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REVIEW

# Outcomes of neck modularity in total hip arthroplasty: an Italian perspective

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## Abstract

**Background** The aim of this study is to conduct a systematic review of clinical outcomes and complications of modular neck THA among Italian cohorts.

**Methods** Only reviewed publications focused on Italian cohort patients in English language were considered for inclusion. Studies were included if they involved patients who underwent total hip replacement surgery with modular necks, and reported aetiology or survival rate or bone stability or clinical scores or complications.

**Results** The studies included in our search reported data on 3714 patients and 3856 hips. Most of the studies were from high-volume surgery centres. The most frequent diagnosis was osteoarthritis that occurred in 2910 cases (75.9%). The average survival rate and average bone stability were 97.20% and 99.37%, respectively. The average HHS improved from 42.1 prior to surgery to 89.52 after surgery. Studies included in our search reported 40 complications. The most frequently reported complication was dislocation (40%).

**Conclusion** This review showed excellent survival rate and bone stability and good clinical outcomes in Italian cohort patients treated with modular neck THA, and these clinical results are comparable with international cohort rates. This review suggests that modular implants represent a very satisfying choice when practised by expert orthopaedic joint surgeons.

**Keywords** Total hip arthroplasty · Modular neck · Modular stem · Modular implants · Complications · Outcomes · Italian cohorts

## Introduction

Total hip arthroplasty (THA) represents a safe and efficient solution for patients suffering of many hip diseases such as osteoarthritis, since it is effective in the pain relief and improvement in quality of life through improved mobility and raised independence [1]. In the last decades, different approaches of THA have been developed such as cemented and cementless techniques; instead, more recently, the use of head/neck modularity has been popularized [2]. The introduction of modularity, since the last 1990s, has changed the approach strategies in primary and revision THA [3]. In the past, modularity was substantially an option in the choice of prosthetic head. Now, the modular THA consists in different parts that may be assembled, and that system allows the surgeon to have a more versatile system. Neck modularity in primary THA aims to recreate the physiological longitudinal and lateral offset and anteversion or retroversion [4]. Modular neck solutions should theoretically improve proper femoral offset restoration, which in turn should determine lower joint reaction forces and better soft tissue tensioning and lower the risk of neck to cup impingement with subsequent implant dislocation. The success of modularity to restore the joint geometry is particularly useful when the anatomy is altered, as in hip dysplasia or in post-traumatic arthritis [5]. In the context of THA revision surgery, neck modularity has the important function in matching the old and the new surgery by varying the offsets to improve the strength of the total system [3]. Analysis of hip anatomy, particularly on the femoral side, has evidenced sex-based anatomic distinction. Women usually have a shorter neck of the femur, a thinner shaft, a minor cervicodiaphyseal (CCD) angle, a

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minor offset and a bigger anteversion of the femoral neck. Modular neck stems are particularly useful when there is a mismatch between the stem size and neck length and when there is a large amount of neck anteversion. These conditions are more common in women than in men [6]. Although the capability of modular neck prostheses to recreate hip configuration in a clinical setting is still debated, the advantages of a near-normal femoral offset should be preventive in reduction in bearing superficies wear, graft loosening and dislocation rates [7]. On the other hand, the introduction of an additional modular junction could increase the risk of implant failure and several cases of modular neck failures and fretting corrosion at the neck–stem junction have been reported [8, 9]. Besides, revision for fractured modular necks could be very difficult, since the reuse of a damaged trunnion should be ideally avoided, and the revision of a well-fixed stem is surgically demanding. The modularity of the implant could present problems related to the mechanical integrity and to the production of particles (fretting) at the interface between the modular neck and the prosthetic stem caused by micro-movements of the two metal components: accurate biomechanical studies have enforced the reliability of the implant in this sense [10]. Few clinical report the experience with modular THA of Italian cohort. The first of them, published in 1985, reported preliminary results obtained in prosthetic implants with modular hip arthroplasty [11], while the most recent has been published in 2017 [12]. However, these reports represent a small part of the overall number of published studies on THA by the Italian orthopaedic community, and we do not know how neck modularity has changed the way of performing this surgery in Italy and above all the contribution of the Italian orthopaedic community on this topic. Therefore, the aim of this study is to conduct a systematic review of clinical outcomes and complications of modular neck THA among Italian cohorts.

