

3D Quantification of Rotator Cuff Anatomy

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INTRODUCTION

The muscles of the rotator cuff are a significant source of pathology, interest and debate. Rotator cuff tears typically begin in the supraspinatus tendon (described by Codman in 1934) but can involve other structures. These tears can cause significant morbidity. Knowledge of rotator cuff anatomy plays a key role in successful surgical methods of repair, especially when trying to reestablish insertion onto the humerus. Anatomic relationships have been detailed in publications, usually with reference to gross insertions on the humerus. Problematically, the three dimensional insertion of the rotator cuff muscles has yet to be precisely quantified. No previous research has detailed the three dimensional nature of the tendon insertions. Understanding of these insertions may aide in analysis of established and newer techniques.

Previous investigations have attempted to derive biomechanical models based upon simple joint angle relationships. Data generated by these methods do not take into account the size and shape of the insertions. The morphology and anatomic relations of the cuff muscles in three dimensions were the subject of this study. Using computer modeling and direct anatomic measurement we quantify insertions in three dimensions with regard to total area, shape of footprint and anatomic relation to a specific landmark (the articular surface of the humeral head).

METHODS

Five shoulders from 4 preserved cadavera were used for this study. All shoulders were inspected for rotator cuff tear and found to be grossly normal or excluded. The shoulders were removed with the scapula intact from the cadavera. Dissection was then performed and each cuff muscle was identified. The humerus was then disarticulated from the glenoid. The tendons were then truncated at their insertions. The infraspinatus and teres minor muscles were found to join each other near their insertion and were therefore identified together and called the posterior rotator cuff. A Microscribe 3-D digitizer (Revision 1.4, Immersion Corporation) was then used to map each insertion. The posterior cuff complex of the infraspinatus and teres minor as well as the supraspinatus were mapped. Software was then used in analysis to digitally reproduce each tendons anatomic footprint with respect to the humerus. The Rhinoceros package Version 1.1 (Robert McNeel and Associates) was used to model the surface data using N.U.R.B.S. (Non-Uniform Rational B-Spline) recreations. The data was graphically reproduced and insertional as well as articular cartilage surface areas were calculated. The data from all specimens were combined and compared via Microsoft Excel. It was analyzed with respect to surface area and cuff insertion normalized to articular cartilage ratios.

RESULTS

The graphical representations of each humeral head and posterior rotator cuff and supraspinatus insertion regions were obtained (the Figure includes the 3D NURBS surfaces from one specimen). A quantitative area was then obtained for each rotator cuff insertion and articular cartilage surface. The articular cartilage areas ranged from 16.81 to 24.7 cm². Insertional cuff areas ranged from 6.33 to 10.82 cm². Ratios of cuff insertional areas to articular cartilage areas were then obtained which ranged from .34 to .45 for each specimen.

CONCLUSION

It was seen from this small sample size that the structure of the insertion of the posterior complex cuff tendons and supraspinatus is broadbased and its area can be quantified. Several studies have attempted to establish the location of the posterior cuff tendons to bony landmarks on the humerus. This is the first anatomic dissection study to show the insertion in graphical format with three dimensional quantification and area calculations. It is clear that the cuff insertions are more complex than has been previously described. Even from this small sample size the ratio of cuff areas to humeral articular cartilage show some consistency.

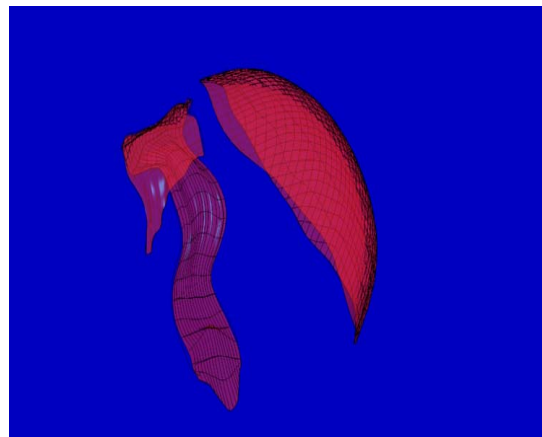


Figure. Depiction of 3D structure of the digitized Rotator cuff insertion and humeral head joint surface.