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Comparison of clinical and radiographic results between total knee arthroplasties using medial pivot and posterior-stabilized prosthesis

A meta-analysis

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Abstract

Objective: To evaluate the clinical and radiographic outcomes of total knee arthroplasties (TKA) between using medial-pivot (MP) and posterior-stabilized (PS) prosthesis. Does MP prosthesis and PS prosthesis influence the clinical results of a TKA?

Methods: An electronic literature search of PubMed Medline and the Cochrane Library was performed from inception to October 1, 2019. A meta-analysis to compare postoperative outcomes of Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score, Knee Society Score (KSS), range of motion (ROM), complications, and radiographic results between MP and PS prosthesis were conducted.

Results: Seven eligible studies involving 934 adult patients (MP group, n = 461; PS group, n = 473) were identified for analysis. This study showed no significant difference between the 2 groups in the WOMAC scores, KSS, ROM, and complications ($P > .05$). The differences of the femorotibial angle, position of implant, and patellar tilt were also not significant between the 2 groups ($P > .05$).

Conclusion: The present meta-analysis has shown that patients with the MP prosthesis have similar clinical results as patients with PS prosthesis. Furthermore, the radiographic results, especially patella tilt angle, were also similar between the 2 groups. Therefore, surgeons should be aware that the types of prostheses are not a decisive factor to ensure successful operation.

Abbreviations: CI = confidence interval, FJS = forgotten joint score, KFS = Knee Society Function Score, KKS = Knee Society Knee Score, KSS = Knee Society Score, MD = mean difference, MP = medial pivot, PS = posterior-stabilized, ROM = range of motion, RR = risk ratio, TKA = total knee arthroplasties, UKA = unicompartmental knee arthroplasty, WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.

Keywords: knee osteoarthritis, medial pivot prosthesis, meta-analysis, posterior-stabilized prosthesis, total knee arthroplasty

1. Introduction

Total knee arthroplasty (TKA) has proven to be highly successful at alleviating pain and improving function in patients with advanced knee arthritis. Although different types of prosthesis have achieved satisfactory clinical results in most patients, kinematics of the normal knee have yet not been restored, such as femoral rollback and screw-home movement.[1–3] It is important to reproduce medial pivot motion and posterior femoral rollback to obtain greater postoperative knee flexion.[4,5] The physiological motion of the knee joint has both medial pivot motion and femoral rollback.

The medial-pivot (MP) prosthesis has been designed to replicate physiological motion of the native knee joint. Its medial articulation is effectively a ball-and-socket joint, with a raised anteroposterior lip preventing "paradoxical anterior movement." Some authors reported better results of TKA with the MP prosthesis.[6–11] However, some authors reported the similar clinical results of TKA between MP prosthesis and PS prosthesis,[12,13] and others reported poor outcomes of TKA with MP prosthesis.[14–16] Therefore, we performed a meta-analysis of clinical studies to answer the following question: does MP prosthesis and PS prosthesis influence the clinical results of a TKA?

2. Methods

2.1. Search strategy

An electronic literature search of PubMed Medline and the Cochrane Library was performed from inception to October 1,

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All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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Table 1

Newcastle–Ottawa scale.

Study	Selection				Comparability		Exposure			Quality score
	Cases definition	Cases representativeness	Controls selection	Controls definition	Comparable for a,b,c*	Comparable for d,e*	Exposure ascertainment	Controls ascertainment	Non-response rate	
Bae DK[12]	1	1	1	1	a,b,c	NA	1	1	1	8
Kim YH[15]	1	1	1	1	a,b,c	d,e	1	1	1	9
Choi NY[16]	1	1	1	1	a,b,c	e	1	1	1	9
Anderson MJ[10]	1	1	1	1	a,b	e	1	1	1	8
Papagiannis GI[13]	1	1	1	1	a	e	1	1	1	8
Samy DA[9]	1	1	1	1	a,b,c	e	1	1	1	9
Indelli 2019[17]	1	1	1	1	a,b,c	e	1	1	1	9

NA = data not available.

Comparability variables: a = age; b = sex; c = body mass index; d = bilateral TKAs; e = single surgeon.

* If all characteristics of a, b, and c were comparable, 1 point was assigned; if one, or two characteristics of d and e were comparable, 1 point was assigned; otherwise, 0 points were assigned.

2019. The search strategy was as follows: (medial pivot) and (posterior stabilized) and [(total knee) OR tka OR tkr], where "tkr" stands for total knee replacement.

