Review Article

Usefulness of modular neck adapter in partial hip revision

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Background and Objective: Modular neck adapters allow different length and offset changes to reach a stable total hip arthroplasty (THA) and permit a quick partial hip revision procedure without removing the existing components. The literature is poor on this matter and about the long-term related outcomes. This narrative review summarizes the most recent literature about these devices as an option of surgical treatment in partial total hip arthroplasty revision (THAr) focusing on indications, clinical and radiological outcomes, and related complications.

Methods: The narrative review of the current available literature was conducted in December 2022 through electronic database. The terms used were: "Head neck taper" OR "Merete BioBall" AND "revision Total Hip Arthroplasty (MeSH Terms)". The timeframe was limited between 01/01/2000 and 01/12/2022. The studies regarding the clinical use of the Merete BioBall® system in hip revision surgery were included, while all the papers concerning modular stem prosthesis were excluded.

Key Content and Findings: The surgical procedure is safe, quick and allows the surgeon to correct a well-fixed stem version, length and offset, besides retensioning soft tissues. Clinical and radiological outcomes are good with low complications rates.

Conclusions: The modular neck adapter system seems to be a good surgical procedure for recurrent dislocation of THA, especially in case of a second THAr surgery. However, the main indication of adapter use remains the isolated acetabular cup revision. The related complications are rare: the worst is the re-dislocation due to an insufficient stem version and length correction. Re-dislocation rates reported in literature vary from 5.2% to 15%. Corrosion or fretting of the modular system are not reported in literature.

Keywords: Hip revision arthroplasty; head-neck adapter; total hip arthroplasty (THA); Merete BioBall

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Introduction

The modularity in total hip arthroplasty (THA) is widely recognized in hip surgery thanks to the advantage of being able to adapt the different acetabular and femoral components geometries to each other (1). However, the incidence of total hip arthroplasty revision (THAr) is increasing due to the high volume of hip prostheses performed worldwide (2,3).

Among the different indications to undergo a new hip surgery after THA, the main ones concern revision of the isolated acetabular component (4), often caused by polyethylene wear and prosthetic dislocation. Stem subsidence, conversions from hemiarthroplasty to THA, and/or ceramic head fracture are other reasons of hip revision (1). Moreover, the recent modular prostheses can lead to different problems like dissociation, breakage, and interfacial fretting corrosion (5-7).

On the other hand, a well-fixed stem component revision usually results difficult to perform and vigorous attempts can carry out to femoral shaft fracture. This event is easier to happen during a second stem re-revision due to the extensively coated prosthesis used previously in the first re-implantation (8). Chung *et al.* (9) in their study on Paprosky femoral type III defects in 96 femoral revisions achieved stable bony in-growth in 92 cases. Jayakumar *et al.* (10) demonstrated evidence of bony in-growth and stable fixation, with no cases of loosening, instability, deep infection, stress shielding, subsidence or osteolysis after 6 years of follow-up. Moon *et al.* (11) also showed similar results in 35 patients after 77.5 months of follow-up.

In these scenarios of THAr, a modular neck adapter that engages the femoral stem could be useful in order to protect the neck-head junction and restore preoperative biomechanics and soft tissue tension when the femoral or acetabular component should be retained or reoriented. This system allows an arthroplasty revision in case of a well-fixed femoral and acetabular components or where different manufacturing systems are used and an off-label pairing is required (12).

Currently, the only head-neck metal adapters commercialized on the market (13-15) is the Merete BioBall® (Merete Medical, Berlin, Germany) (2,12). These adapters are made of Titanium (TiAl6V4) and are available in several lengths (from –3 to +21 mm identified from S to 5XL) to adapt to the characteristics of different morse tapers (12/14, 14/16, 8/10, 10/12, 11/12, 11/13, V40). Additionally, they have a 7.5° offset and the neck-tapers can be rotated 360 degrees to achieve the best stem neck orientation (*Figure 1*).

