Modular versus monoblock stem in revision total hip arthroplasty: a systematic review and meta-analysis

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Background: Total hip arthroplasty (THA) is estimated to grow in the following decades with a consequent increase of THA revisions (rTHA). This systematic review and meta-analysis aims to compare modular and monoblock stem in rTHA surgery, focusing on clinical and radiological outcomes and complication rates.

Methods: A literature search was performed using the following search strategy: ((Modular stem) OR (monolithic stem)) AND (hip review) on PubMed, Scopus, and Cochrane. Randomized controlled trials (RCTs) and observational studies (OS) compared clinical and radiological outcomes, and complication rates for monoblock and modular revision femoral stem were included. The risk of bias was assessed through the Methodological Index for Non-Randomized Studies (MINORS) score. The Review Manager (RevMan) software was used for the meta-analysis. The rate of complications was assessed using odds ratio (OR) with 95% confidence intervals (CIs).

Results: The authors included 11 OS and one RCT with 3,671 participants (mean age: 68.4 years old). The mean follow-up was 46.9 months. There was no prevalence of subsidence for one type of stem. Mean subsidence was from 0.92 to 10 mm for modular stem and from 1 to 15 mm for monoblock stem. Postoperative Harris Hip Score (HHS) showed better results with modular stems without statistical significance [mean difference (MD) =1.32; 95% CI: −1.62 to 4.27; P=0.38]. No statistically significant difference was found for dislocations (OR =2.48; 95% CI: 0.67 to 9.14; P=0.17), infections (OR =1.07; 95% CI: 0.51 to 2.23; P=0.86), intraoperative fractures (OR =1.62; 95% CI: 0.42 to 6.21; P=0.48), and postoperative fractures (OR =1.60; 95% CI: 0.55 to 4.64; P=0.39).

Conclusions: Modular and monoblock stems show comparable and satisfactory clinical and radiological outcomes for rTHA. Both stems are valid and effective options for managing femoral bone deficit in hip revision surgery. The main limitation of this study is the small number and low quality of enclosed studies that compared the two stems. Moreover, the modular stem is usually used for more complex cases with lower quality femoral bone stock.

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Keywords: Modular stem; monoblock stem; revision total hip arthroplasty (rTHA); complication rates; meta-analysis

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Introduction

Background

The number of total hip arthroplasty (THA) is ever-growing (1). Over the decades, several studies investigated the durability of primary implants and follow-ups of up to 25 years with cementless-coated implants (2). It is estimated that THA surgeries will increase by 174% in 2030 with a consequent increase in THA revisions (rTHA), and that volume will double by 2026 (3). The main reasons for rTHA are represented by aseptic loosening (a most significant percentage of 23.19%), followed by instability (22.43%) and infection (22.13%) (4). One of the most critical problems of revision surgery is bone loss in the femoral site (5). The femur metaphyseal bone loss makes implanting a primary proximal fitting stem impracticable because of the need to achieve stability and restore the correct biomechanical parameters (offset, limb length, femoral version) (6). Revision stems are designed to overcome bone loss and restore hip function. One of the most popular was designed by Wagner in the 1980s (*Figure 1*). Its tapered, fluted titanium (TFT) stem wedges into the distal femur, allowing good stability. The tapered shape allows axial stability, and rotational stability is achieved by longitudinal splines along the stem (7). Wagner-type stems obtained success, also presenting some problems (8). The main drawbacks have been: subsidence and dislocation of up to 20% in some cases (9-13). Moreover, fully porous coated stems reach stability both with the overall dimensions and with the osseointegration of their particular coating. Several modular stems (*Figure 2*) were developed to overcome these problems and give intraoperative versatility (14). With this type of implant, the surgeon can perform immediate, reliable, distal fixation and then put a proximal segment to restore leg length, offset, anteversion, and hip biomechanics (15,16).

Highlight box

Key findings

- No statistically significant difference was found for postoperative Harris Hip Score (P=0.38), dislocations (P=0.17), infections (P=0.86), intraoperative fractures (P=0.48) and postoperative fractures (P=0.39) between the two types of stems.

What is known and what is new?

- Nowadays, revision rate after total hip arthroplasty (THA) is increasing for different reasons (aseptic loosening, infection, instability). Due to bone loss, revision stems with diaphyseal press fit should be used in revision surgery. The most used stems are monolithic (tapered fluted) or modular (distal fixation plus proximal segment).
- This systematic review and meta-analysis compare modular and monoblock stems in revision THA (rTHA), focusing on clinical and radiological outcomes and complication rates.

What is the implication, and what should change now?

- Both modular and monoblock stems can be used in rTHA as they show similar and satisfactory clinical and radiological outcomes.

