COMPARISON OF STRAINS IN UNDERLYING GLENOID WITH METAL BACKED AND ALL POLYETHYLENE IMPLANTS USING THE PHOTOELASTIC METHOD

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Introduction

Arthroplasty involves the removal of diseased or injured joint tissue and replacement with metal and/or plastic components. An alteration in the stress and strain environment following arthroplasty is well known. These deviations from the normal strain conditions are believed to lead to bone resorption, implant loosening and eventual failure of the implant. Bone remodeling, while well studied in hip arthroplasty, has received less attention in total shoulder replacement. Failure of glenoid replacements is confounded by many factors including poor bone stock and difficult surgical exposure. [1,2,3,4,5] This study examined the strain differences in intact glenoids and following replacement with a metal backed keeled component and an all polyethylene pegged component with the same articular geometry, using the photoelastic method.

Methods

Three fresh frozen adult upper extremities (mean age 62) were cleaned of all soft tissue and disarticulated, taking care not to damage the labrum or articulating surfaces of the joint. The humerus was severed approximately 20cm from the proximal end and two 8mm diameter holes were drilled to accommodate the testing jig. The acromion and coracoid process were removed from the scapula and it was cut leaving little more than 40cm proximal to the labrum.

PE-1 Photoelastic resin and hardener (Vishay Measurements Group, Raleigh, NC) were then mixed, cast to 2mm thickness and molded to match the contours of the glenoid. To assure proper transfer of surface strains, the glenoid and contoured sheet were degreased with Propanol-1-OL (n-propanol) and adhered using PC-1 adhesive (Vishay Measurements Group, Raleigh, NC). Each glenoid was mounted in low melting point alloy and cooled with water to minimize heat damage. Rosette 45 degree strain gauges (TML, Tokyo, Japan) were attached around the periphery of the glenoid in a plane 12mm proximal to the glenoid surface as described by Maurell [6], except that 8 rather than 6 gages were used.

The glenoid arthroplasty indeed alters the strain state compared to the intact case. This study examined a metal backed and all PE glenoid with the same articular geometry. The metal and plastic implants components followed similar trends in general, shifting strains superiorly under these static testing conditions. Significant differences were noted between the metal backed and all PE implants in the anterior region (regions 2 and 3, Figure 3). The moderately large strain distributions seen here represent the averaged glenoid. This was brought about by the comparison of disparate glenoids, having different bone quality and geometry. [9] This study is limited in the complex kinematics of the shoulder cannot be replicated in vitro. Changes in strain distributions following glenoid arthroplasty represent one factor that can influence outcome.

Results

Preoperative measurements were taken from each intact glenoid to represent the native state. Each specimen was reconstructed using an uncemented metal backed component (SFFT, DePuy International, Leeds, UK) followed by an all polyethylene cemented component (Global, DePuy International, Leeds, UK) fixed with Simplex cement. Each specimen was restested following each surgical procedure. Three photoelastic and three strain gauge measurements were taken at each of the eight strain gauge locations. Corrections were made for reinforcement effects caused by the photoelastic coating. The strain differences in intact glenoids and following replacement with metal backed and all PE implants were noted.

Discussion

Glenoid arthroplasty indeed alters the strain state compared to the intact case. This study examined a metal backed and all PE glenoid with the same articular geometry. The metal and plastic implants components followed similar trends in general, shifting strains superiorly under these static testing conditions. Significant differences were noted between the metal backed and all PE implants in the anterior region (regions 2 and 3, Figure 3). The moderately large strain distributions seen here represent the averaged glenoid. This was brought about by the comparison of disparate glenoids, having different bone quality and geometry. [9] This study is limited in the complex kinematics of the shoulder cannot be replicated in vitro. Changes in strain distributions following glenoid arthroplasty represent one factor that can influence outcome.

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