## Materials and methods

The present work was carried out in accordance with Preferential Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

### Eligibility criteria

Only reviewed publications focused on Italian cohort patients were considered for inclusion. Research was not limited in time. Studies were included if they involved patients who underwent total hip arthroplasty surgery with modular prosthesis and reported aetiology or survival rate or bone stability or clinical score or complications. According to the reviewers' language capabilities, considered studies were those written in English. Studies on animals, in vitro or biomechanical studies and cadaver experimentations were excluded.

### Information sources and search

Electronic research was performed through online databases including PubMed–Medline and the Cochrane Central Registry of Controlled Trials. The research was carried out by two reviewers (A.D.M and A.C.) to identify eligible studies. The utilized search strings were: modular (All Fields) AND ["prosthesis implantation" (MeSH Terms) OR ["prosthesis" (All Fields) AND "implantation" (All Fields)] OR "prosthesis AND modular (All Fields) AND ["neck" (MeSH Terms) OR "neck" (All Fields)] AND ["arthroplasty, arthroplasty, hip" (MeSH Terms) OR ["arthroplasty" (All Fields) AND "arthroplasty" (All Fields) AND "hip" (All Fields)] OR "hip arthroplasty" (All Fields) OR ["hip" (All Fields) AND "arthroplasty" (All Fields)] OR "hip arthroplasty" (All Fields)].

### Study selection

Once the studies eligible for inclusion were retrieved, the full text of relevant articles was obtained and evaluated. A manual research was also performed through the bibliography of each of the relevant articles, to identify potentially missed eligible papers. Duplicates were removed. The study selection process, carried out in accordance with PRISMA flow chart, is shown in Fig. 1.

### Quality assessment of the studies

The quality of the studies was evaluated according to AAOS clinical practice guideline and systematic review methodology [13]. The following questions were used to evaluate the study quality of diagnostic study designs: Was the patient spectrum representative of the patients who will receive the test in practice? Were the selection criteria clearly described? Was the execution of the index and reference tests described in sufficient detail to permit its replication? Is the reference standard likely to correctly classify the target condition? Are the index test results interpreted by an examiner without the knowledge of the reference tests results? A study is considered as high-quality study if it has $<1$ flaw, as moderate-quality study if it has $\geq 1$ and $<2$ flaws, as low-quality study if it has $\geq 2$ and $<3$ flaws and as very low-quality study if it has $\geq 3$ flaws (Table 1).

## Results

From the research performed, 14 studies [3, 6, 10, 12, 14–23] were considered suitable to be included for review. According to AAOS clinical practice guideline and

