Glenohumeral Articular Contact Kinematics of Patients After Total Shoulder Arthroplasty

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Introduction: Total shoulder arthroplasty (TSA) has become a popular clinical choice for treatment of end-stage shoulder degeneration [1]. However, no data has been reported on the glenohumeral joint contact biomechanics in patients after TSA. This information is necessary for the improvement of implant design and surgical implantation technique; so to improve the longevity of the component. This study investigated glenohumeral articular contact kinematics of TSA patients during functional motion of the shoulder using a dual fluoroscopic imaging technique [2].

Materials and Methods: Eleven shoulders in ten patients all at least 2.5 years after surgery (age 40-80) with anatomical shoulder components (Anatomical Shoulder System, Zimmer, Warsaw, IN) were recruited under IRB guidelines and informed consent. The replaced shoulder was scanned while the patient performed abduction and rotation motion using two fluoroscopes (BV Pulsera 12”, Philips Electronics, USA) (Image 1).

Image 1: Dual fluoroscopic imaging system shown with typical patient at 90° abduction maximum external rotation. The shoulder was scanned at approximately 0°, 45° and 90° abduction neutral rotation, and 90° abduction with maximum internal and external rotation. The fluoroscopic images and CAD models of the humeral head, stem and glenoid components were used to create a virtual dual fluoroscopic imaging system (Image 2).

Image 2: Virtual dual fluoroscopic imaging system recreated in computer space allowing 6 DOF manipulation of the components.

The humeral head and stem component positions were adjusted in 6 DOF within the virtual system until their projections matched the patient's TSA images captured during active abduction and rotation. The glenoid model was matched using radiographic beads implanted in the glenoid fixation pegs from the manufacture. The in-vivo TSA position at each abducted and rotated position was therefore reproduced using the TSA models. From these models, the glenohumeral articular contact was determined by the overlap between the humeral and polyethylene glenoid articular surfaces. The contact point was defined as the centroid of the contact area. To make data presentation consistent, contact points of right shoulders were mirrored onto left glenoid surfaces. Each patient was individually investigated, and the contact points were analyzed using contact frequency on the four quadrants of the glenoid surface.

Results: For all positions, 60% of the contact points was found in the superior posterior quadrant of the glenoid surface. Contact was primarily superior to the glenoid midline, representing 80% of the contact points (Image 3).

Image 3: Discrete per quadrant percent occupancy defined as the discrete number of contact occurrences within a quadrant to the total number of positions examined for all patients.

Zero degree abduction neutral rotation exhibited the greatest variation of contact locations, showing no specific quadrant pattern. At no time was contact found at the center of the glenoid surface.

Discussion: This paper presents the first data on in-vivo glenohumeral articular contact kinematics in patients after TSA. These data, when compared to normal healthy subjects exhibit similar contact patterns, indicating that the anatomic sizing and non-conforming component designs might help recreate normal kinematics of the shoulder [3]. Follow up studies should be conducted to investigate the long term effect of the components on patients' function and polyethylene component wear.