ZIMMER BIOMET

Dual Mobility Total Hip Arthroplasty in Displaced Femoral Neck Fracture

Value Analysis Brief

Contents

1. Executive Summary

1.1 Unmet Need

Femoral neck fracture is one of the most common types of hip fracture accounting for more than 50% of all hip fractures.[4,5] Approximately 70% of femoral neck fractures are categorized as displaced and require surgical treatment, typically with hip arthroplasty.[1,2]

In 2010, it was estimated that 22 million women and 5.5 million men in the EU had osteoporosis in accordance with the diagnostic criterion of the WHO.[3] The total number of new fractures in the same year was estimated to be 3.5 million, comprised of 620,000 hip fractures, 520,000 vertebral fractures, 560,000 forearm fractures and 1.8 million other fractures.[11] The 2018 International Osteoporosis Foundation (IOF) EU6 (6 European Union member states) report stated that although hip fractures make up 1/5 of total fractures, they are estimated to incur an estimated 56% of total fracture-related costs.[1]

The management of displaced femoral neck fractures has evolved to more patients receiving THA over HA, likely due to several evidence-based international guidelines supporting the adoption of THA in this cohort.[6-10]

This brief provides health care professionals and policy makers with an overview of the evolution of displaced femoral neck fracture treatment from hemi-arthroplasty to dualmobility total hip arthroplasty based on registry data, clinical papers and governmental guidelines to improve the quality of life of patients.

1.2 Avantage™ Dual Mobility System

The Avantage Dual Mobility system was developed in 1998 based on Professor Bousquet's philosophy and building on contemporary experience with early dual mobility designs. [51]

The Avantage system offers cemented and cementless shells with increasing supplementary fixation to address primary through to complex revision situations. [51]

Avantage Reload Cementless Shell

Avantage 3P Cementless Shell

Avantage Cemented Shell

The Avantage system offers Arcom polyethylene and Vitamin E Highly Crosslinked Polyethylene inserts. Vitamin E Highly Crosslinked Polyethylene is specifically designed to maximize performance through a proprietary process providing [52-56] Exceptional Oxidative Stability [53,56,57] Ultra-low Wear [53,54] and Improved Mechanical Strength. [52,55,56]

1.3 Evidence Summary of Dual Mobility Hip Implants

A systematic literature review and meta-analysis by Lewis et al. (2019) concluded that, overall, total hip arthroplasty (THA) appears to be superior to hemiarthroplasty (HA) in displaced femoral neck fractures.[14] While THA was found to be superior to HA in terms of risk of reoperation and functional / quality of life scores, the risk of dislocation was greater with THA when compared to HA. The authors recommend THA for displaced femoral neck fractures in patients with a life expectancy >4 years and in patients younger than 80 years.

A meta-analysis of dual-mobility THA versus HA in displaced femoral neck fracture (six cohort studies, 983 patients) suggests there is a significantly lower likelihood of dislocation for dual mobility THA compared with HA.[15-20]

Two recent meta-analyses demonstrated a significantly lower incidence of dislocation associated with dual mobility THA implants versus standard THA constructs in primary and revision THA.[21, 22]

A recent matched-pair analysis comparing 4,520 hip fractures treated with dual-mobility THA and 4,520 hip fractures treated with a standard THA found that the use of a dualmobility construct as primary treatment for hip fracture was associated with a lower risk of revision in general and due to dislocation in particular.[23]

The use of dual-mobility THA in displaced femoral neck fractures thus appears to provide better patient quality of life outcomes relative to HA, without the increased risk of dislocation associated with a standard THA construct.

The 2018 International Osteoporosis Foundation (IOF) EU6 (6 European Union member states) report stated that Although hip fractures make up 1/5 of total fractures, they are estimated to incur an estimated 56% of total fracture-related costs.[12]

2. Background

Key Takeaways

Femoral neck fracture is one of the most common types of hip fracture accounting for more than 50% of all hip fractures.[4, 5] Approximately 70% of femoral neck fractures are categorized as displaced and require surgical treatment, typically with hip arthroplasty.[1, 2]

Hip fractures have devastating consequences for patients and their families, including an annual mortality rate of 30% and substantial impairment of independence and health related quality of life.[24]

