Dual Mobility in Total Hip Arthroplasty

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KEYWORDS

• Dual-mobility • Total hip arthroplasty • Revision total hip arthroplasty • Dislocation

KEY POINTS

- Instability continues to be among the most common complications and reasons for revision of a total hip arthroplasty (THA) in North America.
- There is increasing interest in dual-mobility bearings as an alternative to standard articulations, as they are associated with a low risk of instability following both primary and revision THA and may serve as an alternative to traditional solutions for instability including large diameter heads and constrained liners.
- The 2 primary concerns with dual-mobility cups remain wear and intraprosthetic dislocation (IPD).
- IPD is a unique complication reported with dual-mobility implants, and further research is essential to clearly delineate the underlying mechanism of failure to adequately address this complication.
- Concern for increased wear over time and limited data on long-term survivorship in younger patients are concerns as the usage of these implants increases in North America.

INTRODUCTION

Total hip arthroplasty (THA) is one of the most successful and cost-effective procedures in orthopedics.[1,2] It effectively treats pain, improves function, and improves quality of life in patients with end-stage arthritis of the hip.[3] Instability, however, remains a persistent problem, and both the most common cause for revision of a THA and one of the most common complications seen postoperatively resulting in patient morbidity as well as substantial expense.[4] Numerous prosthetic options and surgical approaches have been attempted to both prevent and treat instability, including alternative approaches to the hip, capsular repair, larger femoral heads, and in some cases constrained liners. By virtue of their dual articulation, large jump distance and greater range of motion until impingement occurs, dual-mobility articulations are an attractive option to both prevent and treat instability.

HISTORY OF DUAL MOBILITY

Although dual-mobility articulations are relatively new to the US market, variations on the concept have been used clinically in Europe for more than 35 years. Bousquet developed the first model in the early 1970s in an effort to reduce the incidence of dislocations following primary THA. His development of the dual-mobility articulation is thought to blend the advantages of several attractive

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design options. Not only did the original dual-mobility design take advantage of the inherent stability imparted by a larger femoral head as originally proposed by McKee,[4] it also utilized the low-friction arthroplasty concept as described by John Charnley.[5] Bousquet's dual-mobility design incorporated a cementless metallic acetabular shell and a mobile polyethylene liner component that positively captured a larger prosthetic femoral head, allowing for greater range of motion within the socket and a low risk of dislocation when used for primary and revision THA as well as in the treatment of femoral neck fractures, a patient subset that is notorious for a high risk of instability.[6]

The evolution of Bousquet's innovative design has led to numerous modifications, including those aimed to improve cup fixation, decrease polyethylene wear, and decrease the rates of intraprosthetic and complete dislocation, including alterations to the fixation surfaces and both the cup configuration and mating femoral neck design. First-generation dual-mobility cups relied upon press-fit fixation consisting of 2 pegs that were driven into the pubis and ischium, as well as a screw in the dome combined with an alumina coating sintered onto a nonporous surface. The result of this design resulted in high rates of delamination, third body wear, and loosening.[7,8] Subsequent generations of the dual mobility design no longer utilize an alumina coating, but rather use a dual layer coating of hydroxyapatite and titanium plasma spray to create a more 3-dimensional surface for osseointegration. Additionally, modifications have included changing the shape of the cup to decrease anterior overhang, which may both improve press-fit fixation and prevent iliopsoas tendon irritation.[9] Modifications to the femoral neck have focused on decreasing impingement around the introitus of the mobile polyethylene insert via a highly polished surface and a thin femoral neck. In general, the use of skirted femoral heads is also avoided in an effort to prevent impingement and subsequent intraprosthetic dislocation (IPD). Modifications to the liner have included the introduction of highly cross-linked polyethylene in an effort to decrease wear.[10,11] These modifications and design innovations have effectively resulted in decreased dislocation rates and improved cup survival. The survivorship rates published suggest little or no excess wear associated with dual-mobility implants.[6,12–14]

BIOMECHANICS OF DUAL MOBILITY

Dual-mobility designs incorporate 2 distinct articulations: the first between the femoral head and the polyethylene liner, and the second at the interface between the convex surface of the polyethylene liner and the acetabular shell. The primary articulation is between the femoral head and the polyethylene liner and is engaged during the majority of activities with normal range-of-motion requirements. The secondary articulation, between the polyethylene liner and the acetabular shell, is engaged during activities that exceed normal range of motion, when the neck of the femoral stem contacts the rim of the liner. These 2 articulations allow for greater range of motion, a greater head-to-neck ratio, and a more physiologic effective head size that increases the jump distance and hence resistance to dislocation. Laboratory studies have shown increased range of motion with dual-mobility versus traditional implants. Additionally, a greater distance-to-impingement imparted by the dual articulations has been correlated with decreased impingement and subsequent dislocations.[15,16] Guyen and colleagues[15] experimentally evaluated the range of motion to impingement of dual-mobility implants with 22.2 mm and 28 mm femoral head sizes. The authors found increased range of motion with the dual-mobility implants compared with standard implants, reporting increased flexion of 30.5°, adduction of 15.4°, and external rotation of 22.4° in the dual-mobility implants.[15]

NORTH AMERICAN EXPERIENCE

Only recently has the use of dual-mobility components gained popularity in the United States, with several designs now commercially available following the US Food and Drug Administration (FDA) approval of the first design in 2009. Although several of these designs are ones that have prior experience in Europe, newer designs for the US market include acetabular components with cobalt alloy counter bearings (as opposed to stainless steel as is used widely in Europe), titanium fixation surfaces, and cross-linked polyethylenes.

The Active Articulation E1 dual-mobility hip system (Biomet, Warsaw, Indiana) (**Fig. 1**) includes a cementless cup with a high carbon cobalt chrome molybdenum alloy bearing surface and titanium porous plasma spray coating. The polyethylene liner is highly cross-linked and infused with vitamin E, which potentially prevents oxidative degeneration and increases strength.[17] Although simulated wear studies conducted by the manufacturer suggest a significant reduction in polyethylene wear is achieved with the vitamin E-infused polyethylene, bearing retrieval analysis and clinical studies are still necessary to validate these claims.