Rationale and knowledge gap

The rationale of the study is to compare the outcomes of modular and monoblock stems, in the lack of studies in the literature that have carried out a statistical analysis between the two types of stems. In fact, in presence of a previously published systematic review (17), this study represents the first meta-analysis that analyzes comparative studies between modular and monoblock stems evaluating clinical and radiological outcomes and perioperative complications.

Objective

This systematic review and meta-analysis aims to analyze only studies that compared modular and monoblock stems in rTHA surgery, focusing on clinical and radiological outcomes and complication rates. We present this article in accordance with the PRISMA reporting checklist (available at https://aoj.amegroups.com/article/view/10.21037/aoj-23-33/rc).

Methods

This systematic review and meta-analysis collected data

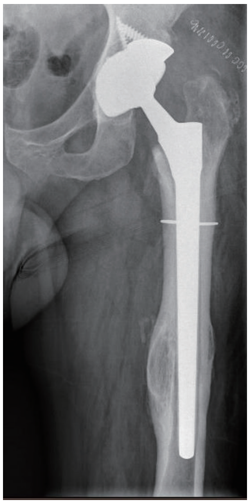


Figure 1 Monoblock stem.

Figure 2 Modular stem.

from studies focused on adult patients undergoing revision total hip replacement with a modular or monoblock stem. A literature search according to Cochrane methodology was performed by two independent reviewers (Parisi FR and Luciano C) that extracted the following data: authors, year of publication, type of study, level of evidence (LOE), number of participants, age, gender, body mass index (BMI) for both groups, follow-up, and results. A flowchart was reported according to Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines. The systematic research literature was performed on 28th February 2023 using the following search strategy: ((Modular stem) OR (monolithic stem)) AND (hip review) on PubMed, Scopus, and Cochrane. No restrictions were applied to the period of the studies. After finding the articles, we manually searched the reference list of those articles to find additional documents. We included randomized controlled trials (RCTs) and observational retrospective or prospective studies in English, which compared clinical and radiological outcomes and complication rates after rTHA. We excluded trials that did not compare two different stem types (modular and monoblock) or with very short follow-up (less than 6 months), studies without clinical and radiological outcomes, and studies focused on primary THA. The comparison analysis between the two types of stems regarded the evaluation of clinical scores, radiological outcomes, dislocation rate, infection rate, and intraoperative and postoperative periprosthetic fractures. Two independent reviewers (Parisi FR and Luciano C) assessed the risk of bias for included studies using the Methodological Index for Non-Randomized Studies (MINORS) score (18). When inconsistencies occurred in the data extraction and the risk of bias assessment between the two independent reviewers, a third investigator (Zampogna B) resolved them. The Review Manager (RevMan) software version 5.4 was used to conduct a meta-analysis. Harris Hip Score (HHS) (19) was evaluated as a continuous outcome using mean difference (MD) with 95% confidence intervals (CIs). The rate of complications was assessed as dichotomous outcomes using an odds ratio (OR) with 95% CIs. We used a fixed-effect model for heterogeneity lower than 55% or random-effect in the case of $I^2>55\%$ (20). The statistical significance of the results was fixed at $P<0.05$.

Results

Results of the search

The literature research identified 1,334 articles. After duplicate removal, 949 articles were screened on title and abstract. The full text of 48 articles was read, and 36 were excluded for the reasons: not comparative studies between types of stems (n=14); primary THA (n=8); not requested outcomes (n=9); non-adequate follow-up (n=5). The articles included in this review were 12 (*Figure 3*).

Included studies

We included 11 retrospective observational studies (ROS) and one RCT. The studies compared clinical and/or

