ISSN 2618-1584 Vol. 7, Issue 3: 44-52, DOI: 10.25236/FMSR.2025.070306

Comparison of Modular Neck Stem and Nonmodular Neck Stem in Primary Total Hip Arthroplasty: Findings of a Meta-Analysis

Gaohan Cai[1,a], Tengfeng Zhuang[1], Wenrui Wu[1], Zhengang Zha[1], Guorong She[1*], Ning Liu[1*]

[1]*The First Clinical College, Jinan University & Department of Orthopedics, The First Affiliated Hospital, Jinan University, 510630, Guangzhou, China*
[a]*820482301@qq.com*
[*]*Corresponding author*

Abstract: *Modular neck stem in total hip arthroplasty (THA) can offer variable option to reconstruct hip anatomy. However, concerns have been raised about the higher risk of revision of modular neck stem due to corrosion recently. We conducted this meta-analysis to supply a quantitative evaluation regarding this issue.We systematically searched PubMed, the Cochrane Library, EMBASE, Web of Science, Scopus, EBSCO from inception to January 2021. The trials comparing the survivorship and complications between modular-neck THA and nonmodular-neck THA were involved in the analysis.6 studies with 820523 participants were included. The outcomes of meta-analysis revealed that there were no significant differences between modular neck stem and nonmodular neck stem in revision rate (RR, 1.43; 95% CI, 0.99 to 2.04; P<0.00001), dislocation rate (RR, 1.38; 95% CI, 0.3 to 2.36; P<0.0001) and infection rate (RR, 1.12; 95% CI, 0.94 to 1.34; P=0.59).The utility of modular neck stem in THA offers similar survivorship compared to nonmodular neck stem. Current study demonstrated that utilization of modular neck stem is a reasonable choice in primary THA.*

Keywords: *Total Hip Arthroplasty, Modular Neck Stem, Revision Rate, Meta-Analysis*

1. Introduction

Total hip arthroplasty (THA) is the safe and effective treatment for patients suffering end-stage hip disorders, since it is able to relieve pain and improve joint function [1]. Its high success rate and proven outcomes come along with higher expectations. Improvement of joint functionality is the further advance in the successes of total hip arthroplasty. Reconstruction of the anatomical parameters of the hip, such as hip center, femoral offset and leg length, is critical in order to obtain satisfied hip function [2, 3]. The introduction of modular neck protheses in THA is aimed to precisely reproduce the natural biomechanics of hip joint with various versions of neck. Modular femoral neck designs can allow the surgeon to adjust leg length, offset, anteversion, head center and neck-shaft angle flexibly compared with nonmodular neck stem. Its benefit potentially leads to optimal soft-tissues balance and greater hip functionality, particularly for patients with difficult anatomies. Furthermore, accurate restoration of hip anatomical parameters has been proposed to reduce the impingement and the dislocation rate.

However, the additional modular junction could raise extra concerns, including the corrosion at the neck-stem junction, implant fracture, and adverse local tissue reactions [4-6]. Recently, the ABG II and Rejuvenate modular neck stems (Stryker, Kalamazoo, Michigan) were recalled voluntarily because revision rate was higher than expected [7]. Few studies have found that mechanical wear of modular neck stems when subjected to load fretting analysis [8, 9]. Corrosion and breakage of modular neck stems has also been frequently reported in revision surgery in terms of intraoperative findings [7, 10]. The Australian Orthopaedic Association National Joint Replacement Registry demonstrated that the revision rate of modular neck stem THAs was almost two-fold in long-term follow-up when compared to nonmodular neck stem THAs [11]. Despite these concerns, some authors have urged caution when considering all types of modular neck stems as alike [12, 13]. A number of studies have reported on decent clinical outcomes and satisfied survival rate [14-17], especially for total hip arthroplasties with ceramic-on-ceramic (CoC) bearings [14]. There are diversities in modular designs, materials and other parameters with the potential to decisively influence outcomes. For instance, adverse local tissue reaction (ALTR) has not been found in THAs with titanium-titanium modular neck [18].

So far, there is a relative scarcity of studies that investigated the differences in the survival rate between modular neck stems and nonmodular neck stems, with no large randomized controlled trials having been researched. To our knowledge, no meta-analysis has been performed regarding this topic. For filling a gap in knowledge, we conducted this meta-analysis to evaluate whether the revision rate is significantly different between modular neck stems and nonmodular neck stems for primary THA. Additionally, the differences of some complications such as dislocation rate and infection rate between two femoral stem designs are discovered according to available data.

