant difference was found between the average area of the glenoid and the type of approach. Posterior structures were difficult to visualize for the subscapularis split approach. Partial tenotomy of the subscapularis allowed placement of resurfacing in 70% of the specimens and total arthroplasty instruments in 90%.

**Conclusions:** The subscapularis splitting approach allows adequate exposure for glenoid-based procedures, and the subscapularis approaches presented expose the glenohumeral joint in a step-wise manner.

**Level of evidence:** Anatomy Study, Cadaver Dissection.

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**Keywords:** Glenohumeral joint; cadaver; subscapularis split; partial tenotomy; full tenotomy; shoulder resurfacing; total shoulder arthroplasty

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The frequency of total shoulder arthroplasty has increased significantly within the last decade.<sup>15</sup> The deltopectoral approach to the shoulder through the subscapularis has proven over time to provide adequate access to the shoulder joint for treatment of fractures to the glenoid or proximal humerus, shoulder resurfacing, total shoulder arthroplasty, and soft tissue repair around the shoulder, including the labrum, rotator cuff, and cartilaginous surfaces of the glenohumeral joint.<sup>13,21</sup> A surgical approach should have the parallel goals of providing adequate exposure for safe performance of the desired procedure, allow for minimal disruption of soft tissue attachments to the region of interest, and avoid putting adjacent neurovascular structures of interest at risk of injury.

The partial and full tenotomies of the subscapularis have both been under scrutiny. Loss of function of the subscapularis has been reported due to failure of the tendon repair or muscular changes, or both, leading to muscle insufficiency,<sup>10,11,30,31</sup> which has the potential to negatively affect clinical outcome.<sup>10,20,23,24,27,29</sup> Multiple alternative approaches have been developed, including the subscapularis split,<sup>14</sup> through the rotator interval,<sup>16</sup> lesser tuberosity osteotomy,<sup>9</sup> subscapularis peel,<sup>12</sup> dual-window subscapularis-sparing approach combined with the subscapularis splitting approach,<sup>3</sup> and the anterior-superior approach.<sup>25</sup>

Some reports have shown primary tendon-to-tendon repairs have inadequate results; however, others have shown it is more efficient and avoids nonunion with osteotomy.<sup>6</sup> A more recent study in which the lesser tuberosity osteotomy was compared with the subscapularis peel found no significant difference in fatty infiltration, strength, and shoulder outcome scores at 2 years of follow-up.<sup>17,18</sup> Despite the alternatives, the subscapularis tenotomy has been the most widely used approach to the glenohumeral joint.

The subscapularis splitting approach has less theoretical risk, but whether it allows adequate exposure of the glenohumeral joint compared with the partial and full tenotomies is unknown. The purpose of the study was to quantify the average area of the humeral head and glenoid exposed with each type of approach, identify 6 anatomic landmarks, and determine the least invasive approach that can be used for placement of the instruments used for shoulder resurfacing and total shoulder arthroplasty. To our knowledge, quantification of the average area of the humeral head and glenoid through the subscapularis approaches presented in this study has not been previously reported.

## Materials and methods

The study used 10 fresh frozen cadaveric limb specimens (each composed of 1 forequarter shoulder). All procedures were performed by the 2 senior authors (A.E.J. and J.R.H.). A standard deltopectoral approach to the shoulder was performed as described below.

## Dissection

With the specimens supine, a 10-cm line was drawn on the skin of the anterior shoulder using a metric ruler to develop the deltopectoral interval. This line was made 3 cm distal to the coracoid process, along the lateral border of the biceps, and parallel to the anterior aspect of the deltoid. An incision was made along this line to expose the cephalic vein. The clavipectoral fascia was exposed and divided just lateral to the coracoid and conjoint tendon. The incision was extended vertically to the coracoacromial ligament and distally to the level of the anterior circumflex artery to expose the subscapularis tendon.

The subscapularis approaches were performed sequentially to further expose the glenohumeral joint. The subscapularis muscle was split in the mid portion, parallel to the plane of pull and in line with the tendon fibers of the muscle. For the partial tenotomy portion of the approach, a vertical incision (perpendicular to the plane of pull of the muscle) was made through the tendinous portion of the muscle 1 cm medial to its insertion on the lesser tuberosity and taken down to where the muscle was split for the subscapularis split. The partial tenotomy was completed for the full tenotomy. A capsulotomy was performed after the subscapularis-splitting approach to expose the glenohumeral joint. The shoulder was externally rotated to relax the nerve and enhance capsule exposure.

## Identification of landmarks

Shoulder resurfacing and total shoulder arthroplasty instruments were placed on the humeral head with each approach (Fig. 1). Six anatomic landmarks (Table I) were identified by direct visualization or palpation, or both. Maximum reach along the anterior and posterior glenoid was identified for each specimen.

## Photographic analysis

After each surgical exposure, the best view, in the opinion of the operating surgeon, was obtained and maintained for photographs using standard surgical retractors to expose the glenohumeral joint. Digital photographs of the exposed glenohumeral joint were taken perpendicular to the dissection from the surgeon's perspective and analyzed using Image J software (National Institutes of Health, Bethesda, MD, USA), as previously described.<sup>2,4,7</sup> This program compared a known distance (ie, a metric ruler in each image) with the actual number of pixels in each image to calculate the square area of the glenoid and humeral head in each exposure.

## Statistical analysis

Statistical analysis consisted of 2-way, repeated measures analysis of variance with Tukey adjustment for pair-wise comparisons. A *P* value of <.05 was considered significant.

## Results

Demographic data for all specimens are included in Table II. One specimen had rheumatoid arthritis of the hands and feet, 1 specimen had rheumatoid arthritis of the

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