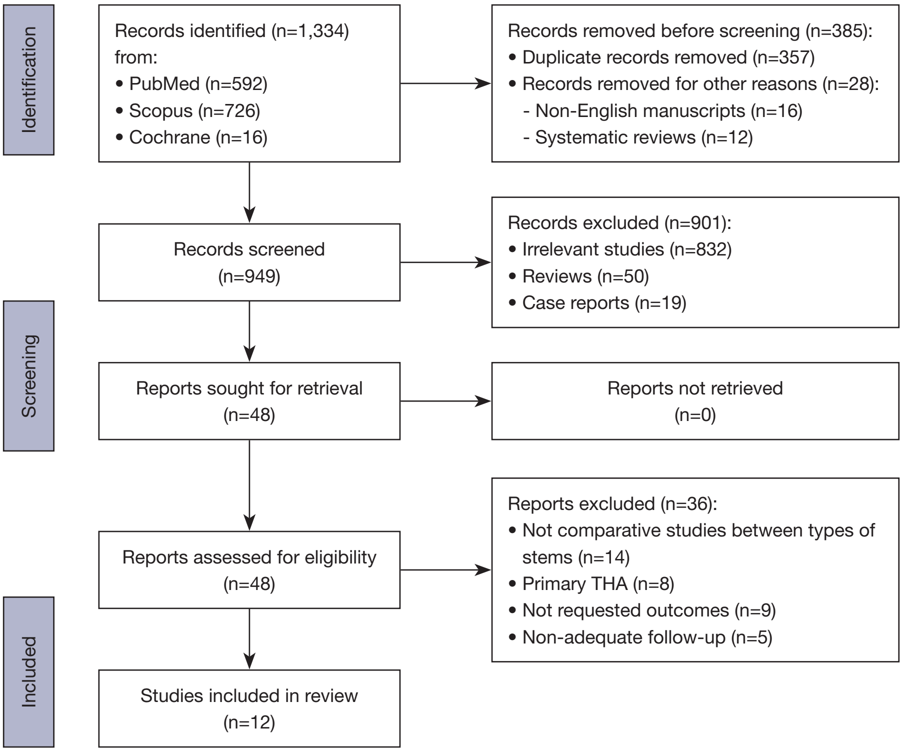


Figure 3 PRISMA 2020 flow diagram. THA, total hip arthroplasty; PRISMA, Preferred Reporting Items for Systematic Review and Meta-Analyses.

radiographic outcomes and complications between two groups of patients who underwent revision THA with a modular or monoblock stem.

Demographic data

The study included a total number of participants of 3,671 patients (*Table 1*). The mean age of the patients involved was 68.4 years old (from 27 to 93 years of age). The BMI ranged from 23.3 to 39.8 kg/m^2, averaging 28.55 kg/m^2. The mean follow-up was 46.9 months (from 193 days to 101.5 months). Stem manufacturer and brand of each study are reported in *Table 2*. MINORS score was calculated for non-randomized studies. The mean value was 17, ranging from 15 to 19 (*Table 3*).

Radiological outcomes

Most of the studies in the review analyzed the subsidence of the prosthetic revision stem on follow-up radiographic exams (*Table 4*). Among the studies, there was no prevalence of subsidence for one type of stem. Mean subsidence was from 0.92 to 10 mm for the modular stem and from 1 to 15 mm for the monoblock stem. Only two of the studies included showed a statistically significant difference in subsidence between the two types of stems: Clair *et al.* (21) reported that subsidence was higher for modular stems than non-modular (P<0.001), while Feng *et al.* (23) reported lower subsidence for modular stem than monoblock (P<0.05).

Effect of intervention

The meta-analysis compared clinical outcomes and perioperative complications between modular and monobloc stem in revision THA. Postoperative HHS showed better results with modular stems but without statistical significance (MD =1.32; 95% CI: −1.62 to 4.27; P=0.38; I^2=76%) (*Figure 4*). The rate of dislocations was lower for revisions with monoblock stems. However, no statistical difference was observed between the groups (OR =2.48; 95% CI: 0.67 to 9.14; P=0.17; I^2=50%) (*Figure 5*).

