Chapter 10
Total Hip Replacement Revision Using a Dual Mobility Cup Cemented into a Metallic Ring

Pascal Bizot

Introduction

The number of patients undergoing THA is constantly increasing. This trend is reported worldwide and results from multiple factors, including the progresses made in the field of hip surgery, the quality of the functional results, the increasing patient life span, the higher functional demand, and the enlargement of THA indications to younger patients and older patients as well. Consequently, the number of patients undergoing THA revision also increased significantly with time [4, 18, 19, 32]. For Kurtz et al. [18, 19], the total number of procedures in the United States from 2009 to 2010 increased by 6.0% for primary total hip arthroplasty, and 10.8% for revision total hip arthroplasty. The number of THA will increase from 174% in 2030, and the number of THA revision will double in 2026. In the same way, Bozic et al. [4], reported an increase of THA revision by 23% between 2005 and 2010 in the US.

However, THA revision remains a challenging procedure for the orthopedic surgeon. The survival rate after THA revision is lower than that after of primary THA, and the complications (mainly loosening, instability, infection, and fracture) are significantly more frequent. Instability is one of the main complications in THA revisions, and also one of the most common cause for re revision [1, 4, 10, 16, 27]. Dislocation generally occurs early, within 2–3 years post operatively. After primary THA, the rate of instability ranged from 0.2 to 7%, whereas after revision surgery, it can increase up to 35% [1, 10, 16, 25, 27].

P. Bizot
Department of Orthopaedic Surgery, Lariboisière Teaching Hospital, Paris, France

Laboratoire Bioingénierie et Bioimagerie ostéo-articulaire (B20A) CNRS UMR7052, University of Paris Diderot, Paris, France
e-mail: pascal.bizot@aphp.fr

E. García-Rey, E. García-Cimbrelo (eds.), *Acetabular Revision Surgery in Major Bone Defects*, https://doi.org/10.1007/978-3-319-98596-1_10

In a retrospective analysis conducted on 539 hips undergoing revision THA done for instability, Jo et al. [16] reported a cumulative risk of re-dislocation and re-revision for all cause of 34.5% and 45.9% at 15 years, respectively.

The mechanism is often multifactorial, and due to impingement and/or soft tissues insufficiencies, which depends on the patient characteristics (age, gender, initial diagnosis, associated diseases), the surgical technique (approach, implant positioning), the implant design (head, neck, cup), and the rehabilitation.

Treatment of instability does remain a challenging procedure. Several surgical options are available, including soft tissues procedures (abductor muscles reconstruction), increase hip length and offset, use of constraint acetabular implants and use of larger femoral heads (in order to increase the range of motion (ROM) before impingement, the head-neck ratio, and the jump distance). Constrained implants restrict the ROM and cause high stress transmission responsible of liner damage, locking mechanism failure, dislocation and loosening. Larger heads increase volumetric wear and reduce PE thickness, and may cause fractures of thin PE liners, tribo-corrosion generated by large torsional forces at the trunnion-head junction, and groin pain secondary to impingement against the iliopsoas muscle. Finally, none appears clearly superior over others, and the literature showed quite disappointing results with these options, especially in patients with high risk of instability [1, 10].

Dual Mobility Cup

Dual Mobility (DM) is a concept first introduced by Gilles Bousquet in France during the 1970s. DM cup combines two bearings: a small joint between the prosthetic head and the mobile PE component, and a large one between the mobile PE component and the inner surface of the metal cup. It is a non-constraint device which provides a greater effective head size and head-to-neck ratio, and is expected to improve the ROM to impingement and joint stability. Mobility occurs at the two bearings, but preferentially at the inner bearing, the outer bearing engages only at the extremes of motion. The original cementless design has been significantly improved: the original cylindro-spherical design has been modified in order to improve the ROM free of impingement, and to avoid psoas tendon-to-cup impingement. The coating of the shell has been also modified by adding either a double coating (hydroxyapatite and titanium plasma spray) or a porous metal coating, to improve bone fixation (Fig. 10.1).

Contemporary DM THA outperforms large diameter heads and constrained liners in terms of wear, stability and survival. Clinical reports on the use of the first generation of implants have shown encouraging results, with survival rates of 81% at 15 years and 75% over 20 years [3, 12]. With improved designs, survivorship has been reported superior to 95% at 6–8 years, but, nowadays, survivorship over 10 years with modern implants are not yet available [7, 8, 12].

