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The dual mobility liner: Is it ready for prime time?

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ABSTRACT

Hip instability remains a pressing complication in primary and particularly revision hip arthroplasty. Dual mobility liners were introduced to combat this very issue in the mid 1970s. Initial concerns with the first generation technology concerning wear and intra-prosthetic dislocation has led to improvements in its development. Second generation technology has since been utilized and long-term studies have provided encouraging results. Dual mobility liners are very powerful, but not end all, solution to the issue of post-operative hip instability and can be a powerful tool when used.

1. Introduction

Hip instability remains an ongoing issue in hip arthroplasty with rates ranging between 1.7% and 3.9% in primaries [1] and up to a 28% incidence in revision surgery [2]. Instability plays a major role for not only patient and surgeon satisfaction, but also has significance on readmission rates [3] and therefore, financial burden to the healthcare system [3,4]. DeMartino et al. [3] reported that approximately one-third of readmissions following revision total hip arthroplasty are instability related. Another study demonstrated that THA cost increased by 27% when simply a closed reduction was required for dislocation and 148% when revision surgery was required [4]. Total hip arthroplasty demand is projected in the United States alone to increase 174% and revision hip arthroplasty by 137% from 2005 to 2030, given the increased life expectancy, aging baby boomer population, and increasingly active patients [5]. The cost burden will also continue to rise, highlighting the need for improvements in techniques and/or technologies.

The unstable hip, in the setting of well-placed components renders revision total hip arthroplasty difficult and unpredictable. Although improvements have been made in terms of materials and head size and offset optimization, the need for continued progress remains. Implant options to minimize dislocation can be accompanied by increased volumetric wear, from the use of a larger head, or decreased range of motion along with significant stress on the implant/bone interface from a constrained liner. In 1975, the dual mobility liner concept was patented by Professor Gilles Bousquet and Andre Rambert to combat the issue of instability and provide an alternative [6]. This concept combined a dual articulating polyethylene surface with the hypothesis of decreasing dislocation risk due to its increased outer diameter polyethylene head size and minimizing wear properties due to its smaller inner head size.

2. Early concerns

The dual mobility liner is a relatively new tool to the United States, only receiving FDA approval in 2009 [3]. With the design and implementation of dual mobility liners, the main concerns of usage include wear rate, given the multiple surfaces on both the concave and convex

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sides, and intra-prosthetic dislocation. The latter, which is a unique complication to this technology, requires revision surgery.

3. Long-term data

A concern with broadly implementing any new technology in orthopaedics is a lack of long-term results, as short-term data can appear promising with long-term catastrophic results. While the dual mobility liner is fairly new to the United States, there is substantial long-term follow-up in the European literature where it has been utilized for over 20 years in both revision and primary hips. France, in particular, has implemented this in up to 30% of all THA's [7,8]. The longest follow-up to date is very promising in relation to the problem it was designed to address, instability. A 22-year follow-up data from Boyer et al. [9] ($n = 240$) showed no dislocations, 10 (4.1%) intra-prosthetic dislocations, and an overall 73.9% global survival rate. Interestingly, patients less than 50 years old showed statistically significant increased rates of aseptic loosening [9 (13%)], intra-prosthetic dislocations [8 (11.6%)], and excessive liner wear [3 (4.3%)], likely due to higher activity levels and thus higher stress/wear rates. These results were despite the infancy/drawbacks of the technology in the first generation dual mobility liner/cup, which have since been improved upon.

4. Wear/material studies

Although the Boyer et al. [9] study showed promising results with instability, it also demonstrated a fair amount of failures, which were helpful in identifying and improving upon the technology of the implant design itself. In particular, the original implant of choice at the time, the NOVAE-1® (Serf, Decines, France) utilized both a non-cross-linked polyethylene with poor wear properties, as well as an alumina-coated stainless steel cup with poor on-growth potential [8]. Polyethylene technology has continued to improve wear rates with better knowledge of sterilization process, packaging, and cross linkage. In fact, wear rate has been documented to be up to 97% lower than first generation polyethylene used in dual mobility liners [10].

Looking at the specific performance of these newer innovations within the dual mobility hip, multiple studies have focused on wear rates of dual mobility components given the introduction of an additional hard on soft bearing surface. A surface analysis study of 40 dual mobility liners retrieved for infection or mechanical failure after an average of 8 years was performed, finding that total wear was similar to a comparison series of fixed bearing metal on poly 22.2 mm heads [11]. Convex sided wear accounted for 1/6 of the total wear, and wear at the retentive collar was present in all cases of intra-prosthetic dislocation, giving the idea that cup position as well as neck metallurgy play a significant role. Another study looking at the role of the second mobility in 12 representative hips showed similar findings of a non-deleterious effect of volumetric wear rates [7].

Two industry-funded studies have been recently published employing modern highly cross-linked polyethylene using joint wear simulation machines. One study simulated scenarios of impingement, abrasion, and loss of one of the dual articulations [12], the other, the effects of microseparation and third body particles [13]. Findings of these studies showed lower wear rates than single articulating THA's, likely due to shear stress reduction at the polyethylene interface.

5. Intra-prosthetic dislocation

A unique complication of dual mobility liners is intra-prosthetic dislocation (IPD). This occurs when the inner head disengages from the poly liner, from which it is constrained to. In the study by Boyer et al. [9], these IPD's were found to be occurring late (average of 9 years 11 months $\pm$ 54 months). This complication was theorized to be coming from wear at the retentive rim of the polyethylene building up slowly over time, as at extremes of range of motion the neck engages the rim causing wear, eventually enough for the inner constraint to fail. Reductions in intra-prosthetic dislocations have been seen with improvement in polywear characteristics as well as knowledge of femoral neck material makeup [9,14]. The largest revision dual mobility publication to date ($n = 994$) with 7.3-year follow-up showed 2 (0.2%) intra-prosthetic dislocations which were attributed to a poor head/neck ratio with impingement occurring early in the range of motion and thus accelerated chamfer wear. In regards to the femoral neck, recommendations for using a narrow polished and smooth geometry would theoretically impart less friction/stress at the chamfer interface and minimize IPD risks [15].

6. Recent data with improved materials

A paper with head-to-head comparison of a group with first generation dual mobility ($n = 437$); 16.5-year follow-up compared to second-generation dual mobility technology ($n = 231$); 5-year follow-up showed 5 cases of dislocation in the first generation group compared to no dislocations in the second generation group at its midterm follow-up. The first generation group had 37 mechanical failures, 15 which included acetabular loosening in the setting of non-hydroxyapatite coated cups, 5 dislocations (2 within 6 years, attributed to technical errors of component malposition and soft tissue handling issues), and 3 IPD's (8, 11, and 16 years). There were no mechanical failures in the second generation group [14].

Wegrzyn et al. [15], the largest study to date on revision dual mobility usage ($n = 994$) hips, prospectively followed patients for a mean of 7.3 years demonstrating 15 (1.5%) dislocations and 2 (0.2%) IPD's. Most important to note, was that 5 of the 15 dislocations were found to be technical errors during the initial placement including, cup malposition ($n = 1$), over shortening of the leg ($n = 1$), and abductor mechanism fixation issues ($n = 3$). The dual mobility liner still needs to have proper placed components and optimized soft tissue tensions for optimal success rates and is not immune from failure. In situations where soft tissue quality is irreparable, it is also not a guarantee for stability as 9 of the 15 cases had severe abductor mechanism dysfunction.