Table 1 Characteristics of the included studies

Author [year]	Type of study	LOE	Modular					Monoblock					Follow-up
			N	Age (years), range/mean	Sex	BMI (kg/m^2), mean ± SD	Paprosky	N	Age (years), range/mean/ mean ± SD	Sex	BMI (kg/m^2), mean ± SD	Paprosky	
Clair *et al.* [2020] (21)	ROS	III	106	21–93	M: 47.2%; F: 52.8%	N.R.	I =30; II =45; IIIA =18; IIIB =13; IV =0	80	21–93	M: 46.25%; F: 53.75%	N.R.	I =3; II =28; IIIA =34; IIIB =11; IV =4	14 months
Pomeroy *et al.* [2022] (22)	ROS	III	27	52–90	M: 66.7%; F: 33.3%	N.R.	I =0; II =5; IIIA =19; IIIB =3; IV =0	37	46–93	M: 45.9%; F: 54.1%	N.R.	I =0; II =12; IIIA =24; IIIB =1; IV =0	193 days
Feng *et al.* [2020] (23)	ROS	III	108	49–82	M: 55.6%; F: 44.4%	26.1±2.8	I =18; II =54; IIIA =24; IIIB =12; IV =0	110	50–83	M: 54.5%; F: 45.5%	25.9±2.5	I =20; II =60; IIIA =25; IIIB =5; IV =0	101.5 months
Huang *et al.* [2017] (15)	ROS	III	160	29–80	M: 48.7%; F: 51.3%	27.3±5.1	I =2; II =13; IIIA =75; IIIB =55; IV =15	129	23–84	M: 42.6%; F: 57.4%	26.5±4.3	I =1; II =12; IIIA =66; IIIB =41; IV =9	6.3 years
Li *et al.* [2016] (24)	RCT	I	32	56–77	M: 43.8%; F: 56.2%	N.R.	I =3; II =10; IIIA =11; IIIB =8; IV =0	33	55–76	M: 48.5%; F: 51.5%	N.R.	I =2; II =12; IIIA =10; IIIB =9; IV =0	12 months
Weiss *et al.* [2011] (10)	ROS	III	812	26–96	M: 55%; F: 45%	N.R.	N.R.	1,073	27–101	M: 51%; F: 49%	N.R.	N.R.	3.4 years
Wang *et al.* [2013] (25)	ROS	III	23	35–76	M: 70%; F: 30%	N.R.	I =4; II =19; IIIA =0; IIIB =0; IV =0	28	46–89	M: 46%; F: 54%	N.R.	I =7; II =21; IIIA =0; IIIB =0; IV =0	5.5 years
Yacovelli *et al.* [2021] (12)	ROS	III	225	53–78	M: 47.1%; F: 52.9%	28.7±5.83	I =0; II =57; IIIA =105; IIIB =45; IV =11	63	62.6±14.2	M: 39.7%; F: 60.3%	29.7±5.87	I =6; II =20; IIIA =24; IIIB =10; IV =3	39 months
Richards *et al.* [2010] (26)	ROS	III	103	70.2	M: 45.6%; F: 54.4%	N.R.	I =4; II =5; IIIA =29; IIIB =58; IV =7	114	68.3	M: 48.2%; F: 51.8%	N.R.	I =1; II =15; IIIA =60; IIIB =31; IV =4	49 months
Cohn *et al.* [2020] (27)	ROS	III	67	54–80	M: 44.8%; F: 55.2%	31.1±7.1	I =11; II =14; IIIA =26; IIIB =9; IV =5	78	48–78	M: 48.7%; F: 51.3%	33.1±6.7	I =2; II =25; IIIA =41; IIIB =5; IV =0	6.3 years
Moreta *et al.* [2019] (13)	ROS	III	24	68–82	M: 45%; F: 55%	N.R.	N.R.	19	85–71	M: 50%; F: 50%	N.R.	N.R.	5 years
Garbuz *et al.* [2006] (28)	Cohort study	III	31	70.5	N.R.	N.R.	N.R.	189	70	N.R.	N.R.	N.R.	709 days

LOE, levels of evidence; N, number of participants; BMI, body mass index; SD, standard deviation; ROS, retrospective observational study; M, male; F, female; N.R., not reported; RCT, randomized clinical trial.

Table 2 Description of the stem manufacturer and brand

Study	Modular	Monoblock
Clair (21)	Restoration Modular (Stryker, Kalamazoo, MI, USA); ZMR (Zimmer, Warsaw, IN, USA); Arcos (Biomet, Warsaw, IN, USA)	Redapt (Smith & Nephew, Watford, UK)
Pomeroy (22)	The Redapt stem (Smith & Nephew, London, UK)	Restoration Modular (Stryker, Mahwah, NJ, USA)
Feng (23)	Link MP modular stem and AK-MR modular stem	Wagner SL stem and AK-SL stem
Huang (15)	MP (Waldemar Link, Hamburg, Germany)	Wagner SL (Zimmer, Warsaw, IN, USA)
Li (24)	S-ROM (DePuy, Johnson & Johnson, Warsaw, IN, USA)	SLR-PLUS uncemented stem plus produced by Preuss Company
Weiss (10)	Lubinus, Exeter, and Spectron	Lubinus (length 170–350 mm; Waldemar Link, Hamburg, Germany), the Spectron revision hip system (165–225 mm; Smith & Nephew Inc., Memphis, TN, USA) and the Exeter long stem (200–300 mm; Stryker, Mahwah, NJ, USA)
Wang (25)	Link MP prosthesis is a tapered, fluted, cementless, modular, titanium stem	Lubinus SP II is a wide collar, double curved, cemented, cobalt chromium alloy stem
Yacovelli (12)	Restoration Modular (Stryker, Kalamazoo MI, USA), or Arcos Modular (Zimmer Biomet, Warsaw, IN, USA)	63 monoblock TFT (Wagner SL; Zimmer Biomet, Warsaw, IN, USA), and 47 FPCC (Arcos One-piece or Solution Stem; DePuy, Warsaw, IN, USA)
Richards (26)	Tapered, fluted, modular, titanium femoral components	Cylindrical, nonmodular, cobalt chromium stems
Cohn (27)	ZMR (Zimmer, Warsaw, IN, USA); Restoration Modular (Stryker, Mahwah, NJ, USA); Arcos (Biomet, Warsaw, IN, USA); Reclaim (DePuy, Warsaw, IN, USA)	Wagner SL (Zimmer, Warsaw, IN, USA)
Moreta (13)	Modular tapered rectangular titanium stem (Modular-Plus®, Smith & Nephew Orthopaedics, Rotkreuz, Switzerland)	Monoblock tapered titanium stem (Wagner®, Sulzer Orthopedics Ltd., Winterthur, Switzerland)
Garbuz (28)	ZMR (ZMR Hip System™, Zimmer, Warsaw, IN, USA) is a tapered, fluted, modular, titanium stem	The Solution component (Solution System™, DePuy, Warsaw, IN, USA) is a cylindrical, cobalt chromium alloy revision stem

