Assessment of the Damage in Retrieved Patella Components

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Introduction: Patellofemoral complications are cited as a leading cause for the failure of total knee replacement (TKR). However, little work exists investigating the damage sustained to components in vivo. This study investigates damage in a series of 24 retrieved patella components by quantifying volume change, wear scar area and damage grading of the articulating surface topology.

Materials and Methods: A total of 24 TKR prostheses were retrieved during revision surgery or at post-mortem. Components comprised of two primary designs, dome (n=11) and conforming (n=13). Mean age of the patient sample at retrieval was 70.6 years (58.7-85 years). Male to female split was 50%. Mean weight and height was 80kg (56-106 kg) and 161cm (110-186 cm) respectively. Volume change of the patella button was calculated by measurement of the existing articulating surface form and comparison to an assumed virgin geometry reconstructed from unworn portions of the component. Measurements were taken using a coordinate measuring machine (CMM) and associated software, calibrated to the range of 1-3μm. Wear scar area was measured by identifying the worn area using a stereomicroscope and manually outlined with indelible ink. Calibrated images of the scar were then recorded using a flat bed scanner and analysed using Image ProPlus software. The overall accuracy and repeatability of the technique was 97% and 0.5% respectively. Damage grading analysis followed the method previously reported by Hood, et al. The articulating surface was divided into four quadrants. Each quadrant was visually inspected for seven different modes of damage (surface deformation, pitting, embedded PMMA debris, scratching burnishing, abrasion, delamination). Note that damage modes outline the visible surface morphology and not the mechanism by which they came to this state. The level of each mode within the quadrant was then quantified on a scale of 0-3. Definition of these grading bands is assessed by the means of extent and severity.

Results: Unfortunately the technique available for measurement of volume change was only applicable to round dome components with a cross-sectional radius of single curvature. This restricted the number of samples which could be analysed to two samples. The total volume change calculated was -9.77±0.28mm³ (mean (n=5) ± 95% CI) and -48.85±4.6mm³ (mean (n=5) ± 95% CI), equating to -1.3 and -45.16 mm³/year. A maximum penetration of -0.591mm was observed for sample 1 at 0° on the lateral region of the articular surface. The maximum penetration observed for sample 2 was -2.705mm, again occurring at 0° on the lateral region of the articular surface (Figure 1).

Figure 1: Wear penetration of the patella articulating surface.

In general the patella component wear scars spanned from medial to lateral with a slight bias towards the superior. Mean scar areas of 78.4±27.3mm² (mean (n=24) ± 95% CI), 92.4±24.9mm² (mean (n=24) ± 95% CI), 51.7±20.3mm² (mean (n=24) ± 95% CI) and 129.6±32.4mm² (mean (n=24) ± 95% CI) were recorded for the superior, medial, inferior and lateral quadrants respectively. The average total wear scar area was 364.3±64.7mm² (mean (n=24) ± 95% CI). No correlation between wear scar area variation and time in situ could be found, r²=0.002. Evidence of damage was present in all components examined. However application of the method developed by Hood et al (1) revealed the potential for misleading results. The total damage score reported for the samples shown in figure 2 was only 17 and 19 respectively. However, gross delamination to the point of wear through to the metal backing was visible in sample 3. Thus the damage score contradicts how any knowledgeable researcher would assess these samples. It is apparent that the scoring method does not account for the chronological progression of damage as later modes can eradicate prior modes. This has particular relevance to the delamination damage mode due to its destructive nature, but could also affect other modes.

Discussion: Volume changes of 1.3 and 45.16 mm³/year were observed for the two components analysed. To the author’s knowledge this is the first recorded estimation of patella creep during clinical usage. Critical analysis of this technique indicated that absolute volume calculated solely using reconstruction of the articulating surface was not accurate due to bulk deformation of the UHMWPE component. A method which considers the entire volume of the component and therefore includes effects of bulk deformation is required. The application of μCT is being investigated and may prove to viable solution. The average wear scar area spanned from M-L in a band and was 364.3±64.7mm² (mean (n=24) ± 95% CI). This was in close agreement to previous authors (2). Lack of consideration of the chronological progression of wear creates ambiguity over application of the method of Hood et al. (1) for grading damage. Further development of this method is required to relate grading to the progression and mechanisms of wear. Detailed studies of UHMWPE wear mechanisms and surface morphology are required to achieve this. It is a current misconception that surface morphology can be linked directly to wear mechanism. Whilst evidence does exist for some damage modes, the level of detail is not yet adequate for application in a damage grading system. Wear scar area was found to be the most consistent method to quantify in vivo damage of patella components. This finding is consistent with analysis of the tibiofemoral joint of TKR. However, a more detailed quantification of change in volume and damage sustained in vivo is required in order to fully assess the clinical performance of PFJ replacements. This will be the focus of future investigations.


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