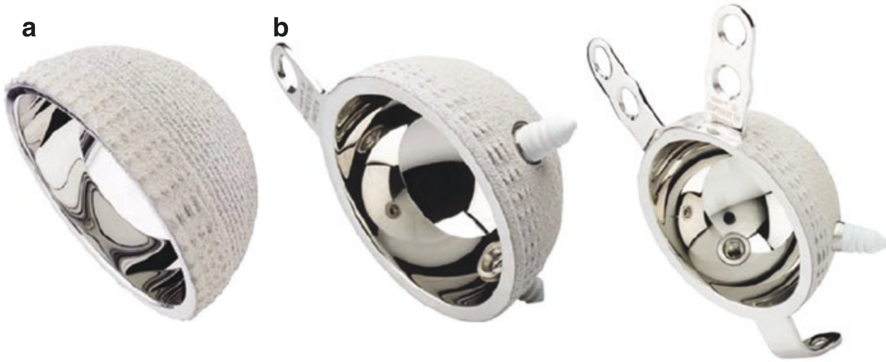

Fig. 10.1 Uncemented dual mobility cups. (Novae®, Serf-Dedienne, France). (**a**) Primary case. (**b**) Revision case

Many series have shown the efficiency of DM in preventing postoperative dislocation both for primary and revision procedures. In primary THA using DM cups, the dislocation rate ranged from 0% to 4.6% even in patients at risk for dislocation, without increase with time [12, 14, 26, 30, 31]. In unstable THA, reports have demonstrated low rates of re-dislocation, ranging from 0% to 5.5% [15, 16, 20, 24]. DM has been also reported with low dislocation rates in revision THA, ranging from 0% to 5% [7, 8, 25, 26]. In a systematic review of the literature including a total of 17,908 DM THAs, De Martino et al. [8] reported a mean rate of dislocation and intra-prosthetic dislocation (IPD) (the prosthetic head dislodges from the mobile PE component) of 0.9% and 0.7% in primary THA, and 3.0% and 1.3% in revision THA. On the same way, Darrith et al. [7] reported for a total of 10,783 primary DM THAs, rates of aseptic loosening, IPD and dislocation of 1.3%, 1.1% and 0.46% respectively, with an overall survivorship of 98.0% at of 8.5 years. For 3008 revisions DM THAs, the rates of aseptic acetabular loosening, IPD and dislocation were 1.4%, 0.3% and 2.2% respectively and the survival was 96.6% at 5.4 years. Both concluded that the use of DM cups is effective in minimizing the risk of instability after both primary and revision THA.

Concerns about increased wear compared to conventional bearings and IPD have been nearly solved with modern designs. IPD is a specific failure which has been noted with the first generation of implants with an incidence of 2–4% [3, 12, 23, 30]. The main mechanism resulted from PE wear at the retentive rim of the component. With improvements of the head-neck geometry, PE damage in the retentive area decreased, and consequently the incidence of IPD decreased ranging from 0% at 6 years to 0.28% at 10 years with the newer generation of implants [7, 8, 31]. The linear penetration rate, used to estimate volumetric wear in conventional metal-on-PE bearings, is ineffective for estimating wear on DM cups because of the presence of two bearings. Wear measurements from retrieved first-generation DM implants have confirmed low wear rates [3, 12]. For Boyer et al. [3], the two articulations of the DM THA do not cause more wear. The median wear rate was 38 mm^3/year, similar to that of cemented PE liners and lower than equivalent cementless liners. On the same way, Gaudin et al. [11] showed that in vitro wear for conventional PE was comparable between a standard and a dual mobility cup, confirming the very good long-term clinical results observed with DM bearing.

Specific DM cups have been designed to secure the cementless fixation in cases of poor bone stock, poor bone quality and in revision cases, with additional pegs, supra-acetabular screws, hook and flanges, and recently with a modular cup for screw fixation and a metallic liner (Fig. 10.1). However, in cases of THA revisions with severe bone loss, uncemented fixation might be compromised, especially if the acetabular implant is placed close to its original position, as it has been recommended for long term maintenance of the hip function. Although other uncemented options have been proposed, sometimes with acceptance of a high hip center (bi lobed cup, tri flanged and jumbo cups, reconstructive cup with trabecular metal), the use of cement may become necessary.