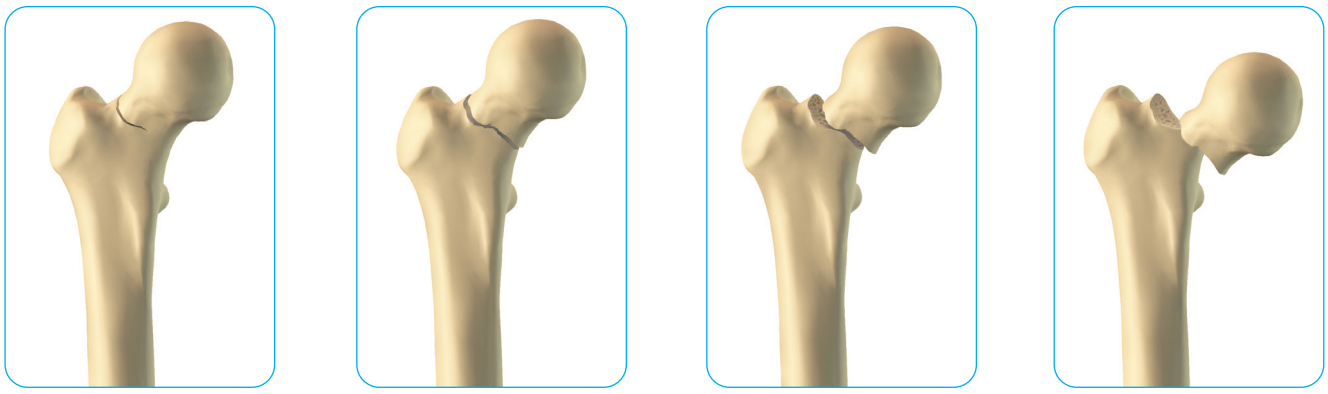
In 2010, it was estimated that 22 million women and 5.5 million men in the EU had osteoporosis in accordance with the diagnostic criterion of the WHO.[3] The total number of new fractures in the same year was estimated to be 3.5 million, comprised of 620,000 hip fractures, 520,000 vertebral fractures, 560,000 forearm fractures and 1.8 million other fractures.[11] The 2018 International Osteoporosis Foundation (IOF) EU6(6 European Union member states) report stated that Although hip fractures make up 1/5 of total fractures, they are estimated to incur an estimated 56% of total fracture-related costs.[12]

The management of displaced femoral neck fractures has evolved to more patients receiving THA over HA, likely due to several evidence-based international guidelines supporting the adoption of THA in this cohort.[6-10]

2.1 Displaced Hip Fractures

A hip fracture is a break occurring at the proximal femur, near the pelvis. Hip fractures are either classified as intracapsular (i.e. at the femoral neck) or extracapsular (i.e. below the femoral neck). Due to their proximity to retinacular vessels, intracapsular fractures are associated with a higher risk of disrupting blood supply to the femoral head, which is a leading cause of avascular necrosis.[2]

For patients with femoral neck fractures, Garden's four-level classification system (Figure 1-1) is used to determine the most appropriate treatment to manage the fracture.[25] Garden type I or II represents non-displaced or impacted fracture patterns, which are associated with minimal femoral neck displacement and a lessened risk of blood supply disruption to the femoral head. Conversely, Garden type III or IV fractures are categorized by greater displacement and substantially higher risk of blood supply loss; surgical treatment is recommended for these patients.[2, 8]



GARDEN I
Incomplete fracture
Minimally displaced
Valgus impacted

GARDEN II
Complete fracture
Non-displaced

GARDEN III
Complete fracture
Partially displaced

GARDEN IV
Complete fracture
Completely displaced

Figure 1: Garden Classification (intracapsular fractures)

2.2 Epidemiology

In 2010, it was estimated that 22 million women and 5.5 million men in the EU had osteoporosis in accordance with the diagnostic criterion of the WHO.[3] The total number of new fractures in the same year was estimated to be 3.5 million, comprised of 620,000 hip fractures, 520,000 vertebral fractures, 560,000 forearm fractures and 1.8 million other fractures. [11]

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Age is the main risk factor for hip fractures with the incidence increasing exponentially with age in both genders, peaking at 75 – 79 years of age.[26, 27] Within countries, the age-standardized incidence of hip fractures in women is approximately double that noted for men.[28] Because of the increasing number of elderly people in the world, the total number of hip fractures in individuals 50 years and older will continue to rise. By 2050, Eurostat projections suggest that 28.1% of the 28 European Union member states (EU-28) population will be aged 65 years and over, representing 147.7 million people. More than 57 million of these will be aged 80 years and over. [11]

2.3 Economic Burden

Hip fracture has been slowly rising over the last 20 years, but now stabilizing to approximately 1 fracture per 1000 patients in the majority of countries. This is despite the aging population and may reflect the increased use of prevention with bone health and falls prevention. The care costs associated with a hip fracture create a significant burden of heath care resource (up to 1.5% of total health care budgets).[13]

The 2018 International Osteoporosis Foundation (IOF) EU6 (6 European Union member states) report stated that although hip fractures make up 1/5 of total fractures, they are estimated to incur an estimated 56% of total fracture-related costs.[12]

For year 2010, the total cost of osteoporosis in the EU, including pharmaceutical intervention, was estimated to be Euro 37 billion (US$40 billion). Two-thirds of this cost was attributed to treating incident fractures, long-term care accounted for 29% and pharmacological prevention just 5%. Excluding the cost of pharmacological prevention, hip fractures represented 54% of the costs. [11] The 2018 International Osteoporosis Foundation (IOF) EU6(6 European Union member states) report stated that although hip fractures make up 1/5 of total fractures, they are estimated to incur an estimated 56% of total fracture-related costs.[12]

