No difference between mobile and fixed bearing in primary total knee arthroplasty: a meta-analysis

Filippo Migliorini1 · Nicola Maffulli2,3,4 · Francesco Cuozzo2 · Marco Pilone2 · Karen Elsner1 · Jörg Eschweiler1

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Abstract
Purpose Both mobile (MB) and fixed (FB) bearing implants are routinely used for total knee arthroplasty (TKA). This meta-analysis compared MB versus FB for TKA in terms of implant positioning, joint function, patient reported outcome measures (PROMs), and complications. It was hypothesised that MB performs better than FB implants in primary TKA.

Methods This meta-analysis was conducted according to the 2020 PRