■ HIP TECHNOLOGIES

Large diameter femoral heads

IS BIGGER ALWAYS BETTER?

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Dislocation remains among the most common complications of, and reasons for, revision of both primary and revision total hip replacements (THR). Hence, there is great interest in maximising stability to prevent this complication. Head size has been recognised to have a strong influence on the risk of dislocation post-operatively. As femoral head size increases, stability is augmented, secondary to an increase in impingement-free range of movement. Larger head sizes also greatly increase the 'jump distance' required for the head to dislocate in an appropriately positioned cup. Level-one studies support the use of larger diameter heads as they decrease the risk of dislocation following primary and revision THR. Highly cross-linked polyethylene has allowed us to increase femoral head size, without a marked increase in wear. However, the thin polyethylene liners necessary to accommodate larger heads may increase the risk of liner fracture and larger heads have also been implicated in causing soft-tissue impingement resulting in groin pain. Larger diameter heads also impart larger forces on the femoral trunnion, which may contribute to corrosion, metal release, and adverse local tissue reactions. Alternative large bearings including large ceramic heads and dual mobility bearings may mitigate some of these risks, and several of these devices have been used with clinical success.

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Large femoral heads, as defined as those bearings of 36 mm and larger, are being used with increasing frequency in modern total hip replacement (THR). The National Joint Registry for England and Wales reported a significant increase in the use of large heads from 5% in 2005 to 26% in 2009,[1] which had increased to 31% by 2012.[2] Similarly, in the United States, less than 1% of all primary THR heads used in 2001 were larger than 32 mm, compared with 58% in 2009.[3] As these devices are being increasingly used in both primary and revision THR, it is important to understand their potential benefits and limitations.

Benefits of larger femoral heads

Large diameter bearings have gained popularity because they are assumed to reduce the likelihood of dislocation. Many studies have demonstrated that post-operative instability is the single most common reason for failure following both primary[4,5] and revision THR.[6] Accordingly, maximising stability is a critical concern for all surgeons who perform these procedures, particularly in patients with risk factors for instability such as female gender, advanced age, neuromuscular or cognitive disorders, substance abuse, soft-tissue deficits about the hip, and previous hip surgery.[7]

Larger heads increase impingement-free range of movement[8] and have the ability to offer longer neck options. These two factors together decrease component-to-component impingement, although bony impingement can still occur.[9,10] An increase in the jump distance, which is the amount of room the femoral head has to travel out of the socket for it to dislocate,[11] may be the most important reason for improved stability. However, this improved jump distance is dependent on a well-positioned acetabular component,[12] which emphasises the importance of surgical technique in maximising stability. Cinotti et al[9] explored the effect that increasing head size has on impingement in both optimally and non-optimally positioned acetabular components, and found limited benefits to increasing head size beyond 32 mm.

The potential benefits of large femoral heads have been recognised and appreciated for years, but there have been two recent randomised clinical studies offering level-one evidence that clearly support the use of larger diameter bearings. An international study

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randomised 644 patients to receive either a 28 mm or 36 mm bearing, and demonstrated a significantly lower dislocation rate at one year for the large diameter group (0.8%) compared with the small diameter group (4.4%), while also demonstrating a strong trend in the sub-group of patients undergoing revision THR (12.2% *vs* 4.9%, respectively).[13] A second study, performed as a multi-center clinical trial of patients undergoing revision THR, randomised patients to receive 32 mm *versus* 36 mm or 40 mm heads; the larger head group demonstrated a significantly lower rate of instability (1.1%) compared with the small head group (8.7%) at a mean of five years after operation.[14] This difference was so significant that the trial was halted early because statistical significance had already been reached.

Limitations of large diameter bearings

Large femoral heads clearly decrease the risk of instability. However, they may have potential downsides that should be understood before using these bearings.

While wear-simulator studies have suggested that larger diameter heads can cause higher volumetric wear of the polyethylene liner,[15] the marked reduction in wear accompanying the introduction of highly cross-linked polyethylene nearly a decade and a half ago has diminished this concern.[16,17]

Assuming the outer diameter of the acetabular shell is kept the same, larger diameter bearings require accordingly thinner polyethylene liners. There have been sporadic case reports of liner fractures in patients with highly cross-linked polyethylene bearings,[18-20] which have caused some degree of concern. Based on the small number of case reports in relation to the large number of THR procedures being performed, this does not seem to be a prevalent clinical problem and have generally been described only in the setting of malpositioned components or suboptimal component designs that have since been improved.

