WEAR PREDICTIONS FOR REVERSE TOTAL SHOULDER REPLACEMENTS

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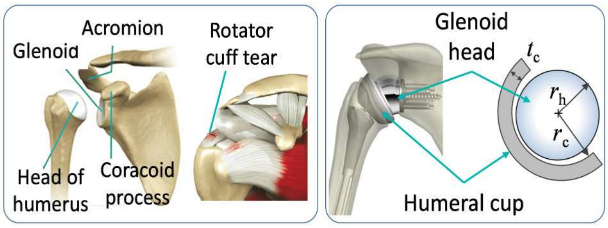
Introduction

Reverse total shoulder arthroplasty (RTSA) has become the gold standard to treat rotator cuff tear arthropathy (Fig.1.a). RTSA is performed by substituting the humeral head and the glenoid cavity by a plastic cup in UHMWPE and a metallic head, respectively (Fig.1.b), in a geometrical reversed configuration with respect to the anatomical one. Major complications affect 27% of cases and mainly regard scapular notching due to cup-bone impingement and wear debris [1]. Unfortunately, wear in shoulder prosthesis has not been largely studied as for hip and knee implants. Indeed, no wear test standards or even shoulder simulators exist, also because of a limited knowledge on shoulder/RTSA dynamics. Additionally, only a few numerical wear models for RTSA can be found in the literature (e.g. [2,3]), mainly focused on the comparison between anatomical and reverse solutions, and which often simulates simplified conditions, such as planar unloaded motions [3] even neglecting fundamental aspects of wear process, i.e. cross-shearing (*CS*) [2].

The aim of the present study is to numerically investigate wear in RTSAs analysing the effect of: a) wear factor and wear law; a) implant geometry; b) inversion of bearing materials, i.e. plastic head + metallic cup, which should reduce the risks associated to scapular notching.



(a) (b)

Fig. 1 Shoulder anatomy and rotator cuff tear (a). Reverse shoulder implant and model geometry (b).

Methods

The wear model for hip implants described in [4] was adapted to shoulder replacements and modified in two main aspects: 1) addition of the relative translation between the head and cup centres in the expression of the sliding velocity; 2) adoption of Bartel's approximated formulas [5] for solving contact analysis. Two wear laws were simulated: the Archard law and a new one for wear of UHMWPE [6]. In particular, different expressions of wear factor *k* were considered, also including the *CS* [4]. It is worth noting that the values adopted for *k* in numerical simulations were originally obtained for hip implants, since no specific *k* for RTSA is currently available in the literature. Numerical simulations were performed for different implant geometries (r_c=18, 19.5, 21 mm; cl=r_c–r_h=5, 50, 500 nm; t_h=6 mm) and inverted bearing materials. As boundary conditions (BCs), high load levels and 3D kinematics, taken from [7] and depicted in Fig.2, were assumed.

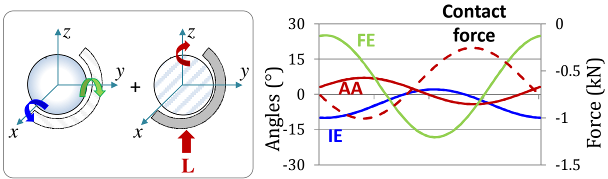
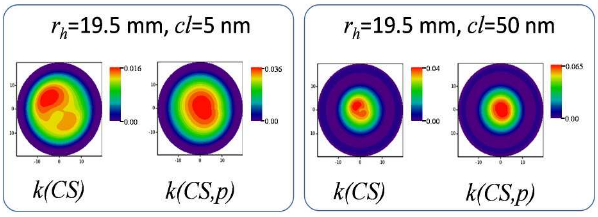


Fig. 2. Simulated BCs. FE: Flexion-Extension; IO: inward-outward rotation; AA: Abduction-Adduction.

Results and Discussion

The wear factor/law were demonstrated to affect significantly wear predictions, which is in agreement with [3,4]. Regardless the implant geometry, variations of volumetric/ linear wear rates higher than 50%, as well as different wear maps, were obtained (Fig.3). Also the implant geometry, and particularly the *cl*, had an important influence on wear. The more conformal implants, the lower the wear depth and the higher the mass loss (Fig.3) [3,4]. The inversion of the bearing materials was shown to be not very significant, with wear rates slightly higher (up to 10%) for the inverted configuration, as in [7].

The estimation and use of RTSA specific k is recommended in future researches because it might limit the model reliability, as suggested in [8].



(a) (b)

Fig. 3. Some preliminary wear predictions. Effect of the wear factor (a) and the implant geometry (b).

References

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