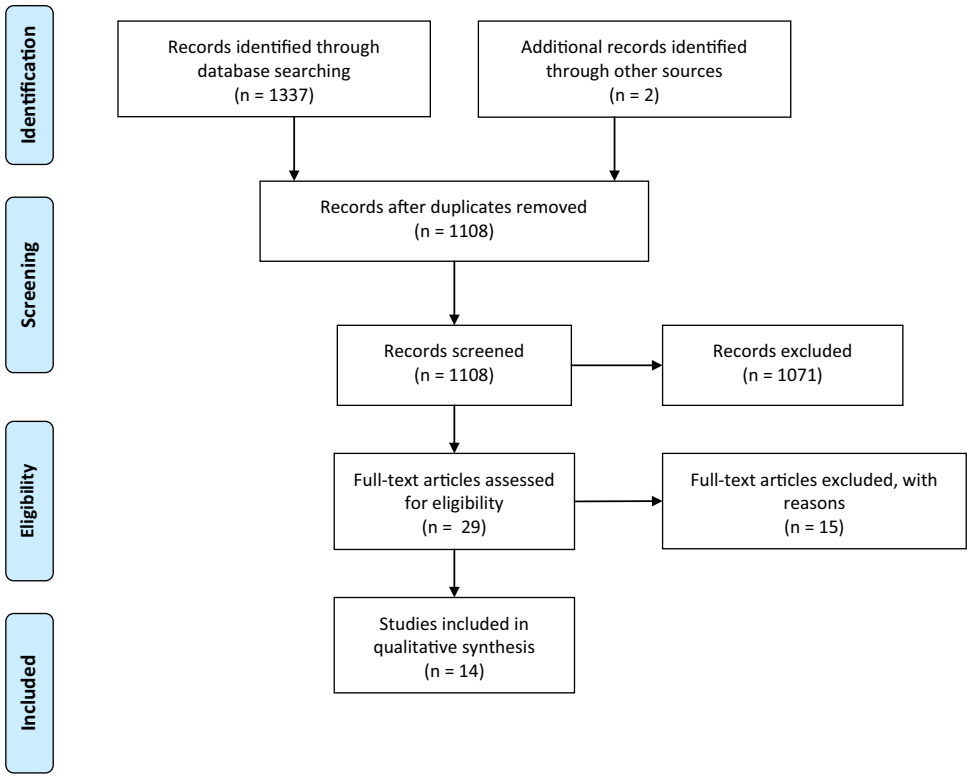


**Fig. 1** PRISMA Flow chart

**Table 1** Study design quality key (AAOS clinical practice guideline and systematic review methodology)

| | |
|---|---|
| High-quality study | < 1 flaw |
| Moderate-quality study | ≥ 1 and < 2 flaws |
| Low-quality study | ≥ 2 and < 3 flaws |
| Very low-quality study | ≥ 3 flaws |

systematic review methodology, all studies have been rated as high–moderate-quality studies. All the included studies were analysed, and the following data were extracted and are summarized in Table 2: year of the study, numbers of patients, numbers of operated hips and average follow-up (months). Overall, the studies included in our search reported data on 3714 patients and 3856 hips. A total of 3775 (98.5%) primary implants and 59 (1.5%) total revisions were performed. The average follow-up was 66.5 months. The primary diagnosis was the following: primary osteoarthritis in 2910 cases (75.9%), dysplasia of the hip in 619 cases (16.1%), osteonecrosis of the femoral head in 74 cases (2%) and other pathologies in 231 cases (6%). Of the 14 studies, one [14] reporting on 22 patients does not contain the aetiology of the total hip arthroplasty. The most frequent surgical technique performed in the studies included in our search was the standard posterolateral surgical approach (62%). Seven studies [6, 16, 18–20, 22, 23] included the survival rate that in our search was estimated to be between

**Table 2** Data of included studies

| Name | Year | No. of patients | No. of hips | Average follow-up (months) |
|---|---|---|---|---|
| Toni et al. | 2001 | 325 | 347 | 21 |
| Bellomo et al. | 2002 | 14 | 14 | 26 |
| Antonietti et al. | 2003 | 208 | 216 | 36 |
| Benazzo et al. | 2007 | 100 | 105 | 44 |
| Traina et al. | 2009 | 2131 | 2131 | 108 |
| Benazzo et al. | 2010 | 222 | 239 | 60 |
| Traina et al. | 2011 | 47 | 61 | 117.2 |
| Bistolfi et al. | 2012 | 190 | 207 | 49.7 |
| Dagnino et al. | 2012 | 48 | 60 | 59 |
| Traina et al. | 2012 | 28 | 32 | 98 |
| Benazzo et al. | 2015 | 143 | 173 | 84 |
| Chillemi et al. | 2016 | 22 | 22 | 12 |
| Ceretti et al. | 2016 | 1 | 1 | 30 |
| Toni et al. | 2017 | 235 | 248 | 186 |
| Total | | 3714 | 3856 | 66.5 |

92.80 [22] and 98.60% [16, 20] with an average of 97.20%. The radiographic analysis showed an average bone stability of 99.37% with a range from 96.70 [21] to 100% [10, 18–20, 22]. Average survival rate and average bone stability were extracted and are summarized in Table 3. In six studies [18–23], patients were assessed before surgery and at

