Large diameter heads

IS BIGGER ALWAYS BETTER?

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Large femoral heads have been used with increasing frequency over the last decade. The prime reason is likely the effect of large heads on stability. The larger head neck ratio, combined with the increased jump distance of larger heads result in a greater arc of impingement free motion, and greater resistance to dislocation in a provocative position. Multiple studies have demonstrated clear clinical efficacy in diminishing dislocation rates with the use of large femoral heads. With crosslinked polyethylene, wear has been shown to be equivalent between larger and smaller heads. However, the stability advantages of increasing diameter beyond 38 mm have not been clearly demonstrated. More importantly, recent data implicates large heads in the increasing prevalence of groin pain and psoas impingement. There are clear benefits with larger femoral head diameters, but the advantages of diameters beyond 38 mm have not yet been demonstrated clinically.

Dislocation continues to be a significant issue after primary and revision total hip arthroplasty (THA). The incidence reported ranges from less than 1% to 5%, with a study on Medicare patients demonstrating a 3.9% dislocation rate within 26 weeks post-operatively after elective THA.[1] Although dislocation is a multifactorial problem, it is well accepted that stability of THA improves with a larger sized femoral head. With an increase in femoral head size, there is a corresponding increase in the head-neck ratio, the range of motion (ROM) before which impingement occurs and the amount of displacement required before the head dislocates (jump distance). The empirical desire to improve stability in THA has translated into an increasing use of large diameter femoral heads over the last decade. This enthusiasm has however been tempered historically with concerns of large heads on wear. The development of hard/hard couples and highly cross-linked polyethylene, thus mitigating the wear issue, has renewed interest in the use of large heads. The aim of this paper is to review the current understanding of the biomechanics of increasing femoral head size in relation to stability and ROM, dislocation and wear rates in clinical studies, and concerns reported in literature.

Biomechanics of large heads: how big can we get?

Crowinshield et al[2] analysed joint stability in a finite element model as a function of femoral head size and acetabular component orientation. They assessed prosthetic impingement free ROM and the degree of vertical head displacement required for dislocation under varying circumstances of femoral head size and cup abduction angles. They demonstrated an almost linear increase in the prosthetic impingement free ROM with an increase in femoral head diameter from 22 mm to 40 mm. Similarly, there was a considerable rise in the displacement required for dislocation, about 5 mm at 45° abduction, going from 22 mm to 40 mm. However, it was substantially dependent on the acetabular cup orientation and decreased as abduction angle increased from 0° to 90°. More importantly, they predicted an increase in the tensile stress at the periphery of the polyethylene with increased verticality of the component, which was further aggravated by increasing the femoral head size. Also, with highly abducted components, femoral head subluxation occurs independent of head size. This can contribute to increased fracture potential, material deformation and instability. Rim cracking of cross-linked polyethylene in such an environment has been reported.[3]

Burroughs et al[4] analysed ROM and stability with varying femoral head sizes in a three-dimensional hip simulator type of model. They found an increase in impingement free ROM with increasing femoral head size from 22 mm to 38 mm. However, there was no significant benefit in terms of prosthetic impingement going from 38 mm to 44 mm. An additional known finding was that skirts on the femoral head predisposed to impingement. They also

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reported continued benefit in maximum displacement prior to dislocation with increasing head size as long as cup abduction was less than 45°.

Do large heads affect dislocations clinically?

There is increasing data to suggest that large femoral head sizes reduce dislocation rates clinically. Jameson et al[4] in a five year analysis of National Health Service patients in England and Wales reported a statistically significant increase in the use of femoral heads of size 36 mm and greater (from 5% in 2005 to 26% in 2009) along with increase in the use of the posterior approach. They found a significant drop in cumulative dislocations in the same period at three months (1.12% to 0.86%), six months (1.25% to 0.96%) and 12 months (1.42% to 1.11%) and at 18 months (1.56% to 1.31%) between 2005 and 2008. In a study of patients undergoing primary THA with head sizes of 36 mm or greater, Lombardi et al[5] reported a dislocation rate of 0.05%, significantly lower than a previous study utilizing head sizes less than 36 mm (0.8%). Importantly, this benefit of decreasing the dislocation rate was also noted in the low dislocation environment of THAs performed via the direct lateral and anterior approaches. A recent prospective, randomized study comparing dislocation rates between revision THAs performed using 36 mm and 40 mm heads with those performed with a 32 mm head reported dislocation rate of 1.1% with 36 mm/40mm heads and 8.7% with a 32 mm head.[6] The study was prematurely terminated in light of these glaring findings.

