REFERENCE POINT INDENTATION TRENDS OF THE HUMAN FEMORAL NECK

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Introduction

Reference point indentation (RPI) is a novel technique with the potential for clinically assessing bone fragility [Diez-Perez, 2010]. The instrument cyclically indents into the bone, with increased indentation implying higher fracture risk. The technique has shown correlation with fragility measurements [Gallant, 2013] and the emerging ability to discriminate between fragile and healthy bone [Diez-Perez, 2010]. This indicates a clinical potential: a) directly, for diagnosis and b) indirectly, for developing understanding of bone fracture and mechanical properties.

Here, we assess indentation of femoral heads retrieved from total hip replacement (THR) surgery. Such measurements aim to gain further insight into the mechanical properties of the femoral neck and the additionally information this can provide beyond existing clinical fracture risk assessment tools.

Methods

With consent, four human femoral heads were collected, from THR and tested with ethical approval (LREC 210/01). The location of the ligamentum-teres was used to identify the medial and lateral directions but without further donor information the anterior/posterior directions could not be differentiated. On the four samples, different areas of the femoral neck (shown in Figure 1) were tested using RPI (Biodent™, Active Life Scientific) at 10 cycles and a 10 N maximum load. The Total Indentation Distance (TID) was used to assess the variation throughout the neck.

Results

Testing longitudinally [B and C] found a 13 to 61%* higher TID than transversely [A], supporting Koester et al's [2008] observations on the preference for crack propagation along the osteons, in the longitudinal direction.

The TID on the surgical cut [B] was 26%* lower than in the proximal cut [C]. Also, when testing around the neck (Figure 1, Right) the TID appeared higher in one of the anterior-posterior directions than the other (i.e. 2 > 4) by 42 to 70%*. The other three orientations (i.e. 1, 3 and 4) were similar though the lateral direction did appear higher (2 to 34%, ns) than the medial direction. These two findings imply a location of increased fragility, in the proximal neck and on the posterior-lateral or anterior-lateral side, though here it could not be identified which. (*$p < 0.05$, ns: $p > 0.05$).

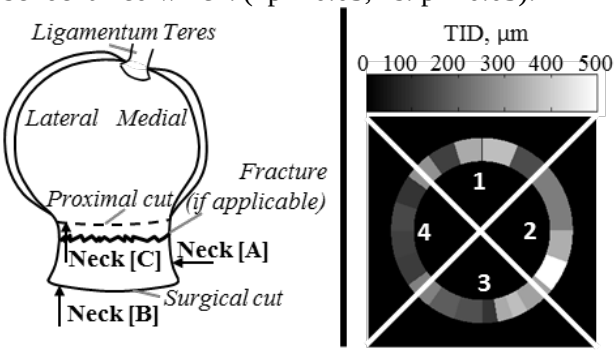

Figure 1: Left: RPI locations of the femoral necks, Right: 1) Medial, 2) and 4) Anterior–Posterior, 3) Lateral

Discussion

Though this study was limited by the small number of samples and the lack of patient information, some interesting effects were still noted. A preferred location and direction of fracture was proposed, based on reduced mechanical integrity, with further RPI around and proximally to distally along the femoral neck being needed to confirm this effect.

These finding support current evidence and give increased understanding into the mechanical properties and failure mechanics of the femoral neck. This is beyond that, which could be found with current clinical measures, supporting RPI as an investigative tool with clinical potential for increased understanding of bone's mechanical properties and fracture.

References

Diez-Perez *et al*, J Bone Miner Res, 25(8):1877-85, 2010. Gallant *et al*, Bone, *in press:*2013. Koester *et al*, Nat Materials, 7(8):672-677, 2008