2.2. Ethic approval

Ethical approval and informed consent are not required for this study. The research data is from published papers.

2.3. Selection of studies

Three authors (XDS, XPG, and XHS) independently selected studies based on the titles and abstracts from these databases. When there was a doubt, full text was retrieved to make a decision. Any disagreement was discussed with the senior authors (ZS), and when consensus could not be reached, that study was excluded.

The inclusion criteria were:

- Primary total knee arthroplasty.
- Comparison of clinical outcomes between MP prosthesis and PS prosthesis.
- Prospective study or retrospective study.
- Cohort study, case control study, or randomized controlled trial.
- Mean follow-up duration of at least 1 year.
- Comparison of at least one of the following outcomes: Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score, Knee Society Score (KSS), range of motion (ROM), and radiographic results.
- Sufficient data for extraction and pooling.

The exclusion criteria were:

- Revision of total knee arthroplasty (TKA) or unicompartmental knee arthroplasty (UKA).
- Review articles or case reports.

2.4. Data extraction

The data of each citation were extracted by 3 independently reviewers (XDS, XPG, and XHS). The characteristics of each study were extracted. Data extracted included: methods, years, mean follow-up, types of prostheses, ROM, radiographic results (femorotibial angle, α angle, β angle, γ angle, δ angle, and patella tilt angle), KSS, complications, and WOMAC score. Any disagreement was resolved by consensus.

2.5. Quality assessment

The quality of each study was assessed by 3 independently authors with the Newcastle–Ottawa scale (Table 1). This scale comprises 3 domains, yielding a maximum score of 9 points for each assessed study. Disagreements were resolved by consensus.

2.6. Statistical analysis

All quantitative analysis of data were performed with Review Manager 5.3, using either a fixed or random effects model, depending on the statistical heterogeneity. Statistical heterogeneity is expressed as P value and I^2. If the P value of the heterogeneity test was $\leq .1$ or $I^2 \geq 50\%$, a random-effects model was used, otherwise a fixed-effects model was adopted. Dichotomous outcomes are summarized using risk ratio (RR) and 95% confidence interval (CI). Continuous outcomes were summarized using the mean difference (MD) and respective 95% CI. The pooled results of effect size were presented graphically as forest plots. Funnel plots were used to evaluate the publication bias.

3. Results

3.1. Search results

A total of 157 potential citations (113 from PubMed, 44 from the Cochrane Library) were reviewed. A flowchart is provided in Fig. 1. Seven studies satisfied the eligibility criteria were included in the meta-analysis. The characteristics of these 7 studies[9,10,12,13,15–17] are shown in Table 2.

3.2. Meta-analysis results

The meta-analysis included 7 studies, involving a total of 934 patients.[9,10,12,13,15–17] The MP group included 461 patients, while the PS group included 473 patients. A funnel plot based on the most frequently cited outcome provided evidence for minimal publication bias (Fig. 2).