In addition to this, there are available modular heads in different materials (ceramic—Biolox® Delta, CeramTec GmbH, Plochingen, Germany or Biolox® Forte, CeramTec GmbH, Plochingen, Germany, and metals—Vivium® CrNiMnMo-ISO5832-9, Merete Medical GmbH, Berlin, Germany) and sizes (from 28 to 58 mm) (1).

Despite the versatility offered by this system, scientific literature about its clinical utility and related complications is very poor and there is few evidence concerning their real use. Revision hip arthroplasty using a modular head-neck adapter is an infrequent surgical procedure with rare outcomes reported (2). The objective of this narrative review is to assess the BioBall® Merete system in terms of clinical and radiological results when performing THA revision. We present this article in accordance with the Narrative Review reporting checklist (available at https://aoj.amegroups.com/article/view/10.21037/aoj-23-22/rc).

Methods

The narrative review of the current available literature was conducted in December 2022 through electronic database PubMed, Scopus and Embase. Electronic search was performed independently by two reviewers (Pautasso A and Bardellini G) using the following terms: “Head neck taper” OR “Merete BioBall” AND “revision Total Hip Arthroplasty (MeSH Terms)”. The timeframe was limited between 01/01/2000 and 01/12/2022. Only English-language articles were selected. Published studies that contained data regarding the clinical use of the Merete BioBall® system in hip revision surgery were included, while all the papers concerning modular stem prosthesis and the related neck complications were excluded. The abstract of the selected articles was evaluated. Furthermore, a manual search within the references of the selected articles was performed by the authors (*Table 1*).

Indications

There is no consensus regarding indications for the use of modular neck adapters in THAr.

Hoberg *et al.* (2), in their study on 95 patients, found out that the 39% of all indications were for recurrent THA dislocations, 38% acetabular component loosening, and 17% acetabular polyethylene liner wear. Forty-four percent of the patients before the implantation of the Merete BioBall® adapter system had one or more revision surgeries.

In the recent systematic review of the Merete BioBall® system described by Novoa *et al.* (1), which involved 194 patients out of 14 studies included, the primary indication of neck-tapers adapter use was the isolated acetabular cup revision surgery (71.6%), followed by THA instability with recurrent dislocation, stem subsidence and conversion from hemiarthroplasty to THA. In this type of surgery, the authors underline how in some cases the stem's morse taper presents damage due to the head removal, either bad pre-coupling, breakage of the components and/or poor extraction technique too. This damage could increase the risk of fretting corrosion. When the damage is low, the taper should be protected through metal adapter and the stem could be retained. In case of substantial damage, the neck or the entire stem block should be replaced (13,17). When a metal adapter is used, it must be adjusted to the morse taper characteristics.

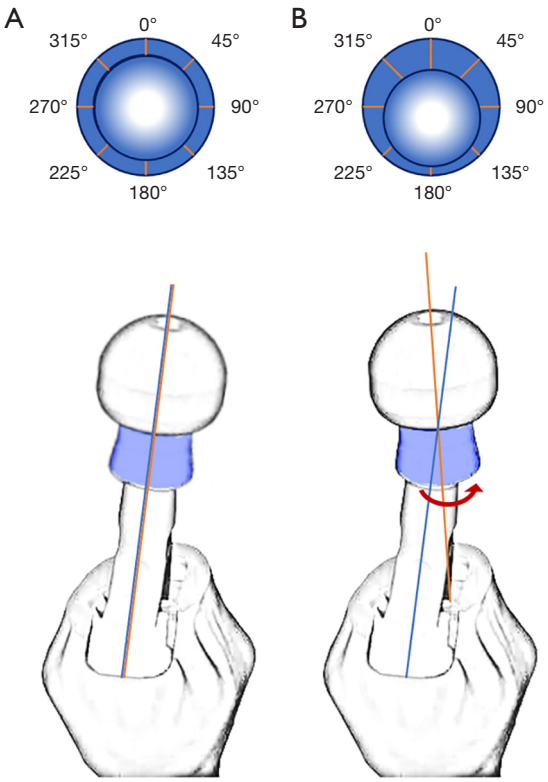

Figure 1 Standard (A) and offset (B) neck-adapter representation.

Besides protecting the head-neck junction, the system is used to increase the length of the taper, the soft tissue tension and the femoral offset. These features are essential in recurrent dislocation revision surgery (*Figures 2,3*), as observed by Woelfle *et al.* (12).

The Merete BioBall® modular head system can help the surgeon to correct femoral stem malpositioning in order to decrease the risk of dislocation. It allows the surgeon to equalize neck length and to correct the stem antetorsion intra-operatively, without the need to revise a stable femoral component, thus avoiding risk of femoral shaft fractures or longer operative times, with simple instrumentation (8).

The most frequent situation where the BioBall system has been useful is in case of a second THAr surgery. The possibility of choosing from a variety of tapers (12/14 and 14/16) is one of the great benefits the adapter offers (2).

Table 1 The search strategy summary

Items	Specification
Date of search	December 16th, 2022
Databases and other sources searched	Embase/PubMed/Scopus
Search terms used	"Head neck taper" OR "Merete BioBall" AND "revision Total Hip Arthroplasty (MeSH terms)"
Timeframe	2000–2022. Exceptions for references of past classifications [e.g., Brooker Classification (16)]
Inclusion criteria	Only English language articles were included
Selection process	Pautasso A and Bardellini G conducted independently the research on the electronic database
Any additional considerations, if applicable	Abstracts of the selected articles were evaluated
	Published studies that contained data regarding the clinical use of the Merete BioBall system in hip revision surgery were included
	All the papers concerning modular stem prosthesis and the related neck complications were excluded

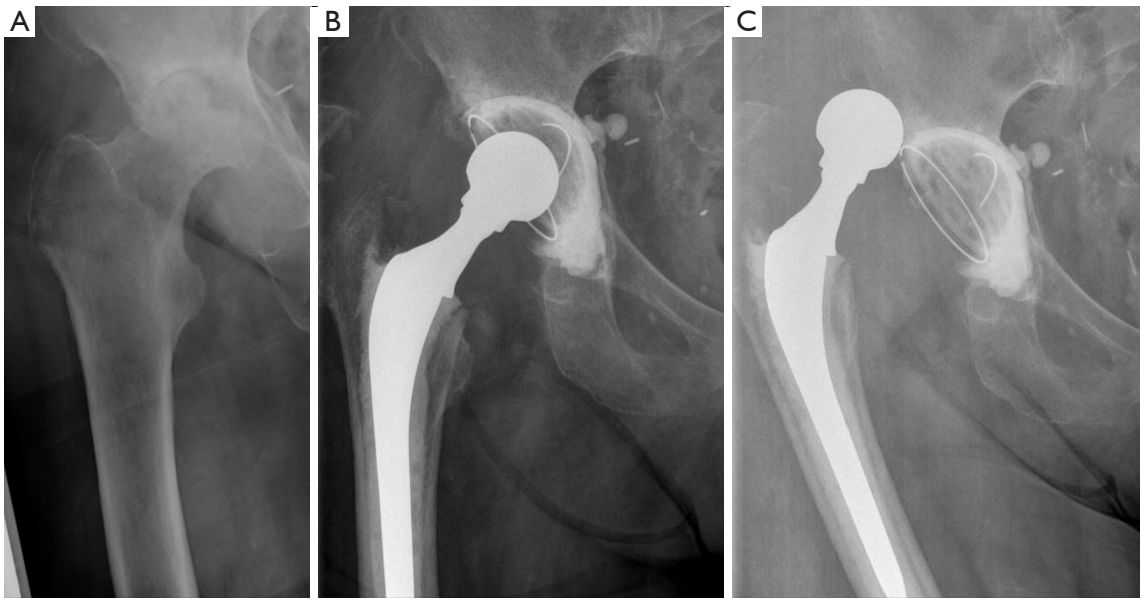

Figure 2 X-rays sequences of authors' clinical case: ANFH (A), THA (B) and THA dislocation (C). ANFH, avascular necrosis of femoral head; THA, total hip arthroplasty.