2.4 Clinical Burden

Hip fractures can have devastating consequences for patients, their families and healthcare systems including an annual mortality rate of 30% and substantial impairment of independence and healthrelated quality of life.[24] Hip fractures also account for more hospital days than any other musculoskeletal injury and represent more than two-thirds of all hospital days due to fracture.[24] Displaced femoral neck fractures, in particular, pose a higher risk of post-fracture healing complications such as avascular necrosis of the femoral head or non-union of the fracture.[2] Therefore, timely surgery for displaced femoral neck fractures remains the gold standard of treatment.[25]

The revision rate of THA and HA in displaced femoral neck fracture patients has been estimated at approximately 0.2% for THA and 1.8% for HA after one year. [35] Revision surgeries are associated with a poor prognosis and an increase in short-term mortality. [36] Patients undergoing revision surgery for hip fracture are at risk for infection, venous thromboembolic disease (VTE), dislocation, pulmonary embolism, and mortality. [37]

2.5 Treatment Pathways, Clinical Guidelines and Care Models

The management of hip fractures depends on individual patient factors (e.g. ambulatory status, age, cognitive function, comorbidities) and fracture factors (e.g. fracture location, type, degree of displacement).[14] Patients with displaced femoral neck fractures (Garden III and IV) are at significant risk for osteonecrosis of the femoral head and fracture non-union. As such, displaced femoral neck fracture are usually managed with hemi-arthroplasty (HA) or total hip arthroplasty (THA).[38] HA is a less complex surgery and has been associated with reduced dislocation rates, reduced blood loss, and lower initial costs.[39] However, some patients treated with HA require conversion to THA due to complications such as acetabular erosion and aseptic femoral loosening.[14, 40]

Widespread implementation of Fracture Liaison Services (FLS) is the objective of International Osteoporosis Foundation's flagship initiative, the Capture the Fracture Programme. The Capture the Fracture Programme, hosted on http://www.capturethefracture org/, provides resources, best practice guidance, and global recognition to help support the implementation of new FLS or improve existing FLS worldwide.[11]

THA on the other hand has been associated with superior patient satisfaction and better postoperative function, and has been increasingly used in recent years to manage displaced femoral neck fracture, especially in younger, more active patients.[14, 41] A systematic review and meta-analysis by Lewis et al. (2019) concluded that THA should be the recommended intervention for displaced femoral neck fracture in patients with a life expectancy greater than 4 years and in patients younger than 80 years. The authors also concluded that HA is a reasonable intervention in patients with shorter life expectancy or greater than 80 years old.

The management of displaced femoral neck fractures has evolved to more patients receiving THA over HA, likely due to several evidence-based international guidelines supporting the adoption of THA in this cohort.[6-10]

The National Institute for Health and Care Excellence (NICE) in the UK published its guideline on the management of hip fracture in adults in 2011 and updated it in 2018 to emphasise the role of total hip replacement in displaced intracapsular hip fracture.[7] The NICE guideline for hip fracture surgery states that THA should be offered to patients with displaced intracapsular hip fractures provided they pass the following criteria: 1) mobilise independently with the aid of no more than a stick; 2) are not cognitively impaired; and 3) are medically fit for anaesthesia and the procedure.[7]

The UK National Hip Fracture Database (NHFD) is currently the largest continuous audit of hip fracture care in the world, with more than 650,000 cases entered since launch in 2007. Two complementary models of care Orthogeriatric Services (OGS) and Fracture Liaison Services (FLS) have been established to ensure that fracture patients reliably receive osteoporosis management and interventions to prevent future falls. Widespread implementation of FLS is the objective of International Osteoporosis Foundation's flagship initiative, the Capture the Fracture Programme. The Capture the Fracture Programme, hosted on http://www.capturethefracture. org/, provides resources, best practice guidance, and global recognition to help support the implementation of new FLS or improve existing FLS worldwide. [11]

3. Evidence Summary

Key Takeaways

A systematic literature review and meta-analysis by Lewis et al. (2019) concluded that, overall, total hip arthroplasty (THA) appears to be superior to hemiarthroplasty (HA) in displaced femoral neck fractures.[14] The authors recommend THA for displaced femoral neck fractures in patients with a life expectancy >4 years and in patients younger than 80 years.

A meta-analysis of dual-mobility THA versus HA in displaced femoral neck fracture (six cohort studies, 983 patients) suggests there is a significantly lower likelihood of dislocation for dual mobility THA compared with HA.[15-20]

Two recent meta-analyses demonstrated a significantly lower incidence of dislocation associated with dual mobility THA implants versus standard THA constructs in primary and revision THA.[21, 22]

3.1 Hemiarthroplasty Versus Total Hip Arthroplasty in Displaced Femoral Neck Fractures

The most recent systematic review and meta-analysis on the topic of HA versus THA in displaced femoral neck fractures, published by Lewis et al. (2019), included randomized and quasi-randomized clinical studies published between 1986 and 2018.[14] Studies were identified through a systematic search of the MEDLINE, EMBASE, and Cochrane Controlled Trials databases. The meta-analysis was conducted following the PRISMA guideline and was registered in the PROSPERO database.

