# Polyethylene wear in Scanhip® arthroplasty with a 22 or 32 mm head

*Sir*—I read with great interest the paper cited above due to the fact that the Centre for Biomedical Engineering, University of Durham, has a current research program in investigating wear in artificial joint replacement especially with reference to femoral head size. We would like to draw both the editor's and the authors' attention to a cautionary note with regards calculating wear volumes and, more importantly, an alternative explanation for the increased wear rate observed in the 32 mm cohort.

First, the wear volume, V, has been calculated from the linear wear or penetration depth d, using the formula $V = \pi r^2 d$, where r is the radius of the head. However, investigations by Kabo et al. (1993) and Hall et al. (1995) have shown that the wear volume gained when using this equation substantially overestimates the value obtained from direct measurement by as much as a factor of two. In studies where relative comparisons are important, the absolute values may not be important, provided the sockets are similar, mathematically speaking. However, if the bores of the socket are different in shape then this will not be the case and the formula by Kabo et al. (1993) or the modified version by Hall et al. (1995) should be used.

Secondly, to a good approximation, the volumetric wear observed in the articulation of ultra-high molecular weight polyethylene (UHMWPE) against a smooth metallic or ceramic surface is proportional to both the sliding distance and the load across the contact. We found that wear is independent of the contact stress—that is, the load divided by the contact area. Accaording to the article, the linear wear would be greater for the 22 mm group due to the higher contact stresses. There is little experimental or theoretical evidence to support this claim, although Barbour et al. (1995) observed an increase in volumetric wear rates for low contact-stresses which is in opposition to the views in this article.

The increase in volumetric wear rates can be explained, in part, by the increase in sliding distance in the 32 mm cohort. The sliding distance in a single motion cycle is proportional to the product of the femoral head radius and the angle of articulation in radians. Thus, the sliding distance per cycle will increase by approximately 1.5 for a 32 mm head relative to a 22 mm one. In the article, the ratio of the volumetric wear of the 32 mm with respect to the 22 mm is 2.95, which is more than twice that expected from sliding distance considerations only. To account for the discrepancy, additional contributions to the wear could have been caused by the reduction in contact stress of the 32 mm heads (Barbour et al. 1995) or differences in the surface roughness of the femoral heads either initially or developed in vivo, in which the latter is due to damage to the metallic counterface caused by radio-opaque agents in bone cement.

**Richard M Hall and Jacqui L Hailey**
*Centre for Biomedical Engineering, School of Engineering, University of Durham, Durham, DH1 3LE, UK*

*Sir*–We thank Drs. Richard M Hall and Jacqui L Hailey for their comments concerning our paper, and for their interpretations of our results. We accept the criticism of the cylindrical wear formula that we used. Using the formulas by Kabo et al. (1993) or Hall et al. (1995), the calculated wear volumes would have been more correct. However, the main purpose of our study was to compare wear caused by the 22 mm and the 32 mm heads, not to measure the absolute values. The use of the alternative formulas would not have changed our conclusions about the difference between the heads.

According to Hall et al. (1995), comparisons of derived and directly measured wear volumes showed approximately 25% overestimation with the cylindrical wear formula and 35% underestimation with the formula by Kabo et al. (1993). Although the modified Kabo formula improves the precision of the wear calculations (Hall et al. 1995), it would not be quite correct in our cases, since it was created for cups like the Charnley cup, having an initially cylindrical portion of the socket bore. The bore of the Scan Hip® is initially conical. Therefore, neither of these formulas will produce exact values of the wear. Moreover, a drawback of the formula suggested by Kabo et al (1993) as well as with its modification is that it cannot be used if the direction of wear is nearly perpendicular to the orifice of the cup.

Barbour et al. (1995) have demonstrated in vitro that low contact stresses gives increased volumetric wear. This is an interesting alternative explanation of our findings but, being given in an in vitro study, it may not be applicable in vivo. If we assume that it is

correct, this observation, together with increased sliding distance of the 32 mm head may well explain the 3 times greater volumetric wear with this head.

**Uldis Kesteris, Hans Wingstrand, Rolf Önnerfält**
*Department of Orthopaedics, Lund University Hospital, S-221 85 Lund, Sweden*

Barbour P S M, Barton D C, Fisher J. The influence of contact stress on the wear of UHMWPE for total replacement hip prostheses. Wear 1995; 181-3; 250-7.

Hall R M, Unsworth A, Craig P S, Hardaker C, Siney P S, Wroblewski B M. Measurement of wear in retrieved acetabular sockets. Proc Inst Mech Eng 1995; 209H: 233-42.

Kabo J M, Gebhard J S, Loren G, Amstutz H C. In vivo wear of polyethylene acetabular components. J Bone Joint Surg (Br) 1993; 75 (2): 254-8.