In cemented revision THR, acetabular reconstruction using unsupported structural allografts has been associated with a high rate of failure. In contrast, when supported by an acetabular reinforcement device, a low rate of failure has been reported [2, 17, 33, 35]. Use of DM cemented directly into the bone without a reinforcement device has encountered controversies. Although Haen et al. [13] have recently reported a rate of loosening of only 1.5% and a 5-year survival rate of 98%, most of the series have reported a high rate of loosening [5, 15, 29]. Therefore, the use of cemented DM implants into a reinforcement may be an interesting option. Many metallic reinforcement devices are available (Müller ring, Bursch ring, Link reinforcement, Kerboull cross). The choice is mainly based on the surgeon habits and the severity of the acetabular lesions. The Kerboull Cross (KC) is an open device, flexible enough to conform with the elasticity of the acetabular bone, and resistant enough to assume a strong fixation. It is composed of two branches. The vertical branch ends distally with a hook that must be inserted under the inferior margin of the acetabulum, and proximally with a rounded plate for ilium screw fixation. The horizontal branch is asymmetrical, shorter forward, which generates a ten degrees ante version. It facilitates restoration of the hip's center of rotation and gave very satisfactory results at long term in THA revision with acetabular reconstruction [17].

Surgical Technique

The revision procedure offers the possibility to restore hip anatomy and mechanic, which involves restoring the bone stock, implanting the components in a correct position with durable bone fixation, and achieving joint stability.

The operation is performed using posterolateral approach or lateral approach with trochanteric osteotomy. A large exposure is necessary in order to remove the initial acetabular components, the cement if present, the granuloma and fibrous membrane. Caution is necessary not to enlarge acetabular bone damage during this step. The degree of acetabular bone defects, assessed preoperatively on radiographs and/or CT scan, is reevaluated per operatively. The stem may be remove or retain, according to its position and fixation. However, if the stem is retained, make sure that the head is modular and can fit to the new DM PE insert.

The first step is to determine the good position and the appropriate size of the KC (Figs. 10.4 and 10.5). Its outer diameter should be not too large (if not the antero-posterior axis does not fit), and close to that of the undamaged acetabulum (possibly measured on the opposite side). One must pay attention that the KC must allow cementing of the DM shell, which means that its inner diameter should be 2 mm superior to that of DM cup. It is paramount to fix the KC in a correct position. The KC must be fixed inferiorly at the superior margin of the obturator foramen by the hook, and superiorly through the round plate with three to four screws to the ilium, at 45° of abduction angle and vertically, which means that the upper plate should not be bent and not shifted anteriorly nor posteriorly. The screws of the plate should be inserted at an angle >40° and posteriorly within 0–10°. In practice, templates are useful to determine the correct size and position of the KC, and also to determine the need for acetabular reconstruction. It is often necessary to reconstruct the roof with a structural allograft. Remaining acetabular defects are treated, either with impaction bone grafting using bone chips, or with structural allografts, possibly supplemented by cement.

Once the acetabular reconstruction is achieved and the final KC is fixed, the correct position of the device (especially the hook) must be verified on an intra operative radiograph before cementing the dual mobility cup. The dual mobility cup is cemented into the KC, with 10 to 15° of ante version and 45° of abduction. The metal shell has circumferential and longitudinal grooves to improve cementing (Figs. 10.2 and 10.3). Its size should be 2 mm inferior to the inner diameter of the KC, in order to preserve a minimal cement mantel of 2 mm. The technique of cementing is a determining factor for fixation quality and device stability with time. The use of cement added with gentamycin and standard viscosity is recommended.

Finally, the modular head (preferentially 28 mm diameter) is inserted into the mobile PE insert. The whole is impacted on the stem trunnion and the hip is finally reduced.

Postoperative treatment involves routinely prophylactic anticoagulation, careful mobilization of the hip and early full weight bearing with two crutches for 6 weeks (Figs. 10.4 and 10.5).

Results

Between July 2007 and April 2011, we performed 40 THA revisions using a dual mobility cup cemented in a KC, in 38 consecutive patients (21 females, 17 males) (Figs. 10.6 and 10.7). The mean age of the patients at the procedure was 74 years (18–90). The number of previous THA per patient ranged from 1 to 6 with a mean of 1.8. The causes of THA revision were mainly aseptic loosening with or without

Fig. 10.2 Cemented dual mobility cup into a Kerboull cross. (*Quattro*®, Lépine, France)

Fig. 10.3 Cemented dual mobility cup with the corresponding Kerboull cross and mobile PE insert. (*Novae Stick*®, Serf-Dedienne, France)

