Mitigating Shear Forces in Total Shoulder Arthroplasty through Inferior Glenoid Component Inclination

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INTRODUCTION:

Total Shoulder Arthroplasty (TSA) is commonly used to alleviate pain and restore function in osteoarthritic (OA) shoulders. Despite the widespread use of TSA, concerns about glenoid fixation, stability, and wear persist, potentially due to excessive glenohumeral shear forces. Significant research has been conducted on how glenoid version affects surgical outcomes, but little is known about how inclination affects muscle and joint forces. This study utilizes an established virtual shoulder biomechanical model to investigate how glenoid component inclination affects the biomechanics of TSA.

METHODS:

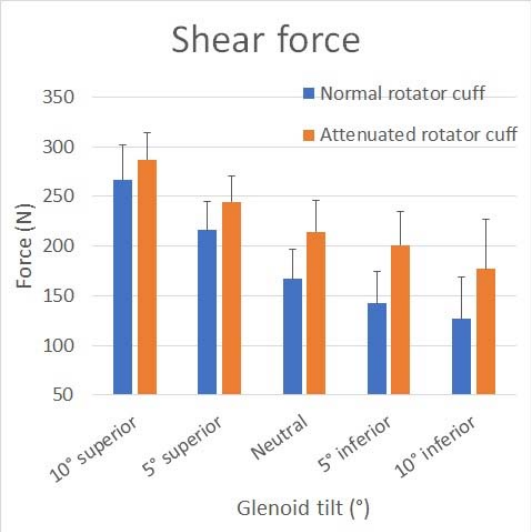
An Upper Extremity Computer Model that comprises of thorax, clavicle, scapula, humerus, radius, and ulna and 31 muscles (divided into 90 lines of action) was used to calculate glenohumeral joint forces following virtual TSA. Five CT scans from pre-op OA patients were used to create five individualized OA models and an experienced orthopedic surgeon performed virtual TSA using a Biomet Comprehensive® Total Shoulder system, applying a version correction to restore glenoid version to neutral. Five different glenoid tilt configurations were tested: neutral (0°), 5° and 10° superior tilt, and 5° and 10° inferior tilt. To investigate how the integrity of the rotator cuff (RC) muscle affects the results of glenoid alignment, two different RC setups were tested: i) healthy RC and ii) attenuated superior cuff (supraspinatus cross-sectional area reduced by 50%). Glenoid joint contact forces (analyzed in compressive and shear), joint stability (compression/shear ratio) and muscle forces were computed for abduction and scapula plane elevation motions.

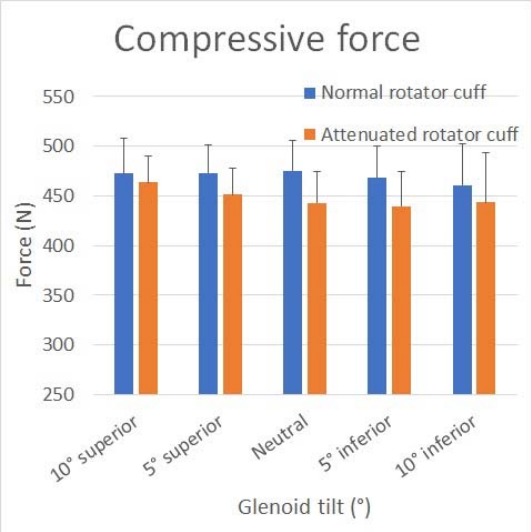
RESULTS:

Glenoid inferior tilt significantly affected glenohumeral joint contact forces (Fig. 1). Shear forces decreased with inferior tilt compared to neutral by 14.9% and 24.1% for 5° and 10° respectively, whereas superior tilt resulted in increased shear forces in the healthy RC models (by 29.2% and 59.1% for 5° and 10° respectively, $p<0.05$ for all pairwise comparisons). The same trend was observed for the attenuated RC models, except that the magnitude of shear forces was higher compared to models with normal cuff muscles ($p<0.001$). The increased shear in the models with the attenuated supraspinatus resulted in a very low compression/shear ratio for both 5° and 10° superior tilt (compared to the other models). For the healthy RC, only the 10° superior tilt showed a very low compressive/shear ratio.

DISCUSSION AND CONCLUSION:

Overall, inferior glenoid component inclination in TSA can reduce glenoid shear forces, which often result in polyethylene wear or loosening. In this study, inferior glenoid inclination resisted the upward deltoid pull and reduced shear forces. Inferior inclination showed great benefit, especially to the models with the attenuated supraspinatus muscle. Overall, the data suggest that neutral and inferior glenoid component inclination may be beneficial for TSA, and more aggressive inclination should be considered for patients with attenuated superior cuff muscles. However, this investigation did not consider glenoid bone quality and how it may be affected by inferior reaming. Future studies should focus on finite element analysis to further understand how glenoid inclination affects glenoid fixation in TSA.


Shear force
Normal rotator cuff
Attenuated rotator cuff
Force (N)
350
300
250
200
150
100
50
10° superior
5° superior
Neutral
5° inferior
10° inferior
Glenoid tilt (°)


Compressive force
Normal rotator cuff
Attenuated rotator cuff
Force (N)
550
500
450
400
350
300
250
10° superior
5° superior
Neutral
5° inferior
10° inferior
Glenoid tilt (°)