2. Materials and Methods

2.1 Search Strategy

This systematic review and meta-analysis has been performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Prisma) guidelines [19]. The review protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) on 26 September 2020 and finally registered on 27 October 2020 (CRD42020211336).We searched PubMed, the Cochrane Library, EMBASE, Web of Science, Scopus, EBSCO and Web of science from inception to January 2021 for comparative studies involving the survivorship and complications of THAs with modular neck stems and nonmodular neck stems. The search strategy comprised the following free text terms and MeSH terms relevant to modular neck, exchangeable neck, hip, replacement, arthroplasty and THA. Medical Subject Headings were used in all searches since it was accessible. Moreover, we searched the involved studies and their reference lists to obtain any potentially related articles. Two reviewers finished all the searches individually.

2.2 Inclusion and Exclusion Criteria

We selected studies if they met the following inclusion criteria: (1) comparative study design; (2) patients undergoing primary total hip arthroplasty with modular neck stems and nonmodular neck stems; (3) reported at least one outcome of revision rates and complications such as dislocation and infection.

We excluded studies based on the following criteria: (1) duplicate references; (2) letters, comments, meeting abstract and practice guidelines; (3) data was deficient or inaccessible. Two reviewers separately filtered the titles and abstracts to recognized possibly relevant studies. Full-text papers of include studies were acquired to evaluate additionally after filtering the titles and abstracts of the identified articles. Decision was draw by third senior reviewer as long as disagreement presented.

2.3 Data Extraction and Quality Assessment

Table 1 Characteristics of the included studies

Study,year	Country	Cases: modular neck group/ nonmodular neck group	Age: modular neck group/ nonmodular neck group (year)	Female: modular neck group/ nonmodular neck group	Follow-up (month)	Study design	Neck metal	MINORS criteria score
AOANJRR 2020 [45]	Australia	10286/410855	NA	NA	NA	Retrospective cohort	NA	15
Colas, 2017	France	8931/315177	NA	5180/195410	47	Retrospective	NA	19

ISSN 2618-1584 Vol. 7, Issue 3: 44-52, DOI: 10.25236/FMSR.2025.070306

[30]						cohort		
Duwelius, 2014 [21]	America	594/284	62/62	282/136	29	Retrospective cohort	Titanium	20
Fitch, 2015 [13]	Italy	692/73469	64,1/67.7	394/43346	108	Retrospective cohort	Titanium	20
Gerhardt, 2014 [22]	Netherlands	95/95	64.5/65.4	NA	12	Retrospective cohort	Titanium	19
Vendittoli, 2018 [23]	Canada	13/32	59.3/53.8	2/9	43.2	Retrospective cohort	CoCr	19

NA: Not applicable; MINORS: The Methodological Index for Non-Randomized Studies.

Data was extracted from the finally included studies by two reviewers. A well-designed data extraction excel database was used for data collection. The recorded items were as follow: general characteristics (first author, publication year, number of participants, age and other baseline characteristics), type of neck alloy, and outcomes of interest (revision rates, dislocation rates, infection rates). We estimated the qualities of the studies with the application of Methodological Index for Non-Randomised Studies (MINORS) [20] (Table 1). MINORS is a valid instrument to assess the methodological quality of studies. The eight-item checklist and twelve-item checklist are scored for non-comparative studies and comparative respectively. Scoring includes 0 = not-reported, 1 = reported but inadequate, or 2 = reported and adequate. Disagreements between the two authors were resolved by third senior author's decision (Table 1).

2.4 Data Synthesis

Data analyses were conducted through RevMan software (version 5.3, Cochrane Collaboration, Oxford, UK). If there were continuous data, the weighted mean difference (WMD) was calculated to evaluate the efficacy of intervention. If there were dichotomous data, we calculated relative risks (RR) and 95% confidence intervals (CI) for each outcome. I2 statistics were applied to identify the presence of heterogeneity among studies. Substantial heterogeneity was measured when I2 value was 50% or higher. A fixed-effects model was performed if the heterogeneity examination presented no statistical significance (I2<50%, P>0.1). Or else, the random-effects model was used. We considered P< 0.05 as statistically significant. Publication bias was assessed using funnel plots. Sensitivity analysis was conducted to assess the effect of a separate study by eliminating in a random sequence.