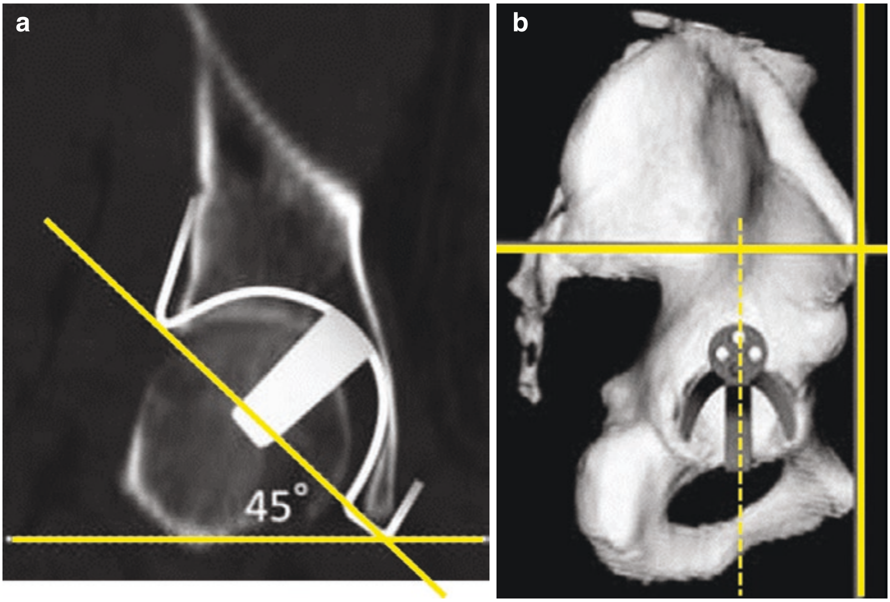

Fig. 10.4 Sizing of the Kerboull Cross (KC) according to the diameter of the acetabulum. (**a**) The KC is correctly positioned and the size is appropriate. (**b**) The vertical axis must be parallel to the anterior plan of the pelvis

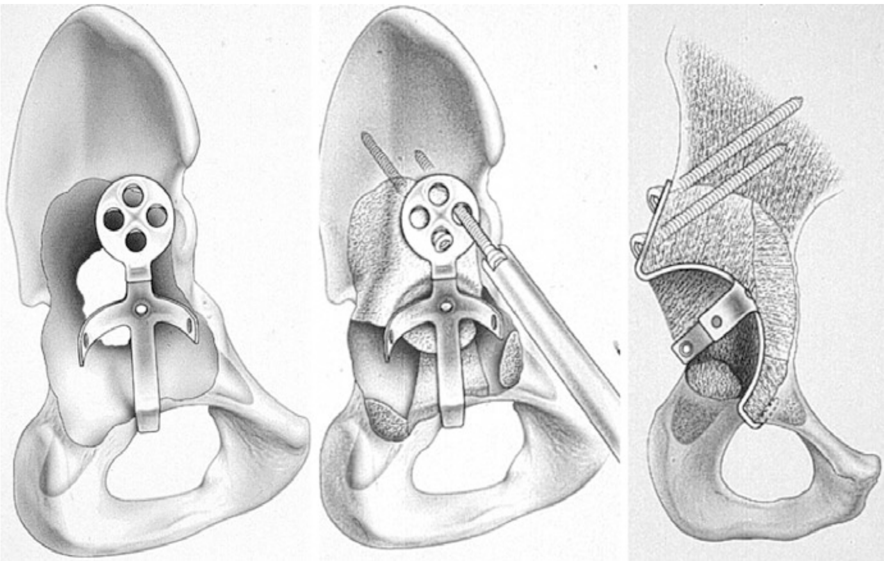

Fig. 10.5 Positioning of the Kerboull plate and reconstruction of the acetabulum using structural allograft. The inferior hook must be positioned under the inferior margin of the obturator hole and the superior plate must be fixed on the ilium, at 45°of inclination. (From Kerboull et al. [17])