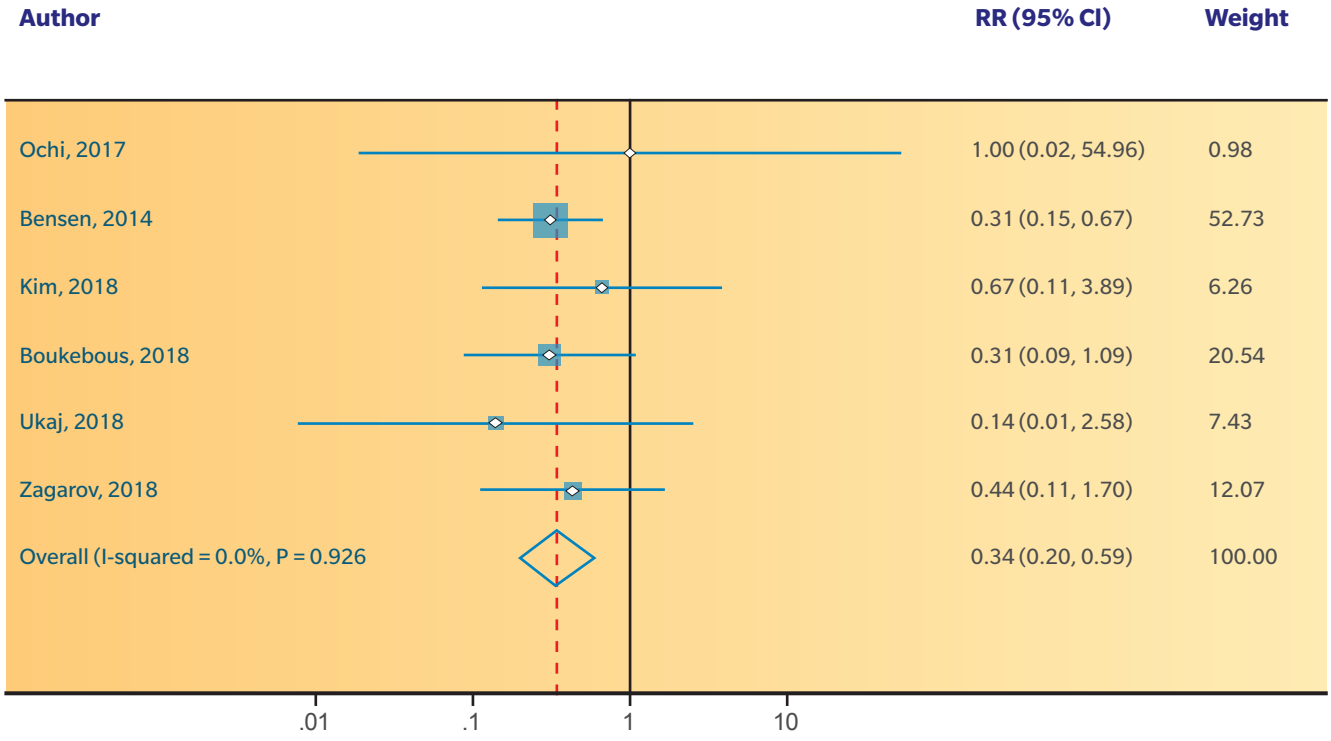
In total, 17 studies comprising 660 THA and 704 HA procedures were included. THA was found to be superior to HA in terms of risk of reoperation (risk ratio, 1.54 [95% CI, 1.01 to 2.35], P = .05), Harris Hip Score (HHS) (mean difference, 5.1 points [95% CI, 1.3 to 8.8], p = 0.009) and on the physical component summary (PCS) of the Short Form-36 (SF-36) (mean difference, 5.2 points [95% CI, 0.8 to 9.7 points, P = 0.02).[14] However, the 4-year incidence of dislocation was higher in the THA group (risk ratio, 0.37 [95% CI, 0.23 to 0.60], p < 0.001). No differences were found in terms of mortality and risk of infection. Furthermore, no statistically significant differences were found in terms of incidence of dislocation beyond 4 years.[14]

Lewis et al. (2019) concluded that, overall, THA appears to be superior to HA. Based on the scientific evidence, the authors recommend THA for displaced femoral neck fractures in patients with a life expectancy >4 years and in patients younger than 80 years. However, the authors found that both HA and THA are justified in patients older than 80 years and in patients with shorter life expectancy.[14]

