WEAR ANALYSIS IN POLYETHYLENE COMPONENTS OF THE TOTAL SHOULDER ARTHROPLASTY

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Introduction

Despite up to 60% of the performed shoulder revisions being estimated to result from loosening due to wear and cold flow deformation of ultra-high molecular weight polyethylene, UHWMPE, the progression of wear in the total shoulder arthroplasty (TSA) has deserved little attention so far. Hence, the aim of this study is to deepen the knowledge regarding the progression of wear in UHWMPE components of anatomical and reverse shoulder prostheses.

Methods

The three dimensional model of the scapula and humerus were generated from the Visible Human Project. The anatomical and reverse shoulder arthroplasties were simulated in Solidworks® following the manufacturer's recommendation. Additionally, the final implant positioning was approved by an orthopaedic surgeon. Regarding the anatomical TSA, 3 cemented, all polyethylene components, with a pegged, an anchor pegged, and a keeled anchorage system, and a cementless, metal-backed component were considered. The humeral head was modelled as a rigid spherical surface, with a variable radius of curvature of 22, 24, or 26 mm to simulate, correspondingly, a radial mismatch of 1, 3, or 5 mm. The reverse TSA was simulated for a cementless humeral stem with a humeral cup of size 38 mm, and a UHWMPE rim thickness of 3, 6 or 9 mm. Like the humeral head, the glenosphere was modelled as a rigid spherical surface. It is relevant to note that no radial mismatch exists between the articular surfaces of the modelled reverse prosthesis.

The loading conditions applied comprised the muscle and joint reaction forces from the 3 main motions of the shoulder joint, i.e., abduction-adduction, anterior-posterior flexion, and lateral-medial rotation. 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 progression of wear was evaluated using the classical Archard's law or a second generation law [Abdelgaied, 2011], with or without the existence of creep deformation. During the analysis, the UHWMPE surface was updated in accordance with the estimated wear until one year was evaluated.

Results

Figure 1 illustrates the wear distribution for an anatomical component, with a pegged anchorage system and a radial mismatch of 3 mm, and a reverse component with a UHWMPE rim thickness of 6 mm. The results show that anatomical components present significantly higher linear wear. Nevertheless, the volumetric wear in the reverse components is quite comparable to that of the anatomical components due to the larger contact areas.

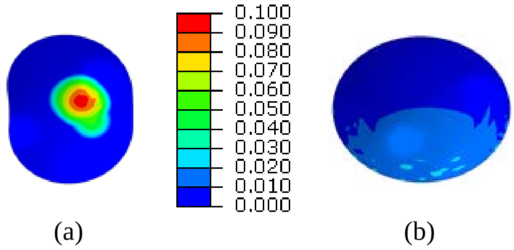

Figure 1: Wear distribution using the classical Archard's law for (a) an anatomical component, with a pegged anchorage system and a radial mismatch of 3 mm, and (b) a reverse component with a polyethylene rim thickness of 6 mm.

Discussion

The UHWMPE wear was successfully estimated for several configurations of the anatomical and reverse prostheses of the shoulder joint. Compared to previously published studies, this work is innovative because it (1) uses a second generation law, in addition to the classical Archard's law, (2) updates the progression of wear on the articular surface, (3) defines a more complete loading condition, and (4) includes a creep law.

References

Abdelgaied *et al*, J Biomech, 44:1108-1116, 2011.
Quental *et al*, Multibody Sys Dyn, 28:83-108, 2012a.
Quental *et al*, J Biomech, 45:S559, 2012b.