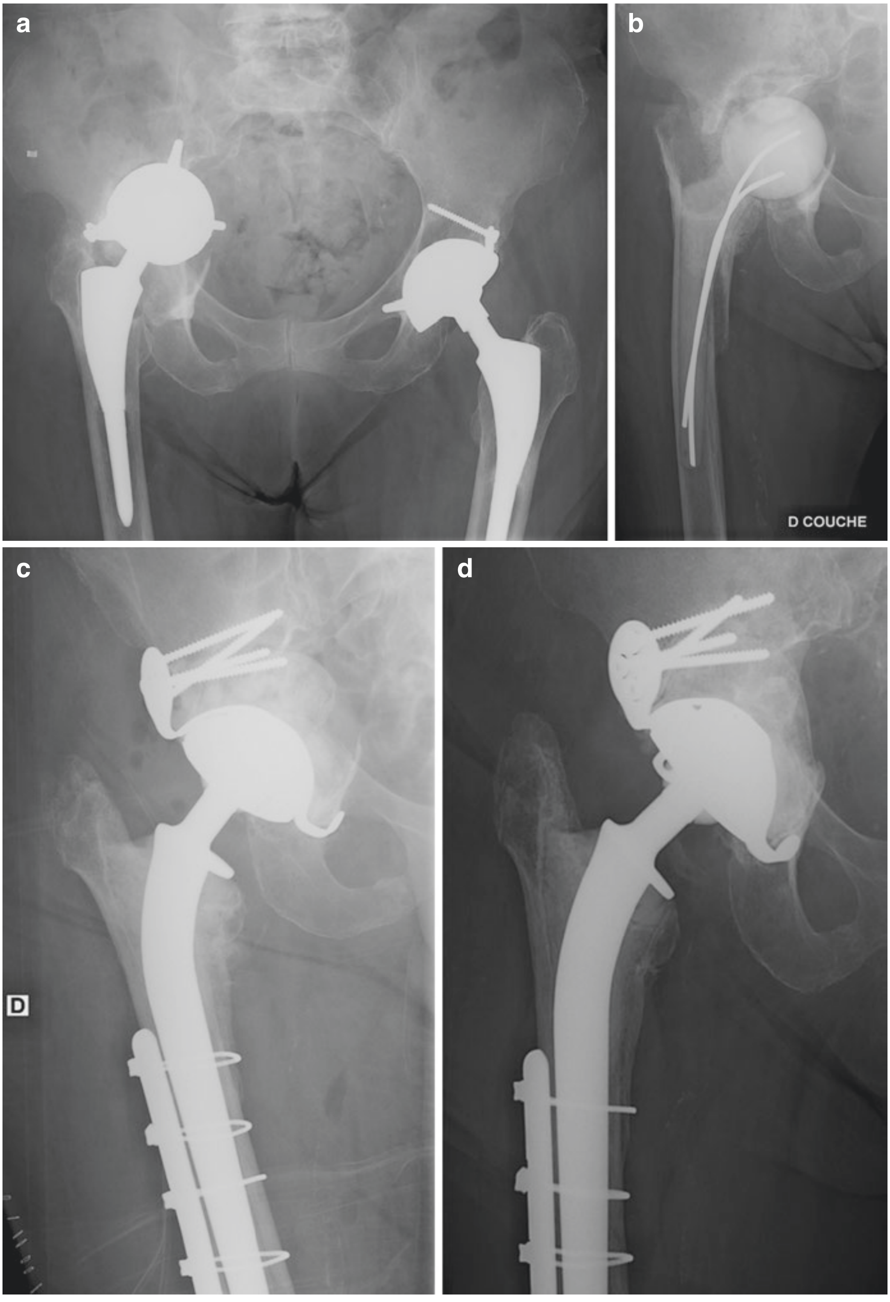

Fig. 10.6 Women, 86 years old, with Parkinson disease and bilateral uncemented THA. (**a**) Deep infection on the left side with socket pelvic migration. (**b**) Two-stage THA revision. Acrylic spacer. (**c**) THA revision using DM cup cemented into a KC after acetabular reconstruction. (**d**) Excellent result at 1.5 years postoperative

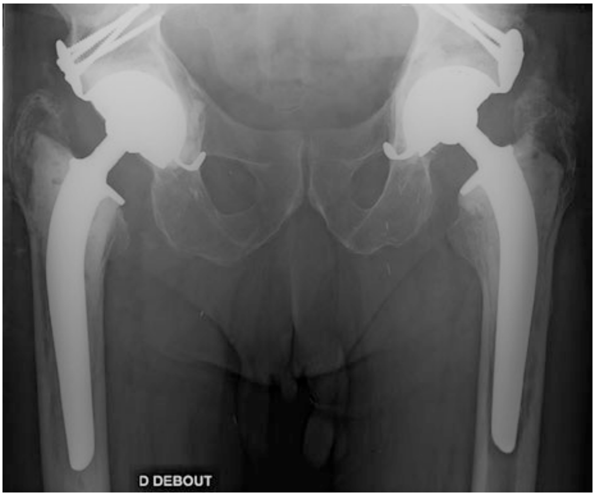

Fig. 10.7 Bilateral THA bipolar revision in a 75 years old man, using DM cup cemented into a Kerboull plate and a cemented stem. Excellent results on both side at 2-years postoperative

osteolysis (30 hips), infection (2d stage) (4 hips), persistent pain (2 hips), recurrent dislocation (2 hips), and peri-prosthetic fracture (2 hips). All the patients had combined acetabular deficiencies (type III or IV according to the AAOS and Paprosky classifications). There were 6 unipolar and 34 bipolar revisions using 22 cemented and 12 uncemented stems (Fig. 10.7). The acetabular reconstruction has been made with structural femoral head allografts (32 hips) or cement (8 hips). The mean diameter of the DM cup was 49 mm (range 45–55). There were 32 heads of 28 mm (25 metallic, 7 ceramic) and 8 metallic head of 22.2 mm diameter.

