Background

Uncemented hip replacements are desirable as potential long-term solutions, but substantial clinical failures still occur due to aseptic loosening of the acetabular component (1). The long term success of uncemented cups is dependent upon early bony ingrowth, to stabilise the component in the skeleton and thereby prevent resorption due to relative motion. Occasional high loads, which occur during stumbling, for example, could compromise the interface and may lead to delayed healing or failure.

Objective

• To assess the effects of high loads on the integrity of the bone-implant interface.
• Assuming idealised patterns of bone ingrowth, according to retrieved specimens (2) and a progressive increase in interface strength over time, mechanical modelling can be used to predict the possibility of rupture of the new tissues during healing.

Method

• Finite element model of the reamed acetabulum (3)
• Fitted with cups with a 1mm and a 0mm interference fit
• Contact analysis with cup-bone friction coefficient of 0.4
• Areas of full bonding simulate bone ingrowth (Fig 2, red)
• Stumbling load applied, according to Bergmann et al (4), (Fig 1)
• Interface shear stress distribution calculated
• Comparison with interface shear strengths (5) indicate the maximum sustainable load at a particular stage of healing

Results

• Highest shear stress for 1mm press fit: 8MPa (#1) • Shear stresses for 0mm interference: 1.4-5.0MPa (#2-15)

Discussion

Assuming interface strength data in the literature (5), 1MPa can be sustained at 2weeks and 10MPa by 16weeks. Therefore, stumbling at 2weeks would be likely to fracture the interface, while stumbling at 16weeks would be unlikely to severely compromise the interface. The interference fit is most likely to be compromised

Stumbling in the first few weeks post-op’ would be unlikely to delay healing, since the effect is similar to hammering during implantation, for which forces are of a similar magnitude (6). Stumbling also appears to be sustainable by a mature interface but may delay healing in the period before complete bony ingrowth has been achieved.

References:
(2) Singh et al. 1993 JBJS 75A: 814
(3) Spears et al. 2000 J Biomech 33: 1471;
(4) Bergmann et al 2001 http://www.medizin.fu-berlin.de/biomechanik;
(6) Kroeber et al. 2002 J Arthroplasty 17: 349

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