TFT, tapered, fluted titanium; FPCC, fully porous-coated cylindrical.

The infection rate was similar among the two groups (OR =1.07; 95% CI: 0.51 to 2.23; P=0.86; I^2=0%) (*Figure 6*). The rate of intraoperative fracture was lower in the monoblock stem group than in the modular stem group but with no statistical significance (OR =1.62; 95% CI: 0.42 to 6.21; P=0.48; I^2=87%) (*Figure 7*). The rate of postoperative periprosthetic fracture was lower with monoblock stems compared with modular stems, but no statistical difference was reported (OR =1.60; 95% CI: 0.55 to 4.64; P=0.39; I^2=0%) (*Figure 8*).

Discussion

Key findings

Periprosthetic femoral bone loss recognizes several causes as osteolysis, stress shielding, periprosthetic infections and fractures, aseptic loosening, metastases, or iatrogenic bone defects after component removal (29-31). Femoral stem loosening due to femoral bone loss account for a complication rate ranging from 58% to 84% in hip revision surgery (32,33). In 1987, the first monoblock, tapered, fluted, coated revision stem was developed in Europe with quick diffusion in the USA (7). In recent decades, new modular stems have been designed to restore biomechanical parameters like offset and limb length without sacrificing implant stability (34). The principal differences between the use of modular and monoblock stem have been evaluated in several studies (35). Modular stems reported a higher chance of intraoperative periprosthetic fracture than monoblock, which reported a higher subsidence risk (17). Compared to a similar systematic review (17), our study analyzed only studies that compared monoblock and modular stems in hip revision surgery. We analyzed

Table 3 MINORS score

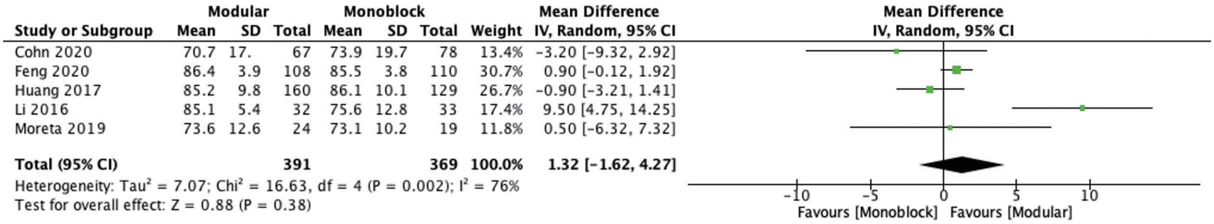
Study	Stated aim	Inclusion of patients	Collection of data	Endpoints appropriate to the aim	Unbiased assessment of the study endpoint	Follow-up	Loss to follow up less than 5%	Prospective calculation of the study size	Control group	Contemporary groups	Baseline equivalence of groups	Statistical analyses	Total
Clair [2020] (21)	2	2	2	2	0	1	0	1	0	2	2	1	15
Pomeroy [2022] (22)	2	2	2	2	0	1	2	1	0	2	2	2	18
Feng [2020] (23)	2	1	2	2	0	2	2	2	0	2	2	2	19
Huang [2017] (15)	2	2	2	2	0	2	0	2	0	2	2	2	18
Li [2016] (24)	2	2	2	2	0	1	1	2	0	2	2	2	18
Weiss [2011] (10)	1	1	2	1	0	2	0	2	1	2	2	1	15
Wang [2013] (25)	2	2	1	2	0	2	2	2	0	2	2	2	19
Yacovelli [2021] (12)	2	2	2	2	0	2	2	1	1	2	2	1	19
Richards [2010] (26)	2	2	1	2	0	2	1	1	0	2	2	1	16
Cohn [2020] (27)	2	1	2	2	0	2	0	2	0	1	2	2	16
Moreta [2019] (13)	2	2	2	2	1	2	0	1	0	1	2	2	17
Garbuz [2006] (28)	2	2	1	2	0	1	2	1	0	2	2	1	16

MINORS, Methodological Index for Non-Randomized Studies.