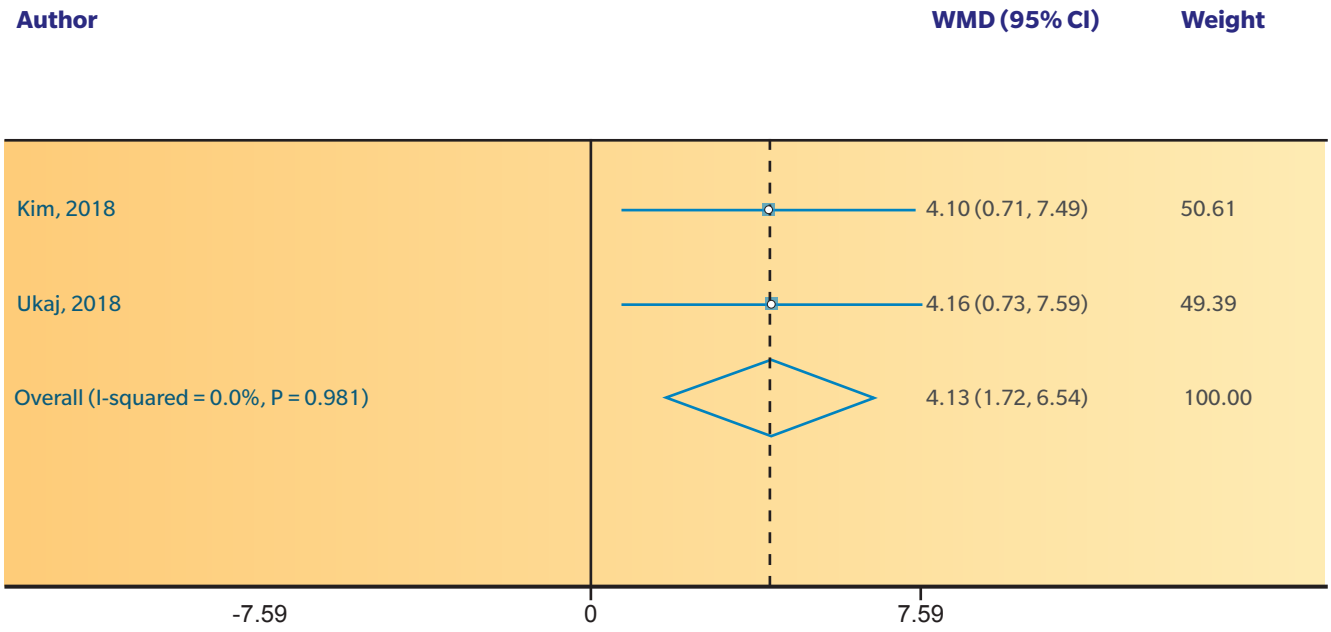
3.2 Hemiarthroplasty Versus Dual Mobility Implants in Displaced Femoral Neck Fractures

Currently, there are no systematic reviews published comparing differences between hemiarthroplasty and dual mobility THA for the treatment of displaced femoral neck fractures. For the purpose of this value analysis brief a meta-analysis was conducted, including randomized controlled trials and cohort studies, to examine the difference between hemiarthroplasty and dual mobility THA on clinical outcomes after hip arthroplasty for displaced femoral neck fractures. Full papers identified through a systematic search of the MEDLINE, EMBASE, and Cochrane Controlled Trials databases were eligible. Risk ratios for dislocation and the weighted mean differences for Harris Hip Score (HHS) were calculated. Fixed-effect (Mantel-Haenszel) models were employed. Stata 15.1 (StataCorp LLC, College Station, TX, USA) was used for statistical analysis.

In total, six cohort studies including 983 patients were identified.[15-20] After a mean follow-up of 2.0 (range, 1.4 – 3.0) years, there was a significantly lower likelihood of dislocation for dual mobility compared with hemiarthroplasty (risk ratio, 0.34 [95% CI, 0.20 to 0.59], $p < 0.001$).



Two studies reported postoperative HHS in 231 patients.[17, 19] The weighted mean difference in HHS was 4.1 points (95% CI, 1.7 – 6.5 points, p < 0.001) in favour of the dual mobility THA group.



This meta-analysis of comparative studies revealed that dual mobility THA is associated with a lower rate of dislocation and a higher HHS score compared with hemiarthroplasty in patients with displaced femoral neck fractures.

3.3 Dual Mobility Versus Standard Implants in Total Hip Arthroplasty

The body of evidence for dual mobility versus standard hip implants consists of two recently published meta-analyses comparing clinical outcomes. Reina et al. (2018) conducted a systematic review and meta-analysis of prospective and retrospective studies that compared dual-mobility constructs with controls for primary or revision THAs between 1986 and 2018.[21] The authors included five studies with primary THAs and six with revision THAs. In primary THA, at a mean follow-up of 7.6 years, an incidence of dislocation of 0.9% was found for the dual-mobility implant group, compared with 6.8% in the standard implant group (p < 0.001). The odds ratios for the standard implant group to the dual mobility group were 4.1 (95% CI, 1.7 to 9.7, p < 0.001) for dislocation, 1.2 (95% CI, 0.2 to 9.5, p = 0.87) for revision, 3.0 (95% CI 1.0 to 9.3, p =0.04) for revision due to dislocation, 1.7 (p = 0.57) for infection, 0.6 (p = 0.53) for fracture, and 1.2 (p = 0.81) for aseptic loosening.[21]