A recent issue that has received significant attention is the potential for corrosion and metal release from the head-neck taper junction leading to adverse local tissue reaction (ALTR) in the periprosthetic soft-tissues.[21] There is a worry that larger heads generate larger frictional torques and larger bending moments on the femoral trunnion and can contribute to corrosion at this junction.[22] This has been demonstrated in a recent retrieval analysis,[23] which had higher corrosion scores in patients with a 36 mm bearing compared with those with a 28 mm bearing. However, increasing head size has not yet been directly shown to have an effect on the incidence of ALTR in patients with metal-on-polyethylene THR. Indeed, taper corrosion is a multi-factorial problem that depends on taper geometry, material compositions of the head and trunnion, surface finish, assembly conditions, and frictional torque at the bearing surface, and as a result cannot be explained solely by the use of large femoral heads.

The majority of cases of ALTR secondary to corrosion that have been reported to date in association with metal-on-polyethylene bearings are in patients with smaller (28 mm or 32 mm) femoral heads, which lends credence to factors other than head size playing a larger role in the development of ALTR.[24]

Large diameter femoral heads have also been linked to an increased likelihood of anterior hip and groin pain, which is thought to be related to anterior soft-tissue impingement, most commonly against the iliopsoas muscle or tendon.[25-27] One recent study demonstrated that large-diameter bearings were associated with a significantly higher rate of groin pain (15% to 18% *vs* 7%) compared with conventional implants.[25] Although this condition can often be overlooked in outcome studies because it is not sufficiently symptomatic enough to lead to revision THR; anterior hip pain from large femoral heads can affect the quality of life of patients, and should not be ignored.

Recently, so-called 'anatomically-contoured heads' have been introduced with the proposed benefit of decreasing this anterior soft-tissue impingement in large diameter THR.[28,29] While these were designed to have no impact on resistance to dislocation or wear performance,[28] it remains to be seen whether these relatively small changes in head shape will improve clinical outcomes and reduce groin pain.

Novel large diameter bearings

While large head metal-on-metal (MoM) bearing use in THR eliminates concerns over polyethylene wear and polyethylene liner fracture, national joint registries have shown significantly higher failure rates for large-head MoMTHR[2,30] and the use of these devices has been largely abandoned.

Ceramic heads, which are currently available in sizes up to 48 mm,[31] offer an alternative large diameter bearing where the surgeon may wish to avoid a large metal head.[32] Ceramic-on-ceramic bearings have extremely low wear rates making them an attractive alternative although some concern has been raised that ceramic-on-ceramic bearings may be predisposed to acoustical phenomena or 'squeaking',[33] which may be more prevalent in larger-diameter bearings.[34] Ceramic heads may also be associated with lower wear rates when paired against a polyethylene liner. While this has been well-established in wear-simulator studies,[35,36] recent clinical studies have begun to demonstrate clinical differences as longer follow-up has become available.[37]

In addition to potential wear improvements, ceramic heads also reduce the risk of modular taper corrosion at the head-neck junction. Retrieval studies have shown the risk of corrosion is not completely eliminated,[38,39] however, the degree of metal release from these junctions is substantially lower when compared with metal heads,[40] lending credibility to the idea that ceramic heads are protective against ALTR.

Dual mobility bearings, which were developed in France in 1974 and have long-term follow-up in European studies, offer another alternative large-diameter bearing.[41-43] While there have been concerns regarding polyethylene wear and intra-prosthetic dislocations with early designs, long-term outcomes for second generation devices have been more promising. These bearings have been demonstrated to be safe, effective, and durable, and are associated with very low rates of instability.[41-43] However, until longer-term clinical results of the second generation devices are available across cohorts that include younger and more active patients, these bearings should continue to be used judiciously.

Conclusions

Large femoral heads are very effective at reducing the risk of post-operative instability following THR. Their utility in decreasing instability in revision THR has been illustrated.

When selecting the appropriate bearing size in patients without specific risk factors for instability, the surgeon must balance the risks of instability with those inherent in large femoral heads, and individualise the choice of bearing size that is in the best overall interest of the patient. Alternative bearing designs such as large ceramic heads, dual mobility bearings, and anatomically contoured heads are in various stages of investigation and use, and may allow large femoral heads to be more widely used by minimising potential risks.