Two patients were lost to follow up and one patient deceased from unrelated cause. All the surviving patients were reviewed with clinical and radiological exams. Two patients had a postoperative partial neurological palsy and one patient had a recurrence of deep infection with cup loosening. One patient had a stem exchange to a cemented stem at 1 year, and one patient had an acetabular revision at 5 months for migration of the KC due to an initial malposition. The average follow-up was 36 months. The mean Merle d'Aubigné hip score was 16.6 ± 1.1 at the last follow up. There was one cup migration. No patient had postoperative hip instability.

Our conclusion was that acetabular reconstruction using a DM cup cemented into a KC gave satisfactory results in terms of fixation and joint stability at short term. It becomes, therefore, an interesting option in THA revisions with acetabular reconstruction, especially in patients at risk for instability. However, results need to be confirmed at longer term.

DM cups cemented in a metal reinforcement have been reported in several series (Table 10.1) [6, 21, 22, 28, 30, 34, 36]. The series were very heterogeneous, in terms of patient characteristics, implants designs and surgical technique. They included 37–104 patients, at a mean follow-up ranging from 1.3 to 6.4 years, resulting in a total of 354 patients at a mean of 3.5 years follow-up. The rate of dislocation ranged from 0 to 10.4%, the rate of aseptic loosening from 0 to 6.4%, and the 5–7-year survival was close to 95%. Our series showed comparable, and even better, results

Table 10.1 Series of dual mobility cups cemented in a metallic reinforcement

	Hips (n)	Follow up (years)	Dislocation (%)	Aseptic loosening (%)	Aseptic revision (%)	Survival rate (%)
Langlais et al. [21]	82	3	1.1	2.2	8	94.6% at 5 years
Schneider et al. [34]	96	3.4	10.4	1	4.2	95.6% at 8 years
Philippot et al. [30]	104	5	3.6	1.2	6.7	96.1% at 7 years
Civinini et al. [6]	33	2	0	0	0	97% at 5 years
Pattyn et Audenaert [28]	37	1.3	5.4	0	0	–
Lebeau et al. [22]	62	6.4	1.6	6.4	8.1	91.9% at 8 years
Wegrzyn et al. [36]	61	7.5	0	0	0	–
Present series	40	3	0	2	2	–

in terms of functional scores, postoperative stability and rate of re-revision. Despite different designs of cemented DM cups and metal reinforcements (guided by the surgeon habitus and the severity of the acetabular lesions), a significant reduction of the risk of postoperative dislocation was reported in all series (except in the series of Schneider et al. [34], confirming the advantage of DM cups (cemented or not) as a way to limit, without eliminating, the risk of postoperative dislocation in THA revision [7, 12, 20, 24, 26, 30].

However, the use of DM cup cemented directly into the bone without a reinforcement device has encountered controversies. Although Haen et al. [13] have recently reported a rate of loosening of only 1.5% and a 5-year survival rate of 98%, most of the series have reported a high rate of loosening, ranging from 20% to 40%, and concluded that in case of severe acetabular bone loss, bone graft and reinforcement are recommended [5, 29]. Rates for aseptic loosening of DM cups cemented in a reinforcement have been reported between 0 and 2.2% within 3 years postoperatively [6, 21, 22, 28, 30, 34, 36]. However, Lebeau et al. [22] reported a rate of loosening as high as 6.4% at longer follow-up, considering cementing quality to be a determining factor of assembly stability. In vitro, Wegrzyn et al. [37] reported a good mechanical resistance of DM cups cemented in a reinforcement, greater than in vivo stress levels, and Ebramzadeh et al. [9] found that cement thickness of 2 mm or less between reinforcement and cup incurred greater risk of loosening than thicknesses of 4 mm or more. This may explain the differences reported in the literature in terms of loosening in series of cemented DM cups, illustrating the need for appropriate sizes and designs of cemented cup (transverse and longitudinal grooves on the metal-back, increments of 2 mm) to improve sealing, and a minimum of 2 mm thickness cement to improve the quality of fixation (Figs. 10.2 and 10.3).