Similarly, in revision THA, an overall dislocation incidence of 2.2% was found for dual mobility, compared with 7.1% ($p < 0.001$) for standard bearings, at a mean follow-up of 4.1 years. The odds ratios for the standard implant group to the dual mobility group were 3.6 (95% CI, 2.0 – 6.4, $p < 0.001$) for dislocation, 2.5 (95% CI 1.6 to 3.8 ($p < 0.001$) for re-revision, 4.9 for (95% CI, 2.2 to 10.6, $p = 0.007$) re-revision for dislocation, 1.5 ($p = 0.32$) for infection, 1.2 ($p = 0.81$) for fracture, and 2.7 ($p = 0.003$) for aseptic loosening.[21]

This systematic review of comparative studies supports the efficacy of dual-mobility constructs to minimize dislocation after both primary and revision THAs in addition to excellent mid-term survivorship compared with control constructs.[21] As with any meta-analysis, further evidence is needed to evaluate the long-term risks and benefits of dual-mobility constructs in the primary and revision THA setting when compared with contemporary conventional implants.

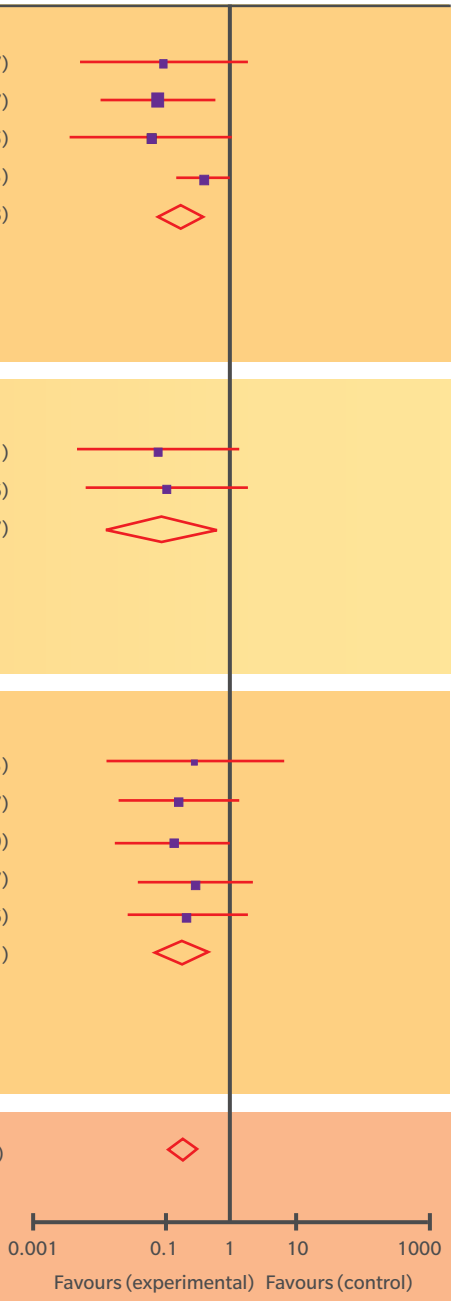
A second meta-analysis was published by Romagnoli et al. (2019), which included 15 studies presenting the results of a total of 1218 dual mobility and 1190 standard hip implants. The meta-analysis showed a significantly lower incidence of dislocation associated with dual mobility THA implants (risk ratio, 0.2 (95% CI, 0.1 to 0.3, $p < 0.001$).[22]

Interestingly, during the subgroup analysis, statistically significant differences in favor of the dual mobility group were also found for primary or revision arthroplasties, displaced femoral neck fractures, and elective procedures (i.e., diagnosis of osteoarthritis, avascular osteonecrosis or rheumatic arthritis). For fracture cases, a risk ratio of dual mobility to standard implants of 0.1 was found (95% CI, 0.0 to 0.7, $p = 0.02$).[22]

Romagnoli et al. (2019) concluded that dual mobility acetabular components decrease the risk of post-operative instability in high-risk patients, both in primary and revision hip arthroplasties.[22] More high-quality studies are warranted to confirm the present data.

Dual mobility acetabular components decrease the risk of post-operative instability in high-risk patients, in both primary and revision hip arthroplasties.

