BONE REMODELLING ANALYSIS AROUND CEMENTED AND CEMENTLESS GLENOID COMPONENTS

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Introduction

Total shoulder arthroplasty, TSA, has become an efficient treatment for several degenerative conditions of the shoulder joint. However, like any other joint replacement, it is associated with a multitude of complications, being the loosening of the glenoid component the most concerning. Based on Wolff's law, many studies relate the mechanism of loosening with the loss of bone resulting from the adaptation of bone to the implant. Bearing in mind that little material exists in the literature regarding the bone adaptation process of the scapula after a TSA, the aim of this work is to evaluate the remodelling process of the scapula around cemented and cementless glenoid components.

Methods

The 3D geometric model of the scapula was generated from the CT images of the Visible Human Project. The replacement of the shoulder joint was virtually simulated in Solidworks® for (1) three anatomical, cemented, all polyethylene glenoid components with a pegged, a keeled and an anchor pegged anchorage system, (2) an anatomical, cementless, metal-backed glenoid component, and (3) a reverse, all metal component. The 3D meshes of these structures were developed in Abaqus® 6.10 using linear tetrahedral elements, and all interfaces were considered perfectly bonded, simulating an idealised immediate post-operative condition.

The bone remodelling model applied was previously validated for a 3D model of the intact scapula, prior to the prosthesis implantation [Quental, In press]. The model is based on a global optimization criterion expressed as the minimization of a function that takes into account both structural stiffness and the metabolic cost of bone maintenance [Fernandes, 1999].

The loading condition applied to the scapula consisted on twelve load cases, which included muscle and joint reaction forces at 10º, 30º, 50º, 70º, 90º, and 110º of arm abduction in the frontal plane and anterior flexion in the sagittal plane. All forces were estimated using a multibody system of the upper limb, capable of simulating both anatomical and reverse conditions of the shoulder joint [Quental, 2012a, 2012b].

The change in the bone adaptation process of the scapula was evaluated in terms of the bone density, with respect to the initial solution.

Results

Figure 1 illustrates the bone adaptation process of the scapula, classified into apposition, equilibrium, and resorption, around an anatomical, cemented component with a pegged anchorage system and a cementless, metal-backed component. In general, the results show that cemented, all polyethylene components do not produce a negative effect on the bone adaptation process of the scapula, whereas cementless, metal components do.

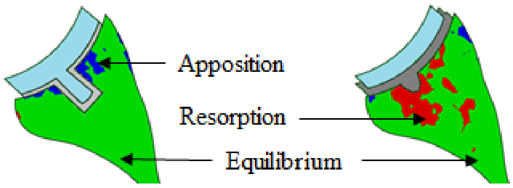

Figure 1: Change in bone density for (a) the cemented, pegged anchorage system, and (b) the cementless, metal-backed component.

Discussion

The bone remodelling adaptation of the scapula after a TSA was successfully evaluated in this study. As far as the bone adaptation process is concerned, the results support that cemented, all polyethylene components are a better option to treat the shoulder joint than metal-based components.

References

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