Conclusion

Dual-mobility cup cemented in a Kerboull Cross fulfills the charge-book of revision THA, in terms of reduced instability and bone fixation, at least at midterm. The procedure is indicated in case of poor bone quality and/or insufficient bone stock, in patients at risk for instability (repeat revisions, advanced age, poor medical status, weakness of abductors). The technique offers several potential advantages, by using an unconstrained device which preserves the range of motion of the hip and increases the jump distance while maintaining PE thickness, by automatically restoring the anatomical hip center and allowing bone stock restoration while protecting the graft from overstresses. An appropriate technique is essential, notably as regard the cross positioning (hook) and the cup cementing (with a minimum cement mantel thickness). The results are encouraging at midterm follow up, in terms of bone fixation and stability, but questions remain about long term fixation.

References

1. Berry DJ. Unstable total hip arthroplasty: detailed overview. Instr Course Lect. 2001;50:265–74.
2. Bonnomet F, Clavert P, Gicquel P, Lefebre Y, Kempf JF. Reconstruction by graft and reinforcement device in severe aseptic acetabular loosening: 10 years survivorship analysis. Rev Chir Orthop. 2001;87(2):135–46.
3. Boyer B, Neri T, Geringer J, Di Iorio A, Philippot R, Farizon F. Long term wear of dual mobility total hip replacement cups: explant study. Int Orthop. 2018;42(1):41–7.
4. Bozic KJ, Kamath AF, Ong K, Lau E, Kurtz S, Chan V, Vail TP, Rubash H, Berry DJ. Comparative epidemiology of revision arthroplasty: failed THA poses greater clinical and economic burdens Than failed TKA. Clin Orthop Relat Res. 2015;473(6):2131.
5. Chen FS, Di Cesare PE, Kale AA, Lee JF, Frnakel VH, Stuchin SA, et al. Results of cemented metal-backed acetabular components. A 10-year-average follow-up study. J Arthroplast. 1998;13:867–73.
6. Civinini R, Carulli C, Matassi F, Nistri L, Innocenti M. A dual-mobility cup reduces risk of dislocation in isolated acetabular revisions. Clin Orthop Relat Res. 2012;470:3542–8.
7. Darrith B, Courtney PM, Della Valle CJ. Outcomes of dual mobility components in total hip arthroplasty: a systematic review of the literature. Bone Joint J. 2018 Jan;100-B(1):11–9.
8. De Martino I, D'Apolito R, Soranoglou VG, Poultsides LA, Sculco PK, Sculco TP. Dislocation following total hip arthroplasty using dual mobility acetabular components: a systematic review. Bone Joint J. 2017 Jan;99-B(ASuppl1):18–24.
9. Ebramzadeh E, Beaulé PE, Culwell JL, Amstutz HC. Fixation strength of an all-metal acetabular component cemented into an acetabular shell: a biomechanical analysis. J Arthroplast. 2004;19:45–9.
10. Fraser GA, Wroblewski BM. Revision of the Charnley low-friction arthroplasty for recurrent or irreducible dislocation. J Bone Joint Surg (Br). 1981;63B:552–5.
11. Gaudin G, Ferreira A, Gaillard R, Prudhon JL, Caton JH, Lustig S. Equivalent wear performance of dual mobility bearing compared with standard bearing in total hip arthroplasty: in vitro study. Int Orthop. 2017;41(3):521–7.
12. Guyen O, Pibarot V, Vaz G, Chevillotte C, Béjui-Hugues J. Use of a dual-mobility socket to manage total hip arthroplasty instability. Clin Orthop Relat Res. 2009;467:465–72.