3. Results

3.1 Search results

After global searching, 1025 references were identified. 387 duplicates were discarded and 587 studies were removed after screening the titles and abstracts. According to inclusion and exclusion criteria, 45 trials were removed after reviewing full-text literature. Among excluded articles, despite the subject of study was regarding the comparison between modular neck stems and nonmodular neck stems, the trial published Mikkelsen et al in 2017 [21] did not reported the revision rate of THAs with two designs. Similarly, the finding of Archibeck et al [22] was deficient of available data about revision rate as well. Eventually, 6 trials were included into our meta-analysis (Fig 1).

ISSN 2618-1584 Vol. 7, Issue 3: 44-52, DOI: 10.25236/FMSR.2025.070306

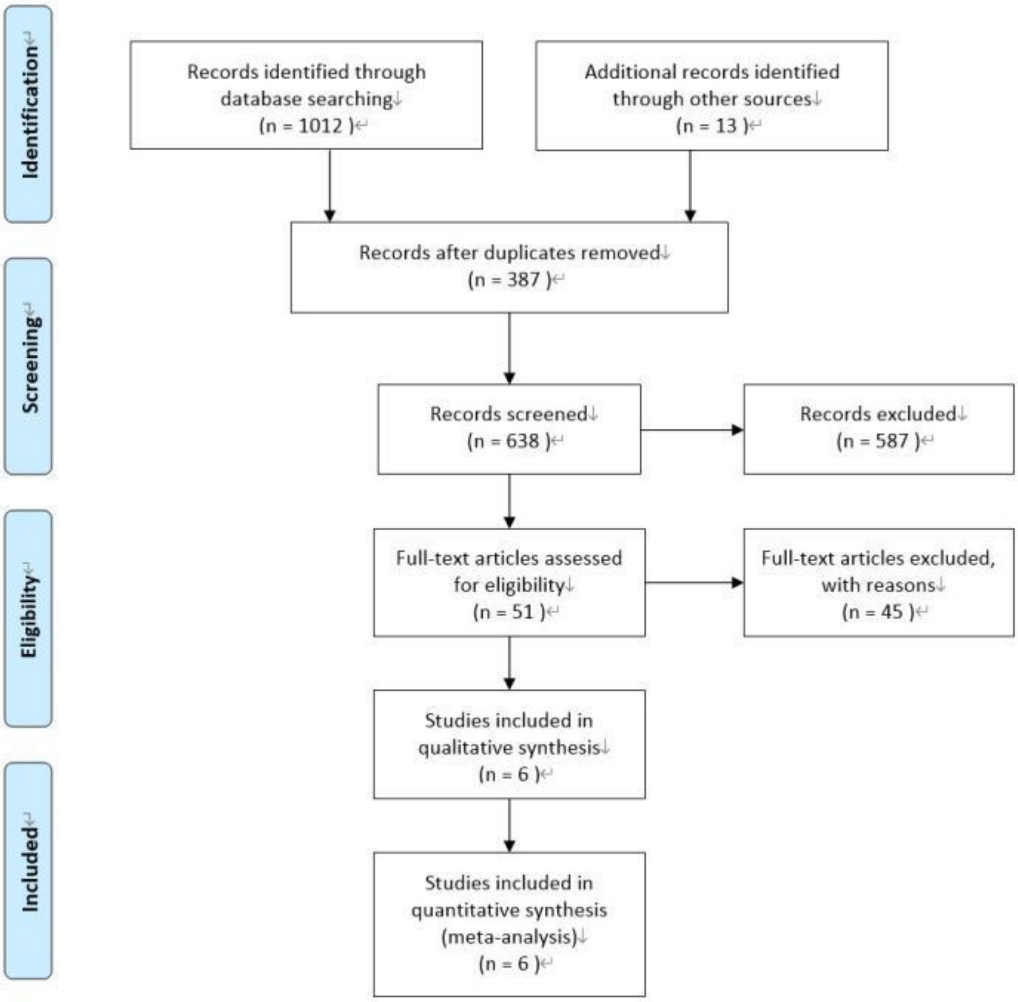

Fig.1 Flowchart of the search of literatures.