**Table 3** Survival rate and bone stability of modular hip prosthesis

| Name | Year | Survival rate (%) | Bone stability (%) |
|---|---|---|---|
| Toni et al. | 2001 | NR | 100 |
| Antonietti et al. | 2003 | 98.60 | 99.30 |
| Traina et al. | 2009 | 96.80 | NR |
| Benazzo et al. | 2010 | 98.28 | 100 |
| Traina et al. | 2011 | 97.50 | 100 |
| Bistolfi et al. | 2012 | 98.60 | 100 |
| Dagnino et al. | 2012 | NR | 96.70 |
| Traina et al. | 2012 | 92.80 | 100 |
| Benazzo et al. | 2015 | 97.60 | 99 |
| Average | | 97.20 | 99.37 |

**Table 4** Harris Hip Score

| Name | Year | Pre-operative Harris Hip Score | Post-operative Harris Hip Score |
|---|---|---|---|
| Benazzo et al. | 2010 | 35 | 96.6 |
| Traina et al. | 2011 | NR | 74.7 |
| Bistolfi et al. | 2012 | 55.5 | 98.5 |
| Dagnino et al. | 2012 | 37 | 89.3 |
| Traina et al. | 2012 | 48.3 | 86 |
| Benazzo et al. | 2015 | 42 | 92 |
| Average | | 42.1 | 89.52 |

3 months, 6 months and annually after surgery with the Harris Hip Score (HHS), a disease-specific scoring system that includes the categories of function, pain, range of motion and deformities. The average HHS improved from 42.1 to 89.52 (Table 4). In two studies [10, 15], the clinical evaluation was made by means of Merle d'Aubigne and Postel score that include the measures of pain, motility and motion with decreasing scores from 6 to 1 (Table 5). In the study by Toni et al. [10], the pre-operative Merle d'Aubigne and Postel score was 11.4 (pain 3.6, mobility 4.0, function 3.8) and the post-operative score was 17.4 (pain 5.9, mobility 5.8, function 5.7). In the study by Bellomo et al. [15], the pre-operative score was 6.9 (pain 2.3, mobility 2.5, function 2.1) and the post-operative score was 13.9 (pain 5.1, mobility 4.7, function 4.1). In 10 studies included in our search were reported 40 complications. (The scores are summarized in Table 4.). Dislocation was the most frequent complication reported in our search, accounting for 40% of the total. Periprosthetic fractures, aseptic loosening, septic loosening and other complication accounted for 20%, 17.5%, 17.5% and 5%, respectively (Table 6). Cases of modular neck failure or fretting corrosion at the neck–stem junction have not been reported.

## Discussion

Modular neck prostheses give the surgeon the possibility to adjust during surgery the length of the limb, the offset, the length and anteversion of the neck, while avoiding the high costs of custom-made prostheses; they may also respond to the technical necessity and the monitoring of the standard product to which custom-made prostheses cannot answer [4]. The survival rate of modular neck THA in our search was estimated to be between 92.80 and 98.60% (average of 97.20%), which was comparable to survival rate from studies from the international orthopaedic community. Wirtz et al. [24] reported a Kaplan–Meier survival analysis of 97% at 10 years. Holt et al. [25] reported a survival rate of 94%. Survival rate at 10 years in the study published by Collet et al. [26] was 94.2%. Silverton et al. [27], Cossetto et al. [28] and Blakey et al. [29] in their series focused on modular stems and reported Kaplan–Meier survival rates, respectively, of 89.4% at 8 years, 96% at 10 years and 97.5% at 5 years. Mihalko et al. published a systematic review on modular neck implants with a survivorship ranging from 91 to 100% at 8.6 years. Regarding radiographic analysis of modular neck THA, a mean value of 99.37% was reported in Italian cohort studies. Wirtz et al. [24] in their series of 163 hips reported a stem stability of 93% at last follow-up. Clinical outcomes of the studies included in our research were assessed with Harris Hip Score and Merle d'Aubigne and Postel score. The mean post-operative HHS was 89.52, and the mean post-operative Merle d'Aubigne and Postel score was 17.4 (pain 5.9, mobility 5.8, function 5.7). HHS values of Italian cohorts are comparable with International community ones. Post-operative HHS in published by Collet et al. [26], Vanbiervliet et al. [30] and Silverton et al. reached, respectively, 94 points at 9.4 years, 90 points at