3.2.1. WOMAC scores, KSS, and ROM. The WOMAC score (0–100) encompasses evaluation of the knee as well as patients'

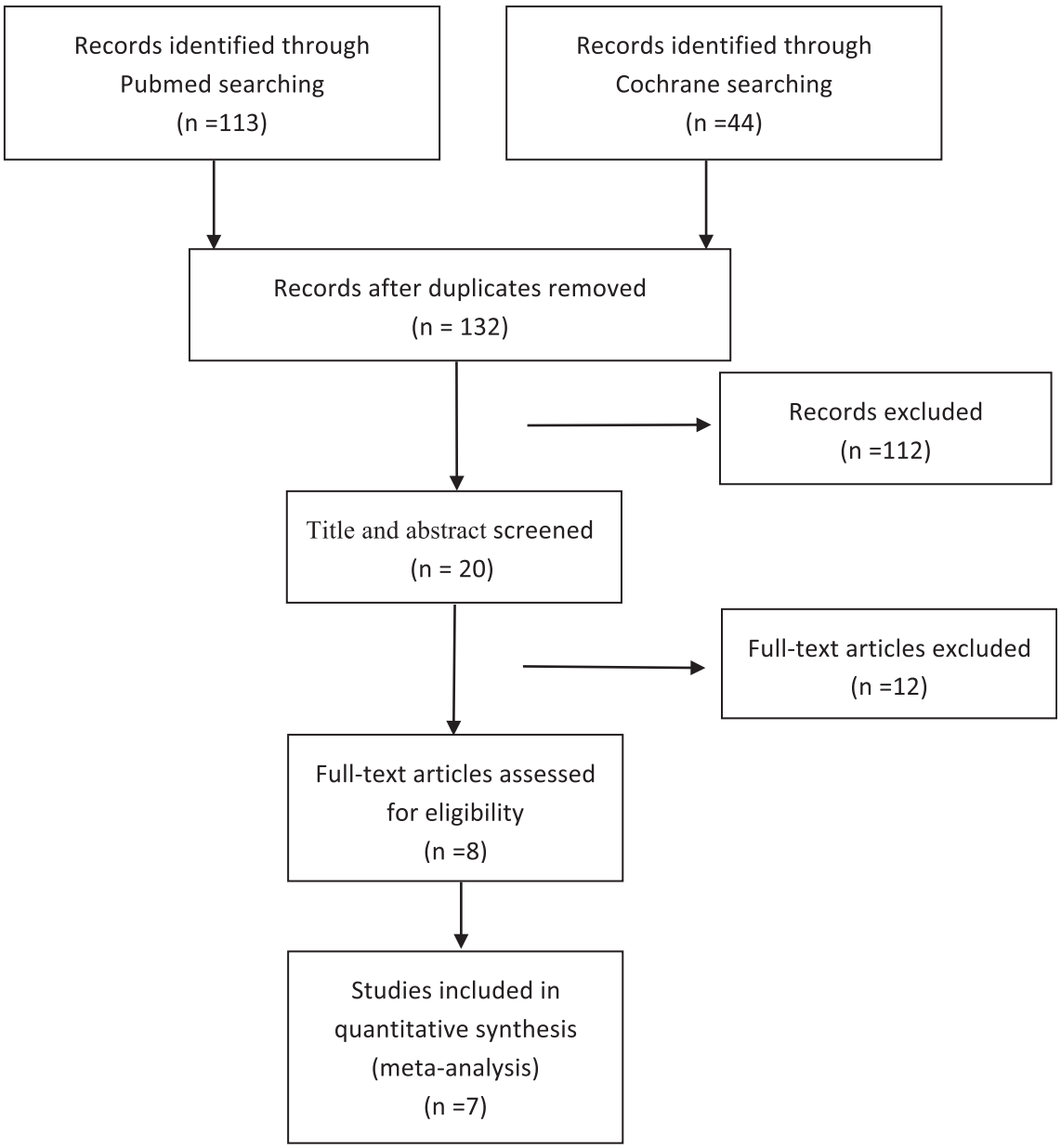

Figure 1. Flow of study selection.

symptoms and functional disability. The KSS consists of the Knee Society Knee Score (KKS; 0–100) and the Knee Society Function Score (KFS; 0–100).

Two studies involving 401 patients provided data on WOMAC score. The MD of the WOMAC score (0–100) was 0.43 ($P = .84$; 95% CI, −3.76–4.63). There was no significant difference between the MP group and the PS group ($P > .05$) (Fig. 3).

Four studies involving 631 patients provided data on KSS. The MD of the KKS and KFS were −2.30 ($P = .31$; 95% CI, −6.77–2.17) and −1.89 ($P = .09$; 95% CI, −4.10–0.32), respectively. The differences between the 2 groups were not statistically significant ($P > .05$) (Fig. 4).

Seven studies involving 934 patients provided data on ROM. The MD of the ROM was −1.68 ($P = .37$; 95% CI, −5.34–1.98). There was no significant difference between the MP group and the PS group ($P > .05$) (Fig. 5).

3.2.2. Radiographic results. The radiographic results consist of femorotibial angle, α angle, β angle, γ angle, δ angle, and patella tilt angle. The α, β, γ, and δ angles[18] were measured according to the method of the American Knee Society.

Four studies involving 624 patients provided data on femorotibial angle. The MD of the femorotibial angle was −0.14 ($P = .73$; 95% CI, −0.97–0.69). There was no significant difference between the MP group and the PS group ($P > .05$) (Fig. 6).

Three studies involving 585 patients provided data on α angle, β angle, γ angle, and δ angle. The MD of the α angle, β angle, γ angle, and δ angle were 0.08 ($P = .89$; 95% CI, −1.11–1.28), 0.04

Table 2

Characteristics of included studies.