3.2 Characteristics of included studies

These 6 trials included a total of 820523 participants. Of these patients, 20611 patients received primary THAs with modular neck stems, and the other 799912 patients received primary THAs with nonmodular neck stems. The baseline characteristics of included trials were summarized in Table 1. The mean follow-up was 48.8 months. The majority of the enrolled participants indicated osteoarthritis as the primary indication for modular THA. Titanium- titanium (Ti-Ti) modular neck stems were used in three studies [13, 21, 22]. Cobalt-chrome (Co-Cr) modular neck stems were used in one studies [23]. Comparison between the groups for complications was recorded in Table 2.

Table 2 Complications for modular neck stem and nonmodular neck stem

Study	implant	Number of hips	Dislocation (%)	Fracture(%)	Loosening (%)	Infection (%)	All-cause survivorship (%)
AOANJRR	Modular	10286	167(1.6%)	143(1.4%)	200(1.9%)	90(0.9%)	822(8%)
	Nonmodular	410855	3162(0.8%)	3304(0.8%)	3758(0.9%)	2948(0.7%)	15547(3.8%)
Colas	Modular	8931	86(1%)	45(0.5%)	300(3.4%)	37(0.4%)	442(4.9%)

ISSN 2618-1584 Vol. 7, Issue 3: 44-52, DOI: 10.25236/FMSR.2025.070306

	Nonmodular	315177	2644(0.8%)	1050(0.3%)	7817(2.4%)	1345(0.4%)	11968(3.7%)
Duwelius	Modular	594	5(0.8%)	8(1.3%)	0	6(1%)	7(1.1%)
	Nonmodular	284	5(1.8%)	4(1.4%)	0	4(1.4%)	3(1%)
Fitch	Modular	692	9(1.3%)	7(1.1%)	10(1.4%)	1(0.1%)	27(3.9%)
	Nonmodular	73469	NA	27(0.94%)	NA	NA	2866
Gerhardt	Modular	95	4(4%)	0	0	0	2(2%)
	Nonmodular	95	4(4%)	0	0	0	2(2%)
Vendittoli	Modular	13	0	0	0	0	6(46%)
	Nonmodular	32	0	1(3%)	1(3%)	1(3%)	9(28%)

NA: Not applicable

3.3 Quality assessment, publication bias and sensitivity analysis

The methodological quality of the included studies was evaluated in terms of the Methodological Index for Non-Randomised Studies (MINORS). For all included studies, results of methodological quality assessment based on MINORS were summarized in Table 1. The average MINORS score for included studies was 18.7/24 (range, 15–20). All six studies had a retrospective study design.

Funnel plot was used to evaluate the publication bias of operative time, which displaced that all studies were within 95% CIs, leaving none outside the edge. Approximately symmetry was also showed in the funnel plot which indicated minimal publication bias (Fig 2). The sensitivity analysis was consistent by eliminating separate study in a random sequence and indicated no significant impact on the results.

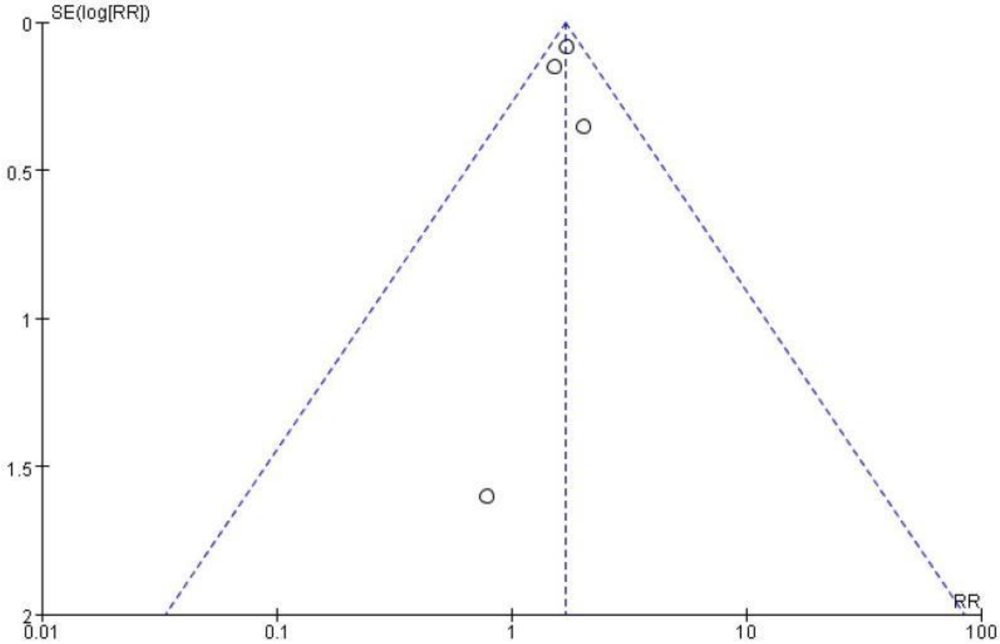

Fig.2 Funnel plot.

3.4 Revision rate

Data on revisions of THA with modular neck stems and with nonmodular neck stems were pooled in meta-analysis. All 6 studies with 820333 patients recorded revision details. The revision rate in the modular neck group (1306/20611, 6.3%) was higher than in the nonmodular neck group (30395/799912, 3.8%). However, the pooled analysis indicated that there was no significant difference between two groups (RR, 1.43; 95% CI, 0.99 to 2.04; P<0.00001) (Fig 3).

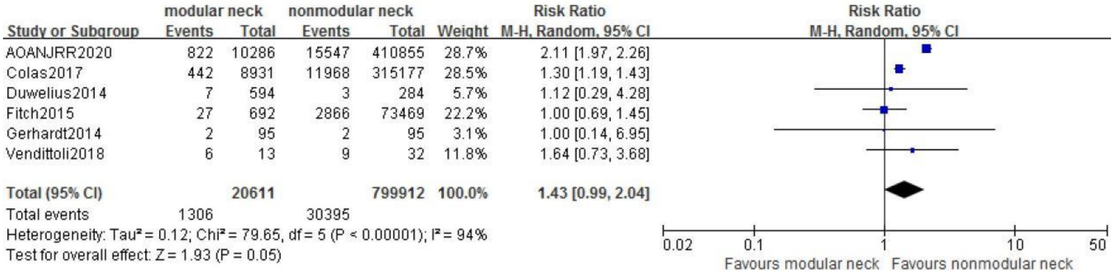

Fig.3 Forest plot for revision rate between modular neck stem group and nonmodular neck stem group.

3.5 Dislocation rate

Comparison between the groups for dislocation rate was recorded in Table 2. After acquiring data from 4 studies, we found that 259 of 19906 (1.3%) patients in the modular neck group and 5812 of 726411 (0.8%) patients in the nonmodular neck group suffered from dislocations. The forest plot indicated that there was no significant difference between two groups (RR, 1.38; 95% CI, 0.3 to 2.36; P<0.0001)(Fig4).

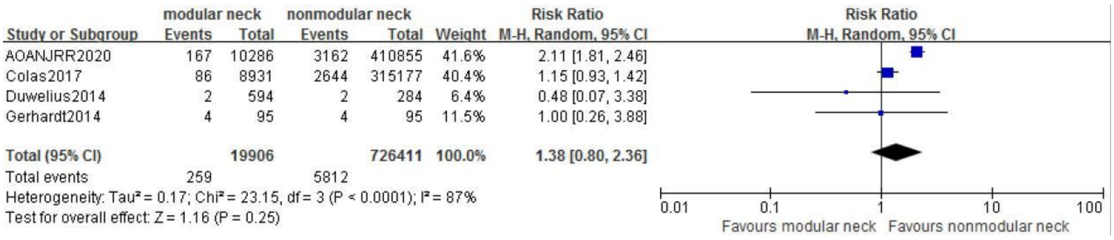

Fig.4 Forest plot for dislocation rate between modular neck stem group and nonmodular neck stem group.

3.6 Infection rate

Meta-analysis of 4 trials with 4431 patients revealed that infection rate in the modular neck group (133/19824, 0.67%) was greater than that in the nonmodular neck group (4298/726348, 0.59%). However, no significant differences were found between two groups (RR, 1.12; 95% CI, 0.94 to 1.34; P=0.59) (Fig 5). This result showed perfect homogeneity, with an I2 of 0%.

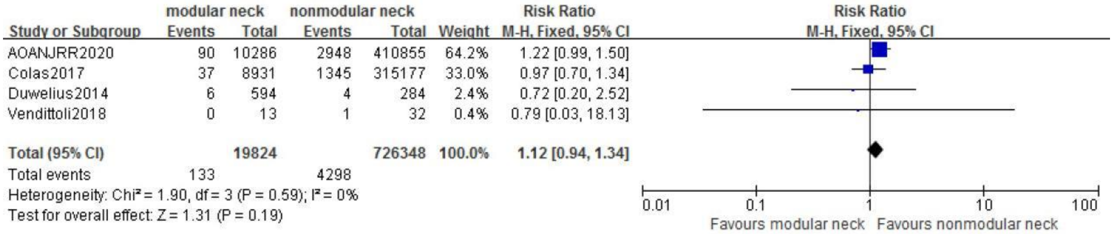

Fig.5 Forest plot for infection rate between modular neck stem group and nonmodular neck stem group.

References

[1] J. A. Walker. Total hip replacement: improving patients' quality of life. Nursing standard (Royal College of Nursing (Great Britain) : 1987) 24(23): 51, 2010

ISSN 2618-1584 Vol. 7, Issue 3: 44-52, DOI: 10.25236/FMSR.2025.070306

[2] D. D. D'Lima, Urquhart A. G., Buehler K. O., Walker R. H., Colwell C. W., Jr. The effect of the orientation of the acetabular and femoral components on the range of motion of the hip at different head-neck ratios. The Journal of bone and joint surgery American volume 82(3): 315, 2000
[3] I. Asayama, Chamnongkich S., Simpson K. J., Kinsey T. L., Mahoney O. M. Reconstructed hip joint position and abductor muscle strength after total hip arthroplasty. The Journal of arthroplasty 20(4): 414, 2005
[4] H. J. Cooper, Urban R. M., Wixson R. L., Meneghini R. M., Jacobs J. J. Adverse local tissue reaction arising from corrosion at the femoral neck-body junction in a dual-taper stem with a cobalt-chromium modular neck. The Journal of bone and joint surgery American volume 95(10): 865, 2013
[5] S. A. Atwood, Patten E. W., Bozic K. J., Pruitt L. A., Ries M. D. Corrosion-induced fracture of a double-modular hip prosthesis: a case report. The Journal of bone and joint surgery American volume 92(6): 1522, 2010
[6] K. Osman, Panagiotidou A. P., Khan M., Blunn G., Haddad F. S. Corrosion at the head-neck interface of current designs of modular femoral components: essential questions and answers relating to corrosion in modular head-neck junctions. The bone & joint journal 98-b(5): 579, 2016
[7] C. P. Walsh, Hubbard J. C., Nessler J. P., Markel D. C. Revision of Recalled Modular Neck Rejuvenate and ABG Femoral Implants. The Journal of arthroplasty 30(5): 822, 2015
[8] T. M. Grupp, Weik T., Bloemer W., Knaebel H. P. Modular titanium alloy neck adapter failures in hip replacement--failure mode analysis and influence of implant material. BMC musculoskeletal disorders 11: 3, 2010
[9] M. Viceconti, Baleani M., Squarzoni S., Toni A. Fretting wear in a modular neck hip prosthesis. Journal of biomedical materials research 35(2): 207, 1997
[10] C. Restrepo, Ross D., Restrepo S., Heller S., Goyal N., Moore R., et al. Adverse clinical outcomes in a primary modular neck/stem system. The Journal of arthroplasty 29(9 Suppl): 173, 2014
[11] I. W. Incoll, Atkin J., Owen J., Keane A., Khorshid O., Cosenza A., et al. Australian orthopaedic surgery training: Australian Orthopaedic Association's strategic education review. ANZ journal of surgery 90(6): 997, 2020
[12] H. U. Cameron. The proximal modular neck in THA: a bridge too far: opposes. Orthopedics 33(9): 641, 2010
[13] D. A. Fitch, Ancarani C., Bordini B. Long-term survivorship and complication rate comparison of a cementless modular stem and cementless fixed neck stems for primary total hip replacement. International orthopaedics 39(9): 1827, 2015
[14] S. Lucchini, Castagnini F., Giardina F., Tentoni F., Masetti C., Tassinari E., et al. Cementless ceramic-on-ceramic total hip arthroplasty in post-traumatic osteoarthritis after acetabular fracture: long-term results. Archives of orthopaedic and trauma surgery 141(4): 683, 2021
[15] C. M. Blakey, Eswaramoorthy V. K., Hamilton L. C., Biant L. C., Field R. E. Mid-term results of the modular ANCA-Fit femoral component in total hip replacement. The Journal of bone and joint surgery British volume 91(12): 1561, 2009
[16] F. Benazzo, Rossi S. M., Cecconi D., Piovani L., Ravasi F. Mid-term results of an uncemented femoral stem with modular neck options. Hip international : the journal of clinical and experimental research on hip pathology and therapy 20(4): 427, 2010
[17] D. J. Cossetto, Goudar A. Mid-term outcome of a modular, cementless, proximally hydroxyapatite-coated, anatomic femoral stem. Journal of orthopaedic surgery (Hong Kong) 20(3): 322, 2012
[18] W. Gofton, Beaule P. E. Serum Metal Ions with a Titanium Modular Neck Total Hip Replacement System. The Journal of arthroplasty 30(10): 1781, 2015
[19] D. Moher, Liberati A., Tetzlaff J., Altman D. G. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. BMJ (Clinical research ed) 339: b2535, 2009
[20] K. Slim, Nini E., Forestier D., Kwiatkowski F., Panis Y., Chipponi J. Methodological index for non-randomized studies (minors): development and validation of a new instrument. ANZ journal of surgery 73(9): 712, 2003
[21] R. T. Mikkelsen, Fløjstrup M., Klem N., Tellefsen R. A., Lund C., Kjærsgaard-Andersen P., et al. Modular Neck vs Nonmodular Femoral Stems in Total Hip Arthroplasty-Clinical Outcome, Metal Ion Levels, and Radiologic Findings. The Journal of arthroplasty 32(9): 2774, 2017
[22] M. J. Archibeck, Cummins T., Carothers J., Junick D. W., White R. E., Jr. A comparison of two implant systems in restoration of hip geometry in arthroplasty. Clinical orthopaedics and related research 469(2): 443, 2011
[23] P. J. Duwelius, Burkhart B., Carnahan C., Branam G., Ko L. M., Wu Y., et al. Modular versus nonmodular neck femoral implants in primary total hip arthroplasty: which is better? Clinical orthopaedics and related research 472(4): 1240, 2014
[24] D. M. Gerhardt, Bisseling P., de Visser E., van Susante J. L. Modular necks in primary hip