**Table 5** Merle d'Aubigne score

| Name | Year | Pre-operative Merle d'Aubigne score | Post-operative Merle d'Aubigne score |
|---|---|---|---|
| Bellomo et al. | 2002 | 6.9 (pain 2.3, mobility 2.5, function 2.1) | 13.9 (pain 5.1, mobility 4.7, function 4.1) |
| Toni et al. | 2017 | 11.4 (pain 3.6, mobility 4.0, function 3.8) | 17.4 (pain 5.9, mobility 5.8, function 5.7) |

**Table 6** Complications

| Name of study | Year | No. of complications | Type of complications |
|---|---|---|---|
| Toni et al. | 2001 | 7 (2%) | Four dislocations (1.15%) |
| | | | One deep infection (0.3%) |
| | | | Two others (0.6%) |
| Antonietti et al. | 2003 | 6 (2.8%) | Six dislocations (2.8%) |
| Benazzo et al. | 2007 | 5 (4.8%) | Three splitting of femur (2.85%) |
| | | | One varus positioning of the stem (0.95%) |
| | | | One dislocation (0.95%) |
| Benazzo et al. | 2010 | 2 (0.8%) | One periprosthetic fracture (0.4%) |
| | | | One dislocation (0.4%) |
| Traina et al. | 2011 | 1 (1.6%) | One periprosthetic fracture (1.6%) |
| Traina et al. | 2012 | 2 (6.25%) | One periprosthetic fracture (3.12%) |
| | | | One aseptic loosening (3.12%) |
| Bistolfi et al. | 2012 | 3 (1.4%) | Two aseptic loosening (0.97%) |
| | | | One dislocation (0.5%) |
| Dagnino et al. | 2012 | 2 (3.3%) | Two dislocations (3.3%) |
| Benazzo et al. | 2015 | 4 (2.3%) | Two aseptic loosening (1.15%) |
| | | | One dislocation (0.58%) |
| | | | One periprosthetic fracture (0.58%) |
| Toni et al. | 2017 | 8 (3.22%) | Four periprosthetic fractures (1.61%) |
| | | | Two septic loosening (0.8%) |
| | | | Two aseptic loosening (0.8%) |
| Total | | 40 (2.4%) | |

6.5 years and 86 points at 4.5 years. There have been several complications associated with the use of modular hip prosthesis. The complication rate in our research ranged from 0.8 [18] to 6.25% [22], and most frequent complication was dislocation (40%). Hashem et al. [31] reported a post-operative complications rate of 29%, with dislocations occurring in 8% of cases. Kouzelis et al. [32] reported an incidence of post-operative dislocations of modular THA ranging from 0.5 to 4%. Barlow et al. [33] showed a complication rate of 13%, and the most frequent complication was greater trochanteric fracture (61.5%). Collet et al. [26] showed a complication rate of 6.5%, and the most frequent complication was periprosthetic fractures (40%). The risk of periprosthetic fractures increased in patients with a high BMI, a high level of activity, a small medullary canal and in those with severe bone loss and poor proximal bony support for the stem [34]. Limitations of our study are certainly the average follow-up of 5 years that enables us to provide only midterm results and the inclusion of different modular prosthetic devices with different coupling and fixation techniques. The Italian cohorts included in our search arise from high-volume arthroplasty centres, and probably, this is not a global and complete national overview of the use of modular hip implants. Moreover, the orthopaedic surgeons involved are all well-trained and expert high-volume hip surgeons; as reported in the literature, high-volume hip surgeons obtain better patient outcomes than low-volume ones [35].

## Conclusion

This review showed excellent survival rate and bone stability and good clinical outcomes in Italian cohorts patients treated with modular THA, and these clinical results are comparable with worldwide rates. This review suggests that modular implants represent a very satisfying choice when practised by expert orthopaedic joint surgeons.

### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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