References	Methods	Years	Patients (n) MP/PS	Prosthesis (MP/PS)	Outcome	Mean follow-up (y)MP/PS
Bae DK[12]	Prospective	2016	150/150	ADVANCE MP prosthesis (Wright Medical, Arlington, TN)/PFC Sigma (Johnson & Johnson Professional Inc., Raynham, MA)	ROM, KSS, WOMAC scores, Femorotibial angle, α angle, β angle, γ angle, δ angle, patella tilt angle, complications	5.2/5.1
Kim YH[15]	Prospective, randomized	2009	92/92	Medial pivot fixed-bearing (WrightMedical)/PFC sigmamobile-bearing prostheses (DePuy, Warsaw, IN)	ROM, KSS, Femorotibial angle, α angle, β angle, γ angle, δ angle, patella tilt angle	2.6/2.6
Choi NY[16]	Retrospective	2016	49/52	ADVANCE MP fixed-bearing prosthesis (Wright Medical, TN)/ACS RP mobile-bearing prosthesis	ROM, KSS, WOMAC scores, Femorotibial angle, α angle, β angle, γ angle, δ angle	5.3/5.3
Anderson MJ[10]	Prospective	2002	20/19	Advance medial pivot (Wright Medical Technology, Arlington, TN)/ Axiom PSK (Wright Medical Technology, Arlington, TN)	ROM, Femorotibial angle, Patella tilt angle, Complications	2/1.2
Papagiannis GI[13]	Prospective	2016	24/22	Medial Pivot fixed-bearing prosthesis (Arlington, TN, Wright Medical, Advance TM)/rotating platform posterior stabilized prosthesis	ROM, KSS	2-3/2-3
Samy DA[9]	Retrospective	2018	76/88	Evolution medial-pivot (MicroPort, Arlington, TN)/ Zimmer persona posterior stabilized (Zimmer, Warsaw, IN)	Complications	1/1
Indelli 2019[17]	Prospective, randomized	2019	50/50	Persona (Zimmer, USA) medially congruent (MC)/ Persona (Zimmer, USA) posterior-stabilized (PS)	Complications, ROM	2/2

α angle = femoral angle, anteroposterior; γ angle = femoral angle, sagittal; β angle = tibial angle, anteroposterior; δ angle = tibial angle, sagittal; KSS = Knee Society Score; MP = medial Pivot, PS = posterior-stabilized, ROM = range of motion, WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.

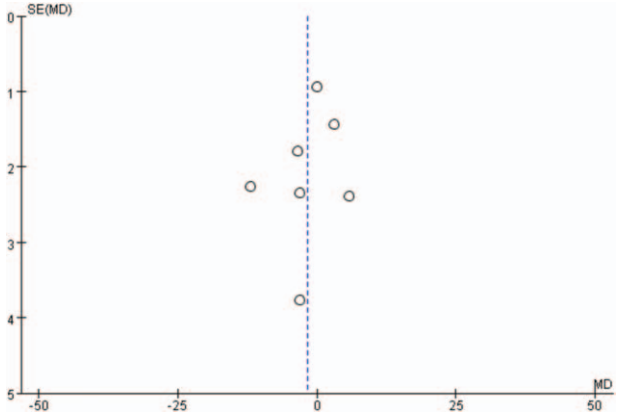

Figure 2. Funnel plot for range of motion.

($P = .82$; 95% CI, –0.31–0.40), 0.37 ($P = .82$; 95% CI, –2.77–3.52), and 0.55 ($P = .11$; 95% CI, –0.12–1.21), respectively. The differences between the 2 groups were not statistically significant ($P > .05$) (Fig. 7).

Three studies involving 523 patients provided data on patella tilt angle. The MD of the patella tilt angle was 1.95 ($P = .06$; 95% CI, –0.08–3.98). There was no significant difference between the MP group and the PS group ($P > .05$) (Fig. 8).

3.2.3. Complications. Four studies involving 603 patients provided data on the complications. There was no significantly greater proportion in either group during the minimum follow-up period (RR = 1.35; $P = .56$; 95% CI, 0.49–3.71), ($P > .05$) (Fig. 9).

4. Discussion

This meta-analysis showed that the clinical results of TKA were similar between the MP group and the PS group in terms of KSS, WOMAC scores, ROM, and complications. Furthermore, there were also no significant differences between the MP group and the PS group in the radiographic results.