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References

1. **Jameson SS, Lees D, James P, et al.** Lower rates of dislocation with increased femoral head size after primary total hip replacement: a five-year analysis of NHS patients in England. *J Bone Joint Surg [Br]* 2011;93-B:876–880.
2. **No authors listed.** National Joint Registry: 10th Annual Report, National Joint Registry for England, Wales and Northern Ireland, 2013. http://www.njrcentre.org.uk/njrcentre/Portals/0/Documents/England/Reports/10th_annual_report/NJR%2010th%20Annual%20Report%202013%20B.pdf (date last accessed 26 June 2014).
3. **Bozic KJ.** Femoral and acetabular component utilization in the United States [abstract]. 39th open meeting of the Hip Society, California, 2011 http://www.hipsoc.org/web/2011%20WM%20Final%20Program.pdf (date last accessed 30 July 2014).
4. **Dobzyniak M, Fehring TK, Odum S.** Early failure in total hip arthroplasty. *Clin Orthop Relat Res* 2006;447:76–78.
5. **Bozic KJ, Kurtz SM, Lau E, et al.** The epidemiology of revision total hip arthroplasty in the United States. *J Bone Joint Surg [Am]* 2009;91-A:128–133.
6. **Springer BD, Fehring TK, Griffin WL, Odum SM, Masonis JL.** Why revision total hip arthroplasty fails. *Clin Orthop Relat Res* 2009;467:166–173.
7. **Werner BC, Brown TE.** Intability after total hip arthroplasty. *World J Orthop* 2012;3:122–130.
8. **Bartz RL, Nobel PC, Kadakia NR, Tullos HS.** The effect of femoral component head size on posterior dislocation of the artificial hip joint. *J Bone Joint Surg [Am]* 2000;82-A:1300–1307.
9. **Cinotti G, Lucioli N, Malagoli A, Calderoli C, Cassese F.** Do large femoral heads reduce the risks of impingement in total hip arthroplasty with optimal and non-optimal cup positioning? *Int Orthop* 2011;35:317–323.
10. **Elkins JM, Pedersen DR, Callaghan JJ, Brown TD.** Bone-on-bone versus hardware impingement in total hips: a biomechanical study. *Iowa Orthop J* 2012;32:17–21.
11. **Burroughs BR, Hallstrom B, Golladay GJ, Hoeffel D, Harris WH.** Range of motion and stability in total hip arthroplasty with 28-, 32-, 38-, and 44-mm femoral head sizes. *J Arthroplasty* 2005;20:11–19.
12. **Sariali E, Lazennec JY, Khiami F, Catonné Y.** Mathematical evaluation of jumping distance in total hip arthroplasty: influence of abduction angle, femoral head offset, and head diameter. *Acta Orthop* 2009;80:277–282.
13. **Howie DW, Holubowycz OT, Middleton R; Large Articulation Study Group.** Large femoral heads decrease the incidence of dislocation after total hip arthroplasty: a randomized controlled trial. *J Bone Joint Surg [Am]* 2012;94-A:1095–1102.
14. **Garbuz DS, Masri BA, Duncan CP, et al.** The Frank Stinchfield Award: Dislocation in revision THA: do large heads (36 and 40 mm) result in reduced dislocation rates in a randomized clinical trial? *Clin Orthop Relat Res* 2012;470:351–356.
15. **Livermore J, Ilstrup D, Morrey B.** Effect of femoral head size on wear of the polyethylene acetabular component. *J Bone Joint Surg [Am]* 1990;72-A:518–528.
16. **Muratoglu OK, Bragdon CR, O'Connor D, et al.** Larger diameter femoral heads used in conjunction with a highly cross-linked ultra-high molecular weight polyethylene: a new concept. *J Arthroplasty* 2001;16(8Suppl1):24–30.
17. **Estok DM 2nd, Burroughs BR, Muratoglu OK, Harris WH.** Comparison of hip simulator wear of 2 different highly cross-linked ultra high molecular weight polyethylene acetabular components using both 32- and 38-mm femoral heads. *J Arthroplasty* 2007;22:581–589.
18. **Blumenfeld TJ, McKellop HA, Schmalzried TP, Billi F.** Fracture of a cross-linked polyethylene liner: a multifactorial issue. *J Arthroplasty* 2011;26:666–665.
19. **Duffy GP, Wannomae KK, Rowell SL, Muratoglu OK.** Fracture of a cross-linked polyethylene liner due to impingement. *J Arthroplasty* 2009;24:158–115.
20. **Moore KD, Beck PR, Petersen DW, et al.** Early failure of a cross-linked polyethylene acetabular liner. A case report. *J Bone Joint Surg [Am]* 2008;90-A:2499–2504.
21. **Cooper HJ, Della Valle CJ, Berger RA, et al.** Corrosion at the head-neck taper as a cause for adverse local tissue reactions after total hip arthroplasty. *J Bone Joint Surg [Am]* 2012;94-A:1655–1661.
22. **Toni A, Baleani M, Bordini B, et al.** "Trunionitis": A cause for concern? *Semin Arthroplasty* 2012;23:248–250.
23. **Dyrkacz RM, Brandt JM, Ojo OA, Turgeon TR, Wyss UP.** The influence of head size on corrosion and fretting behaviour at the head-neck interface of artificial hip joints. *J Arthroplasty* 2013;28:1036–1040.
24. **Cooper HJ, Della Valle CJ, Jacobs JJ.** Biologic implications of taper corrosion in total hip arthroplasty. *Semin Arthroplasty* 2012; 23:273–278.
25. **Bartelt RB, Yuan BJ, Trousdale RT, Sierra RJ.** The prevalence of groin pain after metal-on-metal total hip arthroplasty and total hip resurfacing. *Clin Orthop Relat Res* 2010;468:2346–2356.
26. **Baumgarten KM, McKenzie MJ.** Iliopsoas impingement after total hip arthroplasty ising a large diameter femoral head. *J Bone Joint Surg Case Connector* 2012;2:221–225.
27. **Browne JA, Polga DJ, Sierra RJ, Trousdale RT, Cabanela ME.** Failure of larger-diameter metal-on-metal total hip arthroplasty resulting from anterior iliopsoas impingement. *J Arthroplasty* 2011;26:978–975.
28. **Varadarajan KM, Duffy MP, Zumbrunn T, et al.** Next-generation soft-tissue-friendly large-diameter femoral head. *Semin Arthroplasty* 2013; 24:211–217.
29. **Varadarajan KM, Duffy MP, Zumbrunn T, et al.** A new anatomically contoured large diameter femoral head to alleviate soft-tissue impingement in hip arthroplasty. *Bone Joint J* 2013;95-B(34 Suppl):408.
30. **No authors listed.** Australian Orthopaedic Association National Joint Replacement Registry: Annual Report, 2013. https://aoanjrr.dmac.adelaide.edu.au (date last accessed 30 June 2014).
31. **McDonnell SM, Boyce G, Baré J, Young D, Shimmin AJ.** The incidence of noise generation arising from the large-diameter Delta Motion ceramic total hip bearing. *Bone Joint J* 2013;95-B:160–165.
32. **Galvin AL, Jennings LM, Tipper JL, Ingham E, Fisher J.** Wear and creep of highly crosslinked polyethylene against cobalt chrome and ceramic femoral heads. *Proc Inst Mech Eng H* 2010;224:1175–1183.
33. **Jarrett CA, Ranawat AS, Bruzzone M, et al.** The squeaking hip: a phenomenon of ceramic-on-ceramic total hip arthroplasty. *J Bone Joint Surg [Am]* 2009;91-A:1344–1349.
34. **Choi IY, Kim YS, Hwang KT, Kim YH.** Incidence and factors associated with squeaking in alumina-on-alumina THA. *Clin Orthop Relat Res* 2010;468:3234–3239.