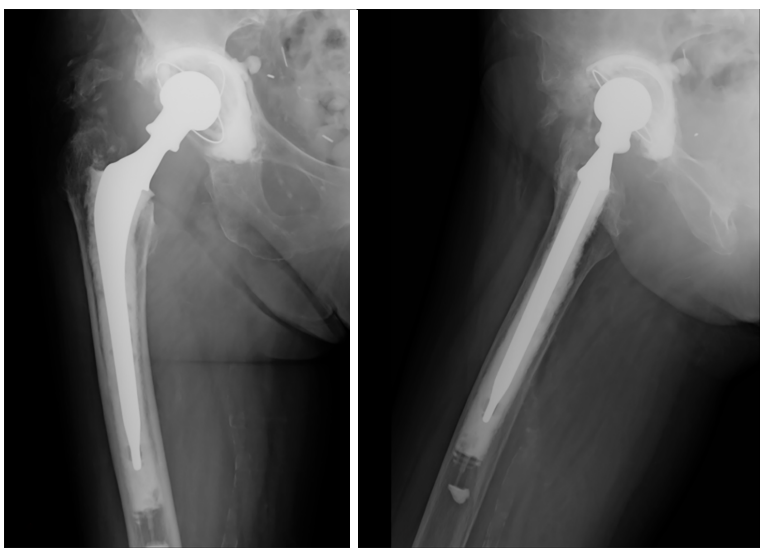

Figure 3 X-rays sequences of authors' clinical case: the two radiological projections after THA revision surgery with Merete BioBall®. THA, total hip arthroplasty.

Clinical and radiological outcomes

Few studies report clinical and radiological outcomes of the Merete BioBall® modular neck adapter system. Hoberg *et al.* (2), in their study on 95 patients, did not find any signs of osteolysis, radiolucency or loosening. The use of modular neck adapters did not impact on the formation of periarticular ossifications, with only 16.1% of patients classified as Brooker type I, 4.4% as Brooker type II, and 1.1% as Brooker type III (16). Radiological information about offset restoration and improvement of leg length was demonstrated by Woelfle *et al.* (12). In their study on 37 patients who performed THA revision with Merete

BioBall®, leg length discrepancy passed from 5.8 to 1.2 mm and offset difference improved from 3 to 0 mm. However, clinical results were not as good as the radiological ones, due to high morbidity and old age of the patients involved in the study. Lakstein *et al.* (18) and De Fine *et al.* (19) in their studies do not show a significant relationship between leg length or femoral offset restoration and the patient's functional recovery.

Clinical outcomes were good in the study by Hoberg *et al.* (2). Patients experienced a Harris Hip Score (HHS) average of 80.9 after surgery with BioBall® System and they were satisfied in 89% of cases. Pain free life was achieved in several cases (86.8%): the mean level of Visual Analogue Scale (VAS) was 1.4. Unfortunately, they did not report any improvement in range of motion (ROM) after surgery.

On the other hand, Woelfle *et al.* (12) had poorer clinical outcomes: the HHS average post-surgery was 54.0 in their series on 37 patients. These patients were older and obtained a low clinical outcome with 20% rate of second revisions. These factors show the restricted and limited indications for the use of modular neck adapters like the Merete BioBall® system.

Dabis *et al.* (20), in a study on 32 patients treated with the Merete BioBall® modular neck adapters, had a very good clinical outcome with 6.3% post-operatory recurrent dislocation rate and a significant improvement in the Western Ontario and McMaster Universities Arthritis Index (WOMAC) questionnaire, confirming the functionality and effectiveness of the system.

