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Prevent/Limit the Edge Loading in Total Hip Replacement

Ehsanollah Torabi Kachousangi[1)*], Reyhaneh Asadirad[1)] and Ken Mao[1)]
[1)] School of Engineering, The University of Warwick
Coventry, CV4 7AL, UK
[*]Corresponding author: e.torabi@warwick.ac.uk

1. Introduction

Using a different kind of biocompatible materials such as polyethylene, metals and ceramics, which have lower wear rate respectively, offer different performance in hip prosthesis. Regardless to the material in use and a technique of the surgery, edge loading happens in all kind of hip prosthesis [1-4]. Preventing or decreasing the effect of this phenomenon, dramatically increases the life cycle of the prosthesis by decreasing the wear rate. Hence young patient can go under surgery and no one sits on wheelchair or has a revision surgery due to the hip prosthesis short life cycle versus human life expectancy.

2. Edge Loading

The change in contact, from conform spherical surface to the edge of the socket produces high force to narrow area that causes the high stress and respectively high wear rate [1].

Slashed muscles regain their strength in several weeks after surgery; in this period of time muscles don't have sufficient strength to keep the joint in place. Hence the ball can be separated from center of the socket in swing phase. If ball gets more than $6\mu m$ [2] separation, strike heel can load the edge in each walking cycle.

Socket should be fit into the acetabulum within safe range of 10° at 45° inclination and 15° anteversion [3]. Socket disposition or hypermobile hip can cause misalignment of prosthesis, which causes the neck to impinge on the edge of the socket. In this case ball would be lifted and comes out from the opposite side of socket.

90° flexion of the hip in step climbing, rising from chair etc. makes edge loading by contact of superior side of the ball to the posterior side of the socket [4].

3. Design, Simulation and analyze

Models are analyzed with Finite element method (FEM) by one of the most advance software in this regard. New design and the one is available in market are tested with Abaqus 6.11 and results are illustrated in Fig 1 and Fig 2 respectively. The Models are made of Alumina with Young's modulus of 380MPa and Poisson's ratio of 0.26. Balls diameter are 56mm and the sockets have 5mm thickness with 2.5mm chamfer edge and radial clearance of $40\mu m$ [1]. Models are tested by $250\mu m$ separation.

Figure 3 clearly shows the components of the new design including the ring (The innovative part) with 2.5mm chamfer edge. The ring is fitted on the socket with compatible geometry in Fig 1. This ring prevents the ball from coming out of the socket; hence it can prevent/limit the edge loading (EL). Fig 1 proves, under stress area of the new design has a reasonable distance to the edge and Von Mises stress (VMS) is reduced to around one-fifth (295MPa) in comparison with old one (1.42GPa in Fig 2).

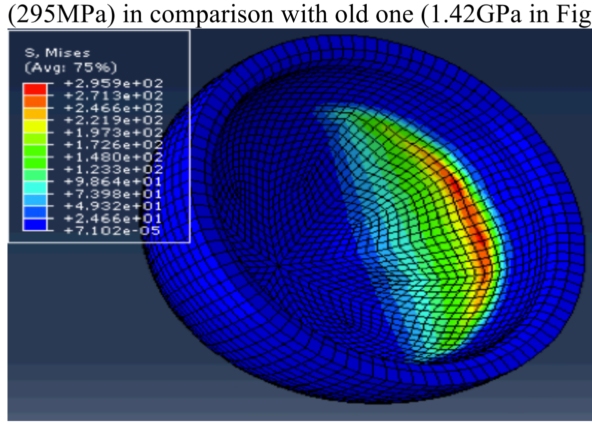

Fig 1. New,295 MPa V.M.S stress under 250µm separation

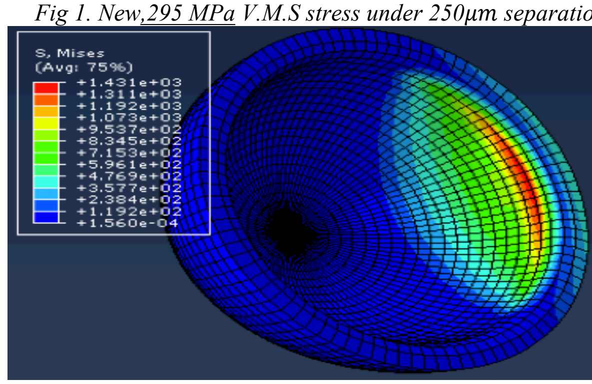

Fig 2.Available,1.42 GPa V.M.S under 250µm separation (EL)

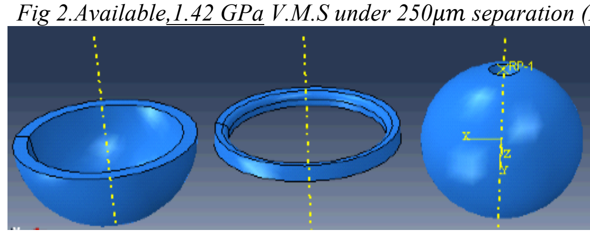

Fig 3. New design components including ring.

4. References

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