Effect of the Glenosphere Position and Size on Reverse Shoulder Prostheses Mobility

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INTRODUCTION:
Reverse shoulder prostheses balance the deficiency of the rotator cuff muscles by semi-constrained articular surfaces and a medial displacement of the rotation centre. These two features provide stability, but also motor function with the remaining deltoid muscle, by increasing its moment arm [1]. However, the rotation center medialization also induces mechanical impingements between bones and implants. The most important impingement occurs at the inferior side of the glenoid during adduction, but the posterior impingement also limits external rotation and may produce a notch [2]. Several ideas have already been proposed to reduce the impingements and improve the mobility of reversed prostheses, such as lateral or inferior displacement of the rotation center, or increase of the glenosphere size [3,4]. The effect of these design parameters have only been evaluated on the maximal range of abduction, for simple movements, and were not related to activities of daily living. The aim of the study was thus to measure the effect of these 3 parameters on the complete allowed range of motion, and to relate it to 4 typical activities of daily living.

METHODS:
CT data of a normal cadaver shoulder were segmented to obtain a dense set of points delimiting the bone surface (www.amira.com). A precise geometric model of the scapula and humerus was then built (www.geomagic.com). The model accuracy was assessed by direct comparison of the reconstructed bony surface with the original CT slices. A CAD software (www.solidworks.com) was then used to perform the bone resection and the prosthesis implantation. The Acqualis reversed prosthesis (Tornier) was used for this study. The original glenoid and humeral components were positioned according to manufacturer’s recommendations by a senior surgeon. The glenoid baseplate was positioned inferiorly, as usually recommended. The mobility of a healthy shoulder was compared to the mobility of 4 different reversed designs: a glenosphere with a diameter of 36 mm centered on the baseplate, a glenosphere with same size displaced inferiorly by 4 mm, a glenosphere with same size displaced laterally by 3.2 mm and a glenosphere with a diameter of 42 mm centered on the baseplate. The ISB standards were used to measure the glenohumeral mobility [5]. The complete mobility map (3 Euler angles) of all allowed gleno-humeral positions was measured with the CAD software. The mobility map was then compared to kinematics measurement on healthy subjects [6] of 4 important daily living activities: 1) hand to the contra lateral shoulder, 2) hand to mouth, 3) combing hair, 4) hand to back pocket. Each movement was divided in three parts, the first third of the movement, the middle third and the last third. For each part of the movement, the set of all allowed positions of the prostheses was compared to the glenohumeral angles of the healthy shoulder. The results are presented as percentage of the allowed movement relative to the healthy shoulder motion.

RESULTS:
The differences of allowed range of motion among each designs appeared mainly in two of the 4 tested movements: hand to back pocket and hand to contra lateral shoulder (Fig 2). There was no impingement associated to hand to mouth, and the combing hair movement was only limited in the first third of the motion.

For the hand to back pocket, the 36 centered had the lowest mobility range, particularly for the last third of the movement. For this movement, the 36 inferior provided the best mobility, followed by the 36 lateral and the 42 centered.

Conversely, for the hand to the contra lateral shoulder movement, the 36 inferior provided the worst mobility in the last part of the movement.

REFERENCES:

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