On the other hand, Amstutz et al[7] in a series of revision THAs demonstrated a recurrent dislocation rate of 13.7% with the use of large femoral heads (> 36 mm). All cases with recurrent instability had poor acetabular cup orientation highlighting the fact that there are other mitigating factors that can lead to dislocation.

Wear performance of large heads: where do they stand?. One of the principles of Charnley's low friction arthroplasty includes use of a smaller diameter (22 mm) head for decreasing polyethylene wear. Sliding distance, velocity and counterface roughness of an articulation affects its wear properties. Large heads increase both the sliding distance and the velocity between articulating surfaces, thus increasing wear. Reduced thickness of the polyethylene with increasing head size also predisposes to early failure. It can also result in increased stress within the material predisposing it to mechanical degradation. Hence, there is a limit to the maximum head size that can be achieved with a given acetabular diameter. Highly cross-linked polyethylene has been promoted to counter these limitations of conventional polyethylene, allowing increased head size. There are limited clinical studies involving large cobalt chrome heads and highly cross-linked polyethylene. Lachiwiecz et al[8] evaluated 90 patients with one type of electron beam irradiated highly cross-linked polyethylene with a minimum follow-up of five years (mean 5.7 (5 to 8)). Mean linear, volumetric wear rate and mean total volumetric wear were adjusted for age, gender, body mass index, femoral component fixation method, activity component of hip score to study the influence of femoral head size. There was no association between femoral head size and the linear wear rate, but there was an association between larger (36 mm and 40 mm) head size with volumetric wear rate and total volumetric wear.

Hammerberg et al[9] studied 94 patients who underwent primary THA with highly cross linked polyethylene and different head sizes. There was no statistical difference in linear wear rates and annual or total penetration rates when 28 mm and 32 mm heads were compared with 38 mm and 44 mm heads. Volumetric wear was higher with bigger heads. They also did not find any differences in range of motion between the two groups.

Other concerns with large femoral heads

The femoral head acts as a major pulley for the action of the psoas major muscle near the hip joint region. A cadaveric study[10] analysing the function and kinematics of psoas major muscle noted that the pressure on the femoral head and tension on the muscle is greatest from 0° to 30° of flexion. This gives the anatomical basis for possible groin pain in patients with large femoral head THA and hip resurfacing. Not only can a socket which is prominent anteriorly cause psoas impingement, but even a large head can cause significant irritation. Bartelt et al[11] reported that the rate of groin pain was 15% after large head metal on metal THA and 18% after total hip resurfacing, much higher than 7% noted with conventional bearing THA at a minimum of 1 year follow-up. The incidence was higher in younger patients and potential factors perceived were psoas impingement and higher activity levels. Similarly, a study involving 116 patients who underwent hip resurfacing with a mean follow-up of 26 months (12 to 61) reported an 18% incidence of groin pain.[12] In 10% patients, activities of daily living were affected, and similar number of patients required pain medication.[13]

Large diameter heads are difficult to reduce during surgery as a larger distance needs to be covered before reduction. This can be of concern, especially with minimally invasive surgeries. The use of higher pulling forces may lead to surface damage of hard bearing surfaces during slippage of the head over the edge of the cup.

Moving ahead: use of the tripolar cup

A dual mobility acetabular component consists of a large, porous coated acetabular component and a bipolar component. There are two articular interfaces, a large polyethylene surface directly opposed to the highly polished metal shell and a standard size femoral head (28 mm or 32 mm) captured within the polyethylene. This concept offers the advantage of greater ROM and improved stability. Clinical studies have demonstrated a lower dislocation rate with this implant in primary[14,15] and revision THA.[16] Issues related to reproducibility of implant fixation and intra-prosthetic dislocation seem to have been reduced with design modifications from the original concept.[17] The use of cross-linked polyethylene can reduce the clinical effects of long-term wear. However, groin pain due to psoas impingement could be a potential issue with this type of design, similar to large head conventional THA and hip resurfacing. Further long-term clinical studies are needed to completely evaluate the outcome of these new-generation dual mobility cups.

Conclusion

Large diameter femoral heads clearly offer advantages in terms of stability with reduction in dislocation rates as demonstrated in clinical studies. However, acetabular component position is a crucial factor in stability. Clinical studies have not demonstrated any benefit of heads larger than 38 mm or 40 mm size in terms of stability and range of motion. With the advent of highly cross-linked polyethylene, wear does not seem to be a major concern, at least in the short-to-midterm follow-up, although longer follow-up is needed. A higher incidence of groin pain is a definite concern with use of large head THA. Dual mobility cups have been associated with lower rates of dislocation. Clinical studies of newer designs of this concept are awaited.

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