Related complications and implants survival

The modularity augmentation in the implants could lead to a well-known phenomenon like dissociation, breakage and interfacial fretting corrosion. In this related case, the modular system could potentially conduct to an adapter-neck junction failure or to an earlier corrosion of the materials. The risk of corrosion has been investigated by Kretzer *et al.* (21): they conducted an *in vitro* study in which they compared four different modular stem prosthesis (Eco-Modular®, Endoplant, Marl, Germany; Varicon®, Falcon Medical, Mödling, Austria; Metha®, Aesculap, Tuttlingen, Germany; SPS-Modular®, Symbios, Yverdon, Switzerland), and the universal modular neck adapter (BioBall®, Merete, Berlin, Germany), finding out that the metal ions released from the implants interface was very low. They also proved that fretting corrosion was minimal when applying forces of normal gait. Nevertheless, fretting corrosion remains a big deal in modular hip endoprosthetics: various studies report up to 34.5% of corrosion when scanning with electron microscopy the components explanted during revisions (6,22,23). In two recent reviews, during BioBall® revision surgeries, the authors did not find any clinical signs of corrosion or fretting (1,2).

The mechanism of modular components failure happens in two modalities: fatigue fractures of the neck adapter caused by surface cracks (24) and third body wear that leads to periprosthetic osteolysis (25).

In literature, Lizano-Díez *et al.* (26) reported one case of stem neck fracture in a patient with a BioBall® 4XL adapter, which happened two years after an isolated acetabular cup revision. This is the only known case of this complication and it could be due to the elevated force created by such a long neck adapter on the stem neck.

Another possible complication cited in literature is the ceramic head fracture when using the BioBall® adapters. Jack *et al.* (27) and Habermann *et al.* (28) had a ceramic head fracture using a 32 mm and a 28 mm alumina ceramic head (Biolox® Forte®), respectively. It is important to note that no cases of ceramic head fracture have ever been reported when using Biolox® Delta® ceramic heads (8,17). As a matter of fact, the Merete BioBall® adapters are coupled only with fourth generation ceramic heads: Biolox® Delta®. In the projecting phase, the modular neck adapters were subjected to the tests of breaking strength (ISO 7206-4; ISO 7206-6; ISO 7206-8; ASTM F2068; ISO 7206-10 and ASTM C1465-08) with good results.

Another possible issue may be the disassembly of the system, especially when using the longest adapters in addition to the offset configuration (29). To date, there are not any known cases of this phenomenon reported in literature: other reviews such as the one by Novoa *et al.* (1) and the one by Hoberg *et al.* (2) confirm this thesis. Hoberg *et al.* (2) reported in their study a 92.8% [95% confidence interval (CI): 84–95%] implant survival at 8.17 years: this confirms the good survival of the adapter. Nevertheless, more studies are needed to confirm the long-term outcome presented.

In addition to this, it is important to know that the BioBall® adapters cannot be coupled with femoral heads under 28 mm of diameter. As such, in case of a revision of a dual mobility cup of small diameter (30), the system has not to be taken into account.

Actually, the most important problem during the use of BioBall® adapters is recurrent hip dislocation after its use. The re-dislocation rates reported in literature vary from

5.2% (2) to 15% (12). The adapter system cannot always compensate big version defects of the acetabular cup and the stem. In these cases, a revision of the components is necessary to obtain a stable hip arthroplasty.

Conclusions

The modular neck adapter system seems to be a good surgical procedure for recurrent dislocation of THA with a well-fixed stem but not positioned correctly or during an isolated acetabular cup revision, which is actually the main indication of implant use. The literature is very poor on this matter and the long-term outcomes have yet to be proven in more clinical trials.

However, the taper adapter system allows different length and offset neck changes to reach a stable THA, it permits the surgeon to perform a quick revision without removing the existing components, and finally, the great flexibility and precision of the system results helpful in cases of unexpected surgical situations like unstable hip prosthesis. Some possible complications related to the implant design were reported but as isolated cases. The neck adapter failure or corrosion phenomena have not been reported to date in literature.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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