35. **Rodriguez JA, Cooper HJ.** Large ceramic femoral heads: what problems do they solve? *Bone Joint J* 2013;95-B(11SupplA):63–66.

36. **Meftah M, Klingenstein GG, Yun RJ, Ranawat AS, Ranawat CS.** Long-term performance of ceramic and metal femoral heads on conventional polyethylene in young and active patients: a matched-pair analysis. *J Bone Joint Surg [Am]* 2013;95-A:1193–1197.

37. **Meftah M, Klingenstein GG, Yun RJ, Ranawat AS, Ranawat CS.** Long-term performance of ceramic and metal femoral heads on conventional polyethylene in young and active patients: a matched-pair analysis. *J Bone Joint Surg [Am]* 2013;95-A:1193–1197.

38. **Kurtz SM, Kocagöz SB, Hanzlik JA, et al.** Do ceramic femoral heads reduce taper fretting corrosion in hip arthroplasty? A retrieval study. *Clin Orthop Relat Res* 2013;471:3270–3282.

39. **Cooper HJ, Urban RM, Wixson RL, Meneghini RM, Jacobs JJ.** Adverse local tissue reaction arising from corrosion at the femoral neck-body junction in a dual-taper stem with a cobalt-chromium modular neck. *J Bone Joint Surg [Am]* 2013;95-A:865–872.

40. **Hallab NJ, Messina C, Skipor A, Jacobs JJ.** Differences in the fretting corrosion of metal-metal and ceramic-metal modular junctions of total hip replacements. *J Orthop Res* 2004;22:250–259.

41. **Stulberg SD.** Dual poly liner mobility optimizes wear and stability in THA: affirms. *Orthopedics* 2011;34:445–448.

42. **Epinette JA, Béracassat R, Tracol P, Pagazani G, Vandenbussche E.** Are modern dual mobility cups a valuable option in reducing instability after primary hip arthroplasty, even in younger patients? *J Arthroplasty* 2014;29:1323–1328.

43. **Plummer DR, Haughom BD, Della Valle CJ.** Dual mobility in total hip arthroplasty. *Orthop Clin North Am* 2014;45:1–8.