arthroplasty without anatomical deformity: no clear benefit on restoration of hip geometry and dislocation rate. An exploratory study. The Journal of arthroplasty 29(8): 1553, 2014

[25] P. A. Vendittoli, Massé V., Kiss M. O., Lusignan D., Lavigne M. Modular junction may be more problematic than bearing wear in metal-on-metal total hip arthroplasty. Hip international : the journal of clinical and experimental research on hip pathology and therapy 29(3): 262, 2019

[26] A. Toni, Sudanese A., Ciaroni D., Dallari D., Greggi T., Giunti A. Anatomical ceramic arthroplasty (AN.C.A.): preliminary experience with a new cementless prosthesis. La Chirurgia degli organi di movimento 75(1): 81, 1990

[27] J. R. Lex, Welch M. D., See A., Edwards T. C., Stavropoulos N. A., Babis G. C. Systematic review of primary total hip arthroplasty using titanium-titanium modular-neck prostheses: the true risk of revision. Hip international : the journal of clinical and experimental research on hip pathology and therapy: 1120700020916870, 2020

[28] E. Sariali, Mouttet A., Pasquier G., Durante E., Catone Y. Accuracy of reconstruction of the hip using computerised three-dimensional pre-operative planning and a cementless modular neck. The Journal of bone and joint surgery British volume 91(3): 333, 2009

[29] D. O. Molloy, Munir S., Jack C. M., Cross M. B., Walter W. L., Walter W. K., Sr. Fretting and corrosion in modular-neck total hip arthroplasty femoral stems. The Journal of bone and joint surgery American volume 96(6): 488, 2014

[30] A. M. Kop, Swarts E. Corrosion of a hip stem with a modular neck taper junction: a retrieval study of 16 cases. The Journal of arthroplasty 24(7): 1019, 2009

