

Using Large Femoral Head as A Bearing Surface in Total Hip Arthroplasty



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Background

Owing to recent improvements in the quality, shape and surface area of the implants for total hip arthroplasty, wear problems, which is one of the chronic complications of total hip arthroplasty, have been solved up to a certain level. However, instability and dislocation of the implants, which is the second most common complication after component loosening, remain unsolved, negatively affecting quality of life and furtherly causing failure of implants. Using femoral head implants smaller than the patient's natural femoral head is a major cause of dislocation. We would like to discuss several issues of using large head implants as a bearing surface.

Wear

Contact surface and sliding distance are major factors in the occurrence of wear particles. As the diameter of the femoral head increases, contact area and the sliding distance of the articular surface also increase. Though the degree of wear may differ by material, this increase also leads to increased volumetric wear, according to the formula $v = \pi \gamma^2 w$ (v , volume of debris from wear; γ , radius of the femoral head; w , linear migration distance of the femoral head). Grinding and adhesion between the femoral head and the acetabular cup is the main mechanism of wear after total hip arthroplasty. In terms of wear, the sliding distance and the repetition of sliding is more important than the load given to the hip joint [1-4]. In case of metal-on-polyethylene implants, volumetric wear increase about 7.5% to 10% for each 1mm increase in femoral head diameter [1]. Frictional torque, which increases proportionally to the femoral head size, is an important factor in the destruction of the contact area between the component and the bone, and in the loosening of the component [5-8]. However, if an articular surface is resistant to wear and enables stable fixation between the component and bone while being minimally affected by changes in femoral head size, using large head implants during total hip arthroplasty may be promising due to its high stability. Therefore, choosing articular surfaces which are highly resistant to wear is a key prerequisite for the use of femoral head implants larger than 36mm [9-10].

Dislocation

Hip joint dislocations are caused by 3 factors; patient-related, operative-related, and implant-related. Implant-related factors include femoral head size, head-to-neck ratio, head-to-metal shell size, and types of the inner liner [11-13]. Compared to small femoral heads, large femoral heads require longer distances of displacement to be dislocated, and thus is more stable. Other advantages of large femoral heads include [1] increased range of motion (ROM) in any direction, [2] decreased component-to-component impaction and while delayed bone-to-bone impingement, proper debridement of the bone causing impaction leads to increased joint motion [3] No need for the use of skirts, which are used with long-neck implants to increase stability of trunnion and femoral head socket area (due to relative increase in head-to-neck ration). For each 1mm increase in femoral head diameter, the ROM in any direction increases by 0.84 ± 0.43 degrees, and the peak moment which resists to dislocation increases by 3.6%. Compared to 32mm-diameter femoral heads, 38mm- and 42mm-diameter femoral heads show increase in ROM of 6% and 16% respectively.

Wear on Trunnion-bore Interface

Morse tapers achieve stability by the cone-in-cone principle, which is caused by compression between the trunnion and the femoral head socket wall. While intimate conical connection between the trunnion and the bore may enable firm contact, ingress and micromovement of the fluid may occur during cyclical mechanical loading due to preexisting microscopic gaps (crevice) on the matins surface of male and female cones. This may lead to disruption of the passive surface oxide layer and susceptibility to mechanically assisted crevice corrosion (MACC, tribocorrosion). Taper design, metal-alloy mismatch (Galvanic corrosion), implant positioning, joint loading magnitude, numbers of loading cycles, frictional torque at the bearing surface, patient and surgical factors (tissue interpositioning, failure to achieve initial engagement) are associated with the development and deterioration of MACC. Particulate debris

and metal ions are released through mechanical and corrosive mechanism, and may lead to several adverse tissue reactions, and in severe cases, may cause mechanical failure at the taper junction. The use of larger femoral heads increases frictional torque, and this results in additional stress at the taper junction, especially in metal-on-ceramic or ceramic-on-ceramic bearing surfaces, rather than metal-on-polyethylene or ceramic-on-polyethylene bearing surfaces. Also, increased offset between the head center and the trunnion interface center of pressure increases the bending moment, and leads to micromotion between male and female tapers, and may trigger trunnionosis-type wear. These reasons provide theoretical support for why the reactions which occur on metal-on-polyethylene bearing surfaces due to metal debris from the taper junction are similar with local adverse tissue reactions caused by metal particles from metal-on-metal bearing surfaces [14-20].

While the increase in femoral head size from 32mm to 36mm leads to 10% improvement in stability, the increase in femoral head size from 40mm to 48mm only leads to 4.7% improvement. This indicates that the increase of femoral head size beyond a certain level may not significantly influence on stability. On the other hand, the peak stress imposed on the trunnion during ambulation increases as the femoral head diameter increases. Compared to 32mm-diameter femoral heads, 40mm-, 44mm-, 48mm-, 52mm-, and 56mm-diameter femoral heads showed peak stress increment of 3.5%, 9.5%, 24%, 40%, and 51% respectively. Considering pros of stability and cons of trunnion-related problems, the use of femoral heads smaller than 40mm is recommended.

Conclusion

Femoral heads larger than 32mm in diameter offer multiple advantages in terms of both function and activity, including improved hip joint stability, decreased dislocation rate, and increased ROM. However, various concerns, including wear generation at the trunnion-bore interface and increased component-bone interface stress due to additional frictional torque, should always be considered when using large femoral head implants. Considering the benefits in stability and trunnion-related problems, femoral heads smaller than 40mm are recommended to be used for total hip arthroplasty.

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