Kim et al[15] reported that the mean KSS was significantly worse in the MP group than that in the PS group, whereas Choi et al[16] and Papagiannis et al[13] reported no significant differences were found between the 2 groups in regards of WOMAC scores and KSS. Furthermore, Macheras et al[19] and

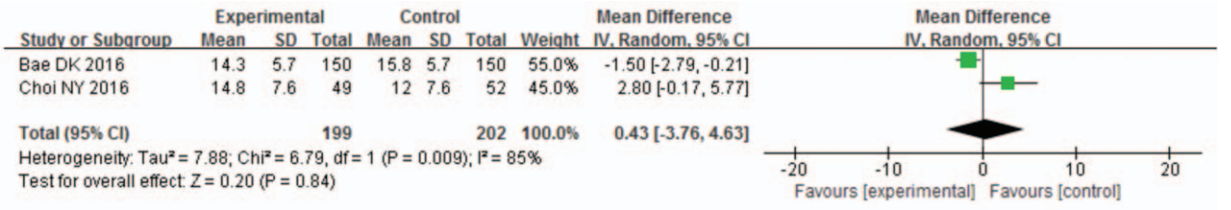

Figure 3. The MD of the WOMAC score (0–100) was 0.43 ($P = .84$; 95% CI, –3.76–4.63). There was no significant difference between the MP group and the PS group ($P > .05$). CI = confidence interval, MD = mean difference, MP = medial pivot, PS = posterior-stabilized, WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.

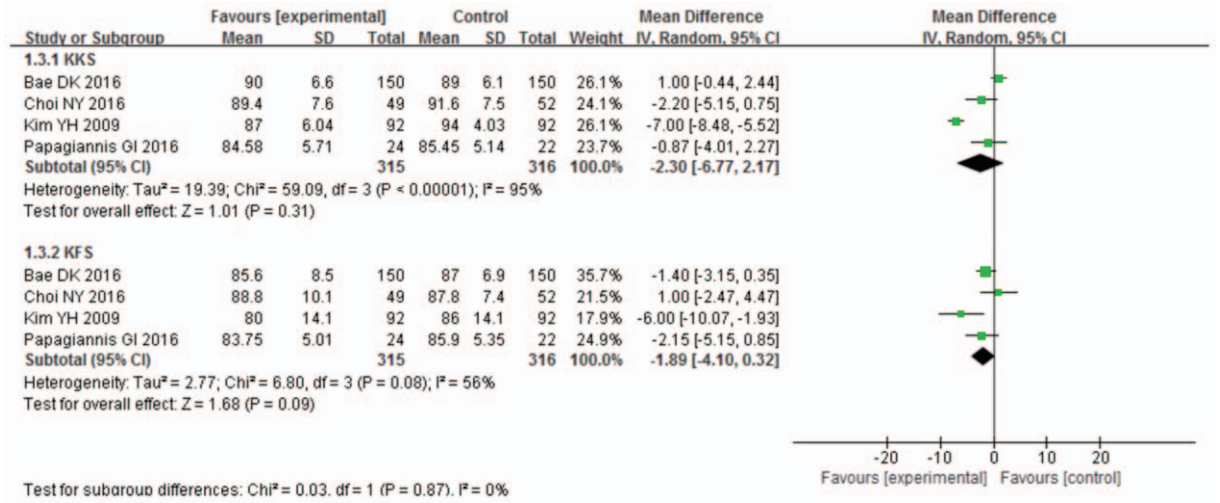

Figure 4. The MD of the KKS and KFS were –2.30 ($P = .31$; 95% CI, –6.77–2.17) and –1.89 ($P = .09$; 95% CI, –4.10–0.32), respectively. The differences between the MP group and the PS group were not statistically significant ($P > .05$). CI = confidence interval, KFS = Knee Society Function Score, KKS = Knee Society Knee Score, MD = mean difference, MP = medial pivot, PS = posterior-stabilized.

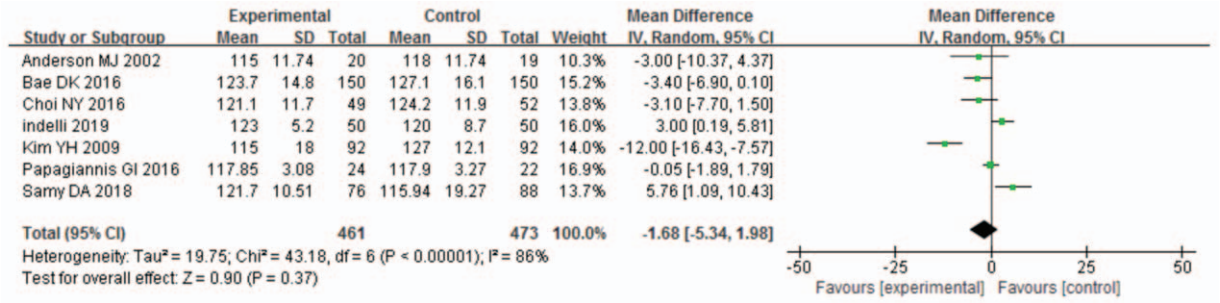

Figure 5. The MD of the ROM was –1.68 ($P = .37$; 95% CI, –5.34–1.98). There was no significant difference between the MP group and the PS group ($P > .05$). CI = confidence interval, MD = mean difference, MP = medial pivot, PS = posterior-stabilized, ROM = range of motion.

Nakamura et al[20] stated there were better KSS and WOMAC scores in patients receiving the medial pivot prosthesis. In our review, there was sufficient data from included studies for pooling of KSS and WOMAC scores, which showed similar results between the MP and PS groups. Although the evaluation of TKA results with these measurements tools was proved to have a good internal consistency,[21] some studies reported the KSS and WOMAC scores following TKA had a high ceiling effect.[22,23] The ceiling effect may be a reason for no differences in the clinical scores in the present study. Nonetheless, we considered it more convincing that the clinical results were able to be evaluated more comprehensively with the combination of objective and subjective outcome systems in our study.

ROM is one of the most important clinical outcomes that reflect the function of knee. The MP prosthesis does not roll back as much as the posterior-stabilized prosthesis with a cam-post mechanism[24] and does not appear to gain as much postoperative flexion angle.[11] In the present study, no significant

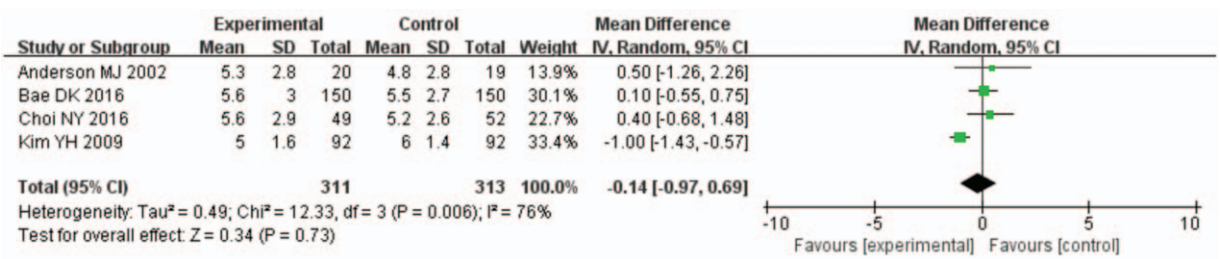

Figure 6. The MD of the femorotibial angle was –0.14 ($P = .73$; 95% CI, –0.97–0.69). There was no significant difference between the MP group and the PS group ($P > .05$). CI = confidence interval, MD = mean difference, MP = medial pivot, PS = posterior-stabilized.

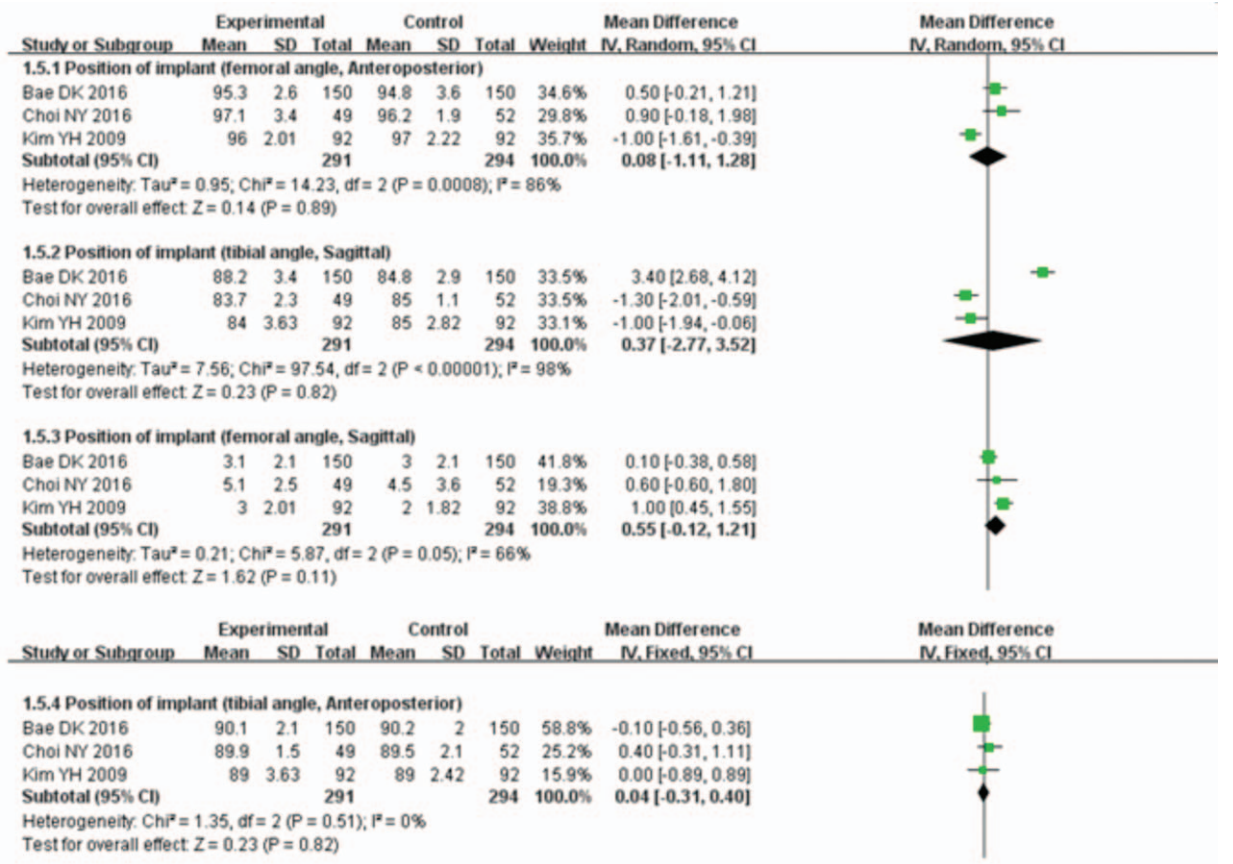

Figure 7. The MD of the α angle, β angle, γ angle, and δ angle were 0.08 ($P = .89$; 95% CI, –1.11–1.28), 0.04 ($P = .82$; 95% CI, –0.31–0.40), 0.37 ($P = .82$; 95% CI, –2.77–3.52), and 0.55 ($P = .11$; 95% CI, –0.12–1.21), respectively. The differences between the MP group and the PS group were not statistically significant ($P > .05$). CI = confidence interval, MD = mean difference, MP = medial pivot, PS = posterior-stabilized.

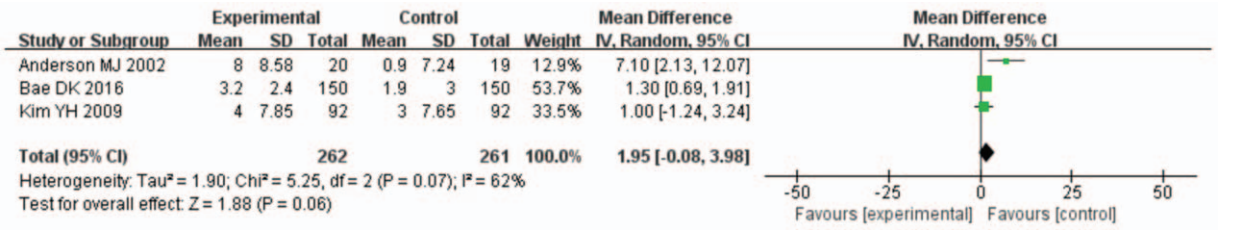

Figure 8. The MD of the patella tilt angle was 1.95 ($P = .06$; 95% CI, –0.08–3.98). There was no significant difference between the MP group and the PS group ($P > .05$). CI = confidence interval, MD = mean difference, MP = medial pivot, PS = posterior-stabilized.

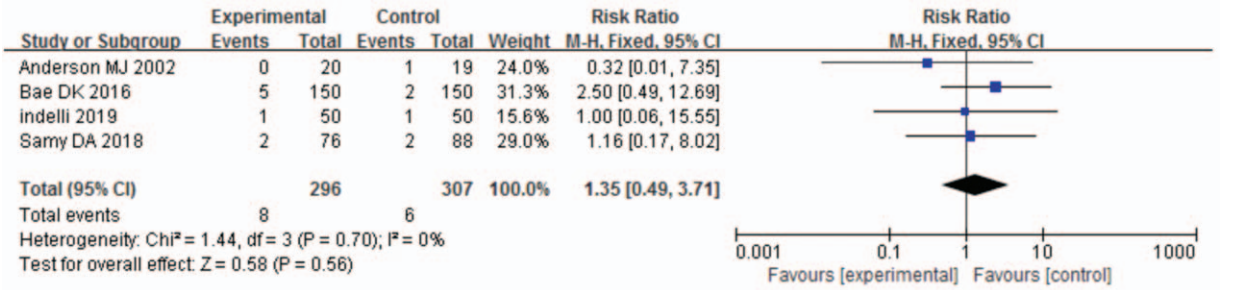

Figure 9. There was no significantly greater proportion of the complications in the MP group and the PS group during the minimum follow-up period (RR = 1.35; $P = .56$; 95% CI, 0.49–3.71), ($P > .05$). CI = confidence interval, MP = medial pivot, PS = posterior-stabilized, RR = risk ratio.

differences were found between the 2 groups regarding flexion-extension ROM, which is in accordance with other studies.[10,12,13,16] However, Kim et al[15] reported the better ROM following TKA with the PS prosthesis compared with MP prosthesis. Some other authors[25,26] stated satisfactory ROM after TKA receiving the MP prosthesis. In summary, the design advantages of the prosthesis may have a certain effect on the improvement of ROM. However, rehabilitation exercises were also a critical factor for improvement of ROM. The Samy et al[9] stated that the improvement of postoperative ROM was satisfactory after rehabilitation exercises by a trained advanced practice physiotherapist. Therefore, we could not ignore the importance of sufficient rehabilitation after surgery, which could affect the improvement of ROM.

The MP motion can reduce the patellofemoral pressure, reproduce normal tibiofemoral kinematics, decrease risk of patellofemoral complications, such as anterior knee pain.[27] Anderson et al[10] reported patients undergoing surgery with MP prosthesis had significantly lower rates of patellofemoral complications compared with patients who underwent surgery with PS prosthesis, while Ishida et al[28] reported the influence of MP prosthesis on the clinical outcome of patellofemoral joint after TKA is still unclear. In our study, we only evaluated patellar tilt angle, and there was not any investigation of the clinical rating system and the other radiographic parameters for patellofemoral joint. Despite these limitations, however, the clinical rating system (KSS and WOMAC scores) and the radiographic results (femorotibial angle, α angle, β angle, γ angle, δ angle, and patella tilt angle) did not differ significantly between the 2 groups in our study. Therefore, we believe whether it was an MP prosthesis or a PS prosthesis, surgeons with excellent surgical technique could perform a successful operation, moreover, we hope that other studies will provide the more experience in the future.

In summary, patients undergoing surgery with MP prosthesis achieved satisfactory clinical results, and the results were similar to those of patients with PS prosthesis. Moreover, the clinical and radiographic results and complication rate were comparable between the MP and PS groups. Beyond that, some other studies[29–31] also found no differences in clinical and radiographic results between knees that had received Cruciate-Retaining prosthesis and those that had received Posterior-Stabilized prosthesis after a medium follow-up. Meanwhile, Ranawat et al[32] reported no differences between the PFC Sigma and Attune knees in KSS score or satisfaction at 2-year follow-up. The results from these studies showed that although the theoretical advantages and design principles of the prosthesis were different, there were no significant differences in mid-term clinical outcomes. Therefore, surgeons should be aware that the types of prostheses are not a decisive factor to ensure successful operation. Of course, further long-term follow-up studies on clinical outcomes and survival rate are needed to determine the advantages of using these innovatively designed prostheses.

Some potential limitations must be acknowledged in our study. First, the different prostheses between the included studies may influence results. However, the design philosophy of MP and PS prosthesis are the same respectively, so we thought that the results are still of clinical significance. Second, lack of survival rate calculation made it impossible to detect the long-term survival advantage of prostheses. Lastly, Forgotten joint score (FJS) was a good indicator of patient satisfaction, but there were not sufficient data for extraction and pooling, whereas the self-assessed WOMAC score can also assess the ability of the patient to perform activities of daily living in more detail. Therefore, we adopted WOMAC score to evaluate patients' subjective feelings. Lastly, future studies with large sample size and additional evaluation indices will provide enhanced analyses.

5. Conclusion

The present meta-analysis has shown that patients with the MP prosthesis have similar clinical results as patients with PS prosthesis. Furthermore, the radiographic results, especially patella tilt angle, were also similar between the 2 groups. Therefore, surgeons should be aware that the types of prostheses are not a decisive factor to ensure successful operation.

Author contributions

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