13. Haen TX, Lonjon G, Vandenbussche E. Can cemented dual mobility cup be used without a reinforcement device in cases of mild acetabular bone stock alteration in total hip arthroplasty? Orthop Traumatol Surg Res. 2015;101:923–7.
14. Hailer NP, Weiss RJ, Stark A, Kärrholm J. Dual-mobility cups for revision due to instability are associated with a low rate of re-revisions due to dislocation: 228 patients from the Swedish hip arthroplasty register. Acta Orthop. 2012 Dec;83(6):566–71.
15. Hamadouche M, Biau DJ, Huten D, Musset T, Gaucher F. The use of a cemented dual-mobility socket to treat recurrent dislocation. Clin Orthop Rel Res. 2010;468:3248–54.
16. Jo S, Jimenez Almonte JH, Sierra RJ. The Cumulative Risk of Re-dislocation After Revision THA Performed for Instability Increases Close to 35% at 15 years. J Arthroplast. 2015 Jul;30(7):1177–82.
17. Kerboull M, Hamadouche M, Kerboull L. The Kerboull acetabular reinforcement device in major acetabular reconstructions. Clin Orthop Rel Res. 2000;378:155–68.
18. Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United states from 2005 to 2030. J Bone Joint Surg Am. 2007;89(4):780–5.
19. Kurtz S, Ong KL, Lau E, Bozic KJ. Impact of the economic downturn on total joint replacement demand in the United States: updated projections to 2021. J Bone Joint Surg Am. 2014;96(8):624–30.
20. Lange JK, Spiro SK, Westrich GH. Utilizing dual mobility components for first-time revision total hip arthroplasty for instability. J Arthroplast. 2018 Feb;33(2):505–9.
21. Langlais F, Ropars M, Gaucher F, Musset T, Chaix O. Dual-mobility cemented cups have low dislocation rates in THA revisions. Clin Orthop Relat Res. 2008;466:389–95.
22. Lebeau N, Bayle M, Belhaouane R, Chelli M, Havet E, Brunschweiler B, Mertl P. Total hip arthroplasty revision by dual-mobility acetabular cup cemented in a metal reinforcement: A 62 case series at a minimum 5 years follow-up. Orthop Traumatol Surg Res. 2017;103(5):679–84.
23. Lecuire F, Benareau I, Rubini J, Basso M. Intra-prosthetic dislocation of the Bousquet dual-mobility socket. Orthop Traumatol Surg Res. 2004;90:249–55.
24. Leiber-Wackenheim F, Brunschweiler B, Ehlinger M, Gabrion M, Mertl P. Treatment of recurrent THR dislocation using of a cementless dual-mobility cup: a 59 cases series with a mean 8 years' follow-up. Orthop Traumatol Surg Res. 2011;97:8–13.
25. Lübbeke RC, Barea C, Köhnlein W, Hoffmeyer P. Revision total hip arthroplasty in patients 80 years or older. J Arthroplast. 2012;27:1041–6.
26. Massin P, Besnier L. Acetabular revision using a press-fit dual-mobility cup. Orthop Traumatol Surg Res. 2010;96:9–13.
27. Patel PD, Potts A, Froimson MI. The dislocating hip arthroplasty: prevention and treatment. J Arthroplast. 2007;22(suppl 1):86–90.
28. Pattyn C, Audenaert E. Early complications after revision total hip arthroplasty with cemented dual-mobility socket and reinforcement ring. Acta Orthop Belg. 2012;78:357–61.
29. Peraldi P, Vandenbussche E, Augereau B. Bad clinical results of cemented cups with metal-backed acetabular components. 124 cases with 21 months follow-up. Rev Chir Orthop. 1997;83:561–5.
30. Philippot R, Adam P, Reckhaus M, Delangle F, Verdot FX, Curvale G, et al. Post-prosthetic dislocation prevention in total hip revision surgery using a dual-mobility design. Orthop Traumatol Surg Res. 2009;95:505–11.
31. Prudhon JL, Desmarchelier R, Hamadouche M, Delaunay C, Verdier R. SoFCOT: Causes for revision of dual-mobility and standard primary total hip arthroplasty: matched case-control study based on a prospective multicenter study of two thousand and forty-four implants. Int Orthop. 2017;41(3):455–9.
32. Ravi B, Croxford R, Reichmann WM, Losina E, Katz JN, Hawker GA. The changing demographics of total joint arthroplasty recipients in the United States and Ontario from 2001 to 2007. Best Pract Res Clin Rheumatol. 2012;26(5):637–47.

33. Regis SA, Bonetti I, Bortolami O, Bartolozzi P. A minimum of 10-year follow-up of the Burch-Schneider cage and bulk allografts for the revision of pelvic discontinuity. J Arthroplast. 2012;27:1057–63.
34. Schneider L, Philippot R, Boyer B, Farizon F. Revision total hip arthroplasty using a reconstruction cage device and a cemented dual-mobility. Orthop Traumatol Surg Res. 2011;97:807–13.
35. Wachtl SW, Jung M, Jakob RP, Gautier E. The Burch-Schneider antiprotrusion cage in acetabular revision surgery: a mean follow-up of 12 years. J Arthroplast. 2000;15:959–63.
36. Wegrzyn J, Pibarot V, Jacquel A, Carret JP, Béjui-Hugues J, Guyen O. Acetabular reconstruction using a Kerboull cross-plate, structural allograft and cemented dual-mobility cup in revision THA at a minimum 5-year follow-up. J Arthroplast. 2014;29:432–7.
37. Wegrzyn J, Thoreson AR, Guyen O, Lewallen DG, An KN. Cementation of a dual-mobility acetabular component into a well-fixed metal shell during revision total hip arthroplasty. J Orthop Res. 2013;31(6):991–7.