Study or Subgroup	Dual Mobility Events	Dual Mobility Total	Fixed Bearing Events	Fixed Bearing Total	Weight	Risk Ratio M-Hi, Fixed, 95% CI
OA, AVN, RA						
Bouchet et al. 2011	0	105	5	108	6.7%	0.09 (0.01, 1.67)
Calon et al. 2014	1	105	26	215	21.1%	0.08 (0.01, 0.57)
Epinette et al. 2015	0	143	7	130	9.7%	0.06 (0.00, 1.05)
Hernigou et al. 2016	5	85	13	85	16.1%	0.38 (0.14, 1.03)
Subtotal (95% CI)		438		538	53.6%	0.17 (0.08, 0.38)
Total events	6		51			
Heterogeneity: $Chi^2 = 3.89$, df = 3 (P = 0.27); $I^2 = 23\%$						
Test for overall effect: Z = 4.32 (P < 0.0001)						
Fracture						
Tarasevicius et al. 2013	0	42	8	56	9.0%	0.08 (0.00, 1.31)
Tarasevicius et al. 2010	0	58	5	67	6.3%	0.10 (0.01, 1.86)
Subtotal (95% CI)		100		123	15.3%	0.09 (0.01, 0.67)
Total events	0		13			
Heterogeneity: $Chi^2 = 0.02$, df = 1 (P = 0.89); $I^2 = 0\%$						
Test for overall effect: Z = 4.32 (P < 0.0001)						
Loosening, Infection, periprostetic fracture						
Chalmers et al. 2017	0	16	1	13	2.0%	0.27 (0.01, 6.23)
Gonzales et al. 2017	1	150	7	166	8.2%	0.16 (0.02, 1.27)
Hernigou et al. 2017	1	35	7	32	9.0%	0.13 (0.02, 1.00)
Jauregui et al. 2016	1	60	7	120	5.8%	0.29 (0.04, 2.27)
Perrin et al. 2017	1	24	5	25	6.1%	0.21 (0.03, 1.66)
Subtotal (95% CI)		285		356	31.1%	0.19 (0.07, 0.51)
Total events	4		27			
Heterogeneity: $Chi^2 = 0.37$, df = 4 (P = 0.98); $I^2 = 0\%$						
Test for overall effect: Z = 3.33 (P < 0.0009)						
Total (95% CI)		823		1017	100.0%	0.16 (0.09, 0.30)
Total events	10		91			
Heterogeneity: $Chi^2 = 4.85$, df = 10 (P = 0.90); $I^2 = 0\%$						
Test for overall effect: Z = 5.98 (P < 0.00001)						
Test for subgroup differences: $Chi^2 = 0.45$, df = 2 (P = 0.80). $I^2 = 0\%$						



4. Implications of Dual Mobility Hips in Displaced Femoral Neck Fractures

A randomized study of eighty one patients [42] and a meta-analysis [38] indicated that displaced femoral neck fracture patients treated with THA versus HA have better functional outcomes, including Harris and Oxford hip scores and walking distance. Yet, a major hurdle for THA adoption has been that displaced femoral neck fractures have a reported dislocation rate of approximately 10%, roughly five times higher than the dislocation rate in primary THA (Figure 5-1).[43] However, lower rates of revision and revision due to dislocation have been reported with the use of Dual Mobility Construct (DMC) in patients with displaced femoral neck fracture.[23] Additional longitudinal studies are needed to corroborate this evidence, but the early results are promising for the adoption of DMC in this challenging patient cohort.

Dual-mobility THA is associated with a lower rate of dislocation and a higher HHS score compared with hemiarthroplasty in patients with displaced femoral neck fractures.

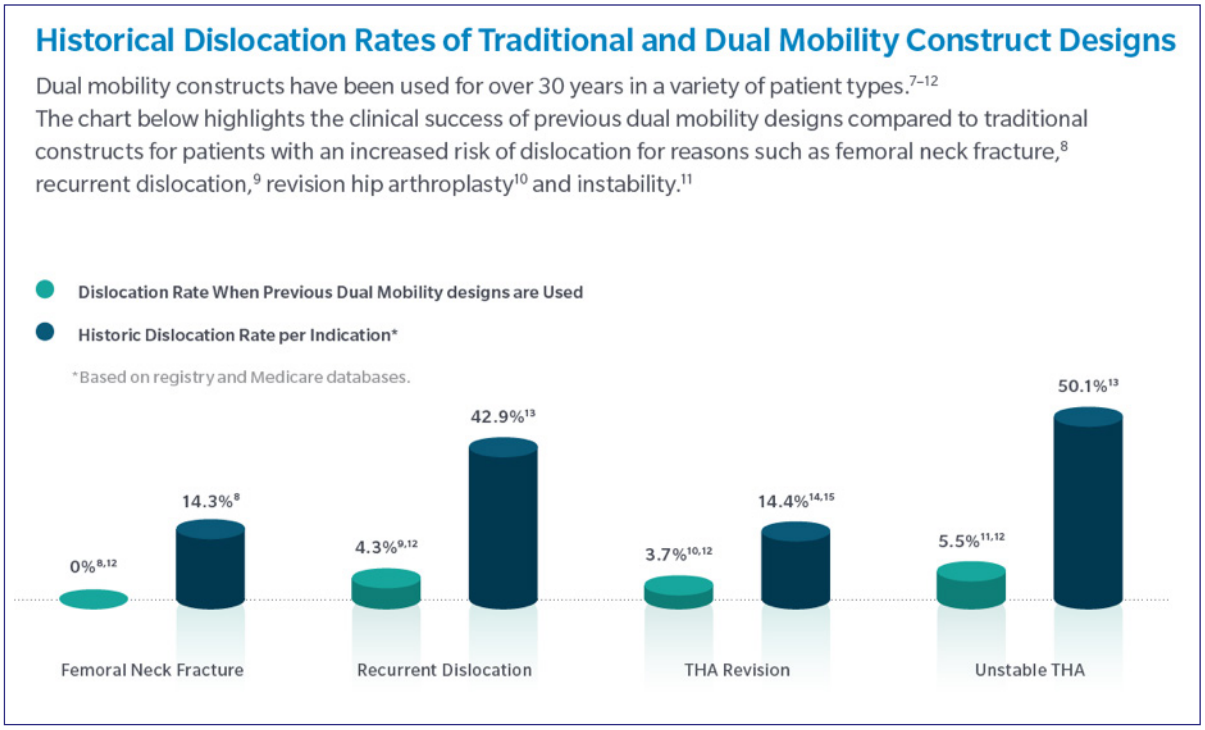


Figure 5-1: Historical Dislocation Rates of Traditional and Dual Mobility Construct Designs

5. Product Profile: Avantage® Acetabular System

Increased Range of Motion (ROM) with Dislocation Resistance

The Avantage system offers cemented and cementless shells with increasing supplementary fixation to address primary through to complex revision situations.