Table 4 Radiological outcomes

Study	Subsidence (mm)		Subsidence >5 mm		Subsidence >10 mm	
	Modular	Monoblock	Modular	Monoblock	Modular	Monoblock
Clair (21)	10±6	15±9	31	9	–	–
Pomeroy (22)	3.15	2.13	–	–	1	1
Feng (23)	0.92	2.20	–	–	1	3
Huang (15)	0.95±2	1.93±3	5	11	1	2
Wang (25)	1.4	2	1	2	–	–
Yacovelli (12)	3.55±6	2.44±3.3	50	9	–	–
Cohn (27)	2.17±2	3.13±5.6	7	10	–	–
Moreta (13)	1.75±3.44	1±2.6	–	–	–	–

Data are presented as mean ± SD, mean or n. SD, standard deviation.

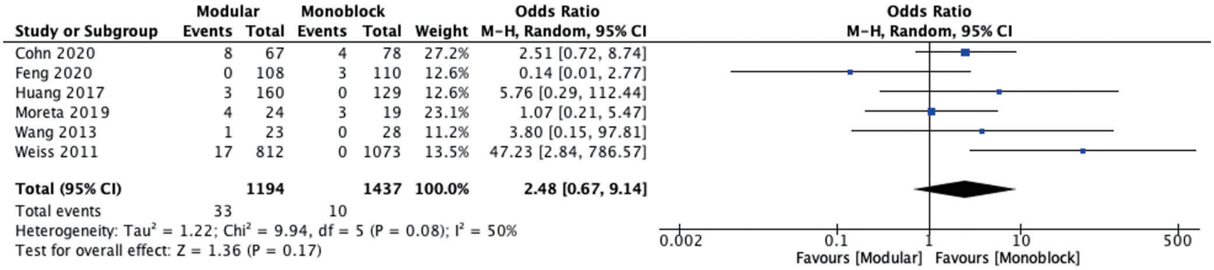


	Modular			Monoblock				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Cohn 2020	70.7	17.	67	73.9	19.7	78	13.4%	-3.20 [-9.32, 2.92]
Feng 2020	86.4	3.9	108	85.5	3.8	110	30.7%	0.90 [-0.12, 1.92]
Huang 2017	85.2	9.8	160	86.1	10.1	129	26.7%	-0.90 [-3.21, 1.41]
Li 2016	85.1	5.4	32	75.6	12.8	33	17.4%	9.50 [4.75, 14.25]
Moreta 2019	73.6	12.6	24	73.1	10.2	19	11.8%	0.50 [-6.32, 7.32]
Total (95% CI)			**391**			**369**	**100.0%**	**1.32 [-1.62, 4.27]**

Heterogeneity: $Tau^2 = 7.07$; $Chi^2 = 16.63$, df = 4 ($P = 0.002$); $I^2 = 76\%$

Test for overall effect: $Z = 0.88$ ($P = 0.38$)

Figure 4 Harris Hip Score. SD, standard deviation; IV, inverse variance; CI, confidence interval.

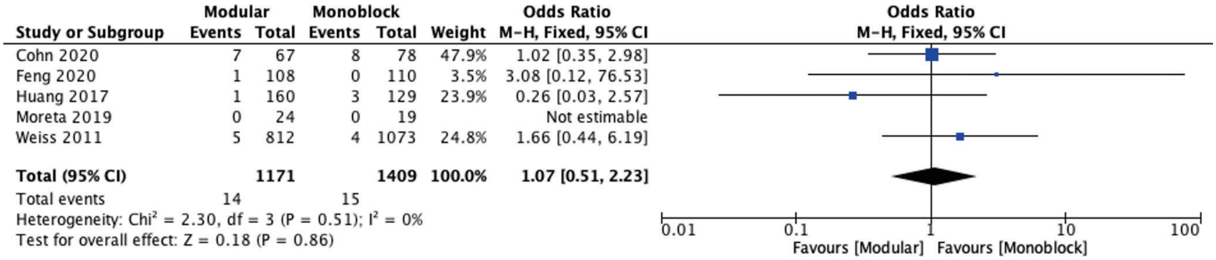


	Modular		Monoblock			Odds Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI
Cohn 2020	8	67	4	78	27.2%	2.51 [0.72, 8.74]
Feng 2020	0	108	3	110	12.6%	0.14 [0.01, 2.77]
Huang 2017	3	160	0	129	12.6%	5.76 [0.29, 112.44]
Moreta 2019	4	24	3	19	23.1%	1.07 [0.21, 5.47]
Wang 2013	1	23	0	28	11.2%	3.80 [0.15, 97.81]
Weiss 2011	17	812	0	1073	13.5%	47.23 [2.84, 786.57]
Total (95% CI)		**1194**		**1437**	**100.0%**	**2.48 [0.67, 9.14]**
Total events	33		10			

Heterogeneity: $Tau^2 = 1.22$; $Chi^2 = 9.94$, df = 5 ($P = 0.08$); $I^2 = 50\%$

Test for overall effect: $Z = 1.36$ ($P = 0.17$)

Figure 5 Dislocation. M-H, Mantel-Haenszel; CI, confidence interval.

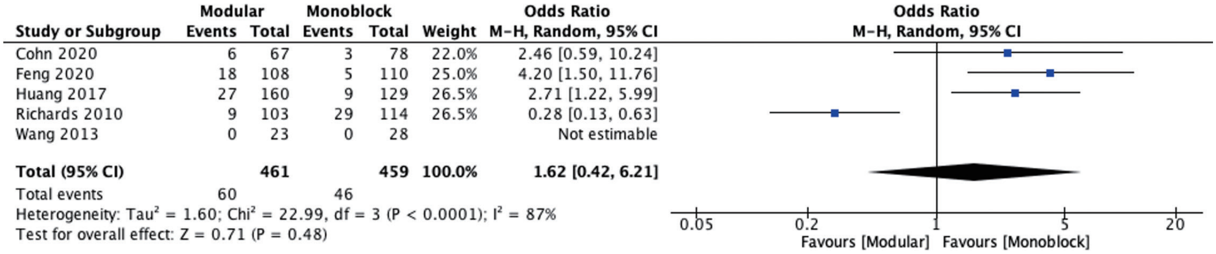


	Modular		Monoblock			Odds Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Fixed, 95% CI
Cohn 2020	7	67	8	78	47.9%	1.02 [0.35, 2.98]
Feng 2020	1	108	0	110	3.5%	3.08 [0.12, 76.53]
Huang 2017	1	160	3	129	23.9%	0.26 [0.03, 2.57]
Moreta 2019	0	24	0	19		Not estimable
Weiss 2011	5	812	4	1073	24.8%	1.66 [0.44, 6.19]
Total (95% CI)		**1171**		**1409**	**100.0%**	**1.07 [0.51, 2.23]**
Total events	14		15			

Heterogeneity: $Chi^2 = 2.30$, df = 3 ($P = 0.51$); $I^2 = 0\%$

Test for overall effect: $Z = 0.18$ ($P = 0.86$)

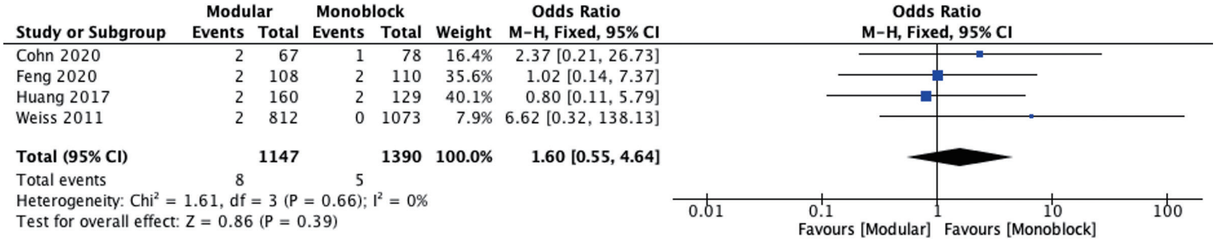
Figure 6 Infection. M-H, Mantel-Haenszel; CI, confidence interval.



Study or Subgroup	Modular Events	Modular Total	Monoblock Events	Monoblock Total	Weight	Odds Ratio M-H, Random, 95% CI
Cohn 2020	6	67	3	78	22.0%	2.46 [0.59, 10.24]
Feng 2020	18	108	5	110	25.0%	4.20 [1.50, 11.76]
Huang 2017	27	160	9	129	26.5%	2.71 [1.22, 5.99]
Richards 2010	9	103	29	114	26.5%	0.28 [0.13, 0.63]
Wang 2013	0	23	0	28		Not estimable
Total (95% CI)		**461**		**459**	**100.0%**	**1.62 [0.42, 6.21]**
Total events	60		46			

Heterogeneity: $Tau^2 = 1.60$; $Chi^2 = 22.99$, df = 3 ($P < 0.0001$); $I^2 = 87\%$
Test for overall effect: Z = 0.71 (P = 0.48)

Figure 7 Intraoperative fracture. M-H, Mantel-Haenszel; CI, confidence interval.