[31] S. Colas, Allalou A., Poichotte A., Piriou P., Dray-Spira R., Zureik M. Exchangeable Femoral Neck (Dual-Modular) THA Prostheses Have Poorer Survivorship Than Other Designs: A Nationwide Cohort of 324,108 Patients. Clinical orthopaedics and related research 475(8): 2046, 2017

[32] I. P. Gill, Webb J., Sloan K., Beaver R. J. Corrosion at the neck-stem junction as a cause of metal ion release and pseudotumour formation. The Journal of bone and joint surgery British volume 94(7): 895, 2012

[33] D. T. Bernstein, Meftah M., Paranilam J., Incavo S. J. Eighty-six Percent Failure Rate of a Modular-Neck Femoral Stem Design at 3 to 5 Years: Lessons Learned. The Journal of bone and joint surgery American volume 98(12): e49, 2016

[34] P. I. Brånemark, Adell R., Albrektsson T., Lekholm U., Lindström J., Rockler B. An experimental and clinical study of osseointegrated implants penetrating the nasal cavity and maxillary sinus. Journal of oral and maxillofacial surgery : official journal of the American Association of Oral and Maxillofacial Surgeons 42(8): 497, 1984

[35] A. M. Kop, Keogh C., Swarts E. Proximal component modularity in THA--at what cost? An implant retrieval study. Clinical orthopaedics and related research 470(7): 1885, 2012

[36] S. Y. Jauch, Huber G., Hoenig E., Baxmann M., Grupp T. M., Morlock M. M. Influence of material coupling and assembly condition on the magnitude of micromotion at the stem-neck interface of a modular hip endoprosthesis. Journal of biomechanics 44(9): 1747, 2011

[37] B. J. Vundelinckx, Verhelst L. A., De Schepper J. Taper corrosion in modular hip prostheses: analysis of serum metal ions in 19 patients. The Journal of arthroplasty 28(7): 1218, 2013

[38] J. F. Somers. Metal ion levels in ceramic-on-ceramic THR with modular necks: analysis of cobalt and chromium serum levels in 30 healthy hip patients. Hip international : the journal of clinical and experimental research on hip pathology and therapy 25(5): 484, 2015

[39] D. J. Berry, von Knoch M., Schleck C. D., Harmsen W. S. The cumulative long-term risk of dislocation after primary Charnley total hip arthroplasty. The Journal of bone and joint surgery American volume 86(1): 9, 2004

[40] H. C. Amstutz, Lodwig R. M., Schurman D. J., Hodgson A. G. Range of motion studies for total hip replacements. A comparative study with a new experimental apparatus. Clinical orthopaedics and related research (111): 124, 1975

[41] A. Matsushita, Nakashima Y., Jingushi S., Yamamoto T., Kuraoka A., Iwamoto Y. Effects of the femoral offset and the head size on the safe range of motion in total hip arthroplasty. The Journal of arthroplasty 24(4): 646, 2009

[42] B. M. Jolles, Zangger P., Leyvraz P. F. Factors predisposing to dislocation after primary total hip arthroplasty: a multivariate analysis. The Journal of arthroplasty 17(3): 282, 2002

[43] J. M. Vigdorchik, Sharma A. K., Elbuluk A. M., Carroll K. M., Mayman D. J., Lieberman J. R. High Offset Stems Are Protective of Dislocation in High-Risk Total Hip Arthroplasty. The Journal of arthroplasty 36(1): 210, 2021

[44] S. Byström, Espehaug B., Furnes O., Havelin L. I. Femoral head size is a risk factor for total hip luxation: a study of 42,987 primary hip arthroplasties from the Norwegian Arthroplasty Register. Acta orthopaedica Scandinavica 74(5): 514, 2003

ISSN 2618-1584 Vol. 7, Issue 3: 44-52, DOI: 10.25236/FMSR.2025.070306

[45] F. Traina, De Fine M., Tassinari E., Sudanese A., Calderoni P. P., Toni A. Modular neck prostheses in DDH patients: 11-year results. Journal of orthopaedic science : official journal of the Japanese Orthopaedic Association 16(1): 14, 2011
[46] Australian Orthopaedic Association National Joint Replacement Registry. Annual Report 2020. Available at: https://aoanjrr.sahmri.com/annual-reports-2020. Accessed January 30, 2021.