The cylindro-spherical cup design with superior hood and inferior aperture is designed to maximise superior head coverage and increased range of motion in adduction. A smooth inferior superior transition is optimised to reduce psoas irritation while a flattened pole optimises cup impaction and enhances the equatorial press fit of the cementless cups. [51]

The Avantage system offers Arcom polyethylene and Vitamin E Highly Crosslinked Polyethylene inserts. Vitamin E Highly Crosslinked Polyethylene is specifically designed to maximize performance through a proprietary process providing: [52-56] Exceptional Oxidative Stability [53,56,57], Ultra-low Wear [53,54] and Improved Mechanical Strength. [52,55,56]

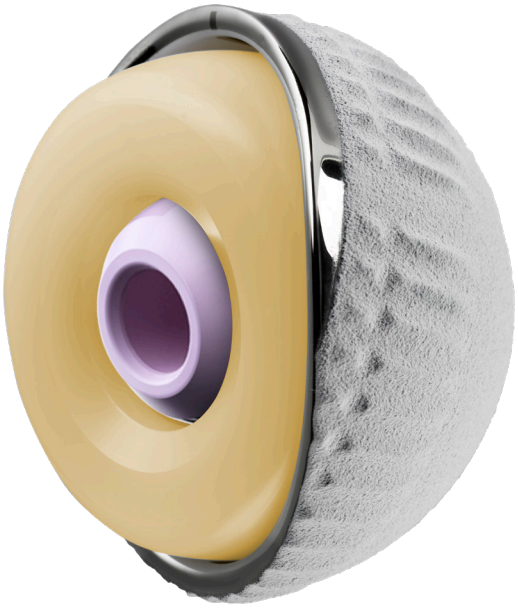


Figure 5-1: AVANTAGE Acetabulum System

Strong Clinical Heritage

Zimmer Biomet has over 10 years of clinical experience in dual mobility hip replacement with the Avantage™ system. The Avantage™ system was developed in 1998 based on Professor Bousquet's philosophy and built on contemporary experience with early dual mobility designs.

Table 1: Clinical results from the use of the Avantage system.

Reference	Details	Outcome
Bedencic K, Kavcic G, Tumpej J.[47]	Series of 1000 consecutive Avantage dual mobility cups used for THA in 901 patients for various pathologies (fracture of the femoral neck, osteoarthritis and avascular necrosis). There were 612 females and 289 males with a mean age of 76.8 years at the time of their operation (from 29 to 98). 808 patients with a total of 883 dual mobility cups were available for the final analysis.	No dislocations recorded at the mean follow-up of 8.9 years. There were also no cases of aseptic loosening (longest follow up 14 years). Harris Hip Score significantly increased for cases of osteoarthritis and avascular necrosis (from 44.9 to 90.4).
Fresard, P-L. et. al.[48]	134 THA were done between 1998 and 2002 with Avantage Press-Fit double mobility cup and ArCom® polyethylene. The mean age of patients was 74 ± 6 years (range 65–94 years). The mean follow-up was 5.4 years (range, 0.15–10 years).	No dislocation occurred in this series. Three revisions were documented for aseptic loosening. The overall survival rate at 7.2 years was 96.3 % (95 % confidence interval 92.2–100) using cup revision for aseptic loosening as the end point.
Semenowicz J. et. al.[49]	280 cementless Avantage and Avantage Reload cups were implanted in 260 women aged between 29 and 79 years (60.9 years on average) in the years 2004–2010. The follow-up period ranged from 2.7 to 9.7 years, 7.0 years on average.	None of the patients demonstrated postoperative prosthesis instability. Aseptic loosening was observed in 19 cups in 18 women (7.3%). The cumulative survival rate of the Avantage cup was 0.94 at 5 years and 0.86 at 8 years.
Graversen et. al.[50]	20 patients (18 females, 2 males) median age of 83 years (interquartile range 81–88 years), who were treated with the Avantage dual mobility cup (Biomet) due to an acute displaced (Garden type 3 or 4) FNF. All patients had a dementia diagnosis and were considered unable to follow the rehabilitation program with restriction of hip flexion and external rotation. The median follow-up time was 12.1 (0.4–47.6) months.	None of the patients experienced dislocation or received revision surgery in the follow-up period.

6. References

** Laboratory testing is not necessarily indicative of clinical performance.*

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