Study or Subgroup	Modular Events	Modular Total	Monoblock Events	Monoblock Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Cohn 2020	2	67	1	78	16.4%	2.37 [0.21, 26.73]
Feng 2020	2	108	2	110	35.6%	1.02 [0.14, 7.37]
Huang 2017	2	160	2	129	40.1%	0.80 [0.11, 5.79]
Weiss 2011	2	812	0	1073	7.9%	6.62 [0.32, 138.13]
Total (95% CI)		**1147**		**1390**	**100.0%**	**1.60 [0.55, 4.64]**
Total events	8		5			

Heterogeneity: $Chi^2 = 1.61$, df = 3 ($P = 0.66$); $I^2 = 0\%$
Test for overall effect: Z = 0.86 (P = 0.39)

Figure 8 Postoperative periprosthetic fracture. M-H, Mantel-Haenszel; CI, confidence interval.

12 articles with a total population of 3,671 patients. A meta-analysis was conducted on the clinical outcomes (HHS) and intraoperative and postoperative complications. The results did not show statistically significant differences between the two stems. In particular, analyzing the results obtained with HHS, Feng *et al.* (23), Li *et al.* (24), and Moreta *et al.* (13) showed better results for modular stems, although Huang *et al.* (15) and Cohn *et al.* (27) reported higher values in favor of the monoblock ones. No statistically significant differences existed between the monoblock and modular stem dislocation rate. According to studies by Huang *et al.* (15), Cohn *et al.* (27), Moreta *et al.* (13), Wang *et al.* (25), and Weiss *et al.* (10), the monoblock stems had a reduced dislocation rate. Only one study, published by Feng *et al.* (23), showed dislocation results in supporting modular stems. Data regarding infection rate resulted similar between the two groups without a clear prevalence. There was no statistically significant difference between modular and monoblock stems in intra and postoperative fractures rate. Once more, data analysis reveals that monoblock stems had a lower but not significant rate of intraoperative fractures than modular stems. Especially, studies conducted by Feng *et al.* (23), Huang *et al.* (15), and Cohn *et al.* (27) demonstrated a decreased incidence of intraoperative fractures with the monoblock stems, while Richards *et al.* (26) showed a lower risk of intraoperative fractures with the modular ones. According to current results of postoperative fractures, Cohn *et al.* (27) and Weiss *et al.* (10) showed a higher risk with modular stems. Radiological results showed that monoblock stems had subsidence (measured in millimeters) more frequently than modular stems, according to Clair *et al.* (21), Feng *et al.* (23), Huang *et al.* (15), Wang *et al.* (25), and Cohn *et al.* (27). Possible reasons are due to surgeon inexperience, wrong sizing, misdiagnosed intraoperative fractures (36). Studies comparing implant survival with 5-year follow-up reported comparable data. Li *et al.* (24) reported the modular stem at 92.31% and the monoblock stems at 85.71%, while Wang *et al.* (25) reported a rate of 91.3% and 88.2%, respectively. The literature analysis has highlighted many data without significant differences in clinical and postoperative outcomes using modular and monoblock stems in revision total hip replacement. An important factor is highlighted by Clair *et al.* (37) about the cost of implants: nonmodular stems are significantly less expensive than modular implants. This analysis should be considered, because all hospitals have a budget cap today.

Strengths and limitations

To our knowledge, our systematic review and meta-analysis is the first that analyzes only comparative studies between modular and monoblock stems evaluating clinical and radiological outcomes and perioperative complications. The main limitation of this study is the small number and low quality of enclosed studies that compared the two stems. Moreover, the modular stem is usually used for more complex cases with lower quality femoral bone stock, even if many authors did not analyze the femoral bone stock with radiographic scores. In addition, differences in surgeon experience and surgical skill may differ as well and influence the preference of implant.

Comparison with similar research

A paper published by Koutalos *et al.* (17) analyzed 46 non-comparative studies reporting the outcome of modular or monoblock stems. This review analyzed clinical and perioperative outcomes demonstrating that monoblock stems had a lower intraoperative fracture rate but a greater risk of failure with statistically significant data. Moreover, their data reported a statistically significant HHS favoring the modular stems.

Explanations of findings

In clinical practice, the significance of the given data should be helpful in the planning and decision-making process for the revision of total hip replacement with femoral deficiency. In the literature, few reviews analyze modular and monoblock stems in hip revision surgery. Both modular and monoblock stems can be used in rTHA as they show similar and satisfactory clinical and radiological outcomes.

Implications and actions needed

Further research must consider a more homogeneous evaluation of clinical parameters: the return to activity and daily living, the assessment of bone mineral density over time, the influence of BMI on the onset of stress shielding, and revision implant failure, in addition to clinical scores. Moreover, there is a lack of data stratification according to the surgical approach used, the type of bone damage, and the number of hip procedures the patient underwent.

Conclusions

The modular and monoblock stems present satisfactory and comparable clinical and postoperative outcomes. Both revision stems are a valid and effective option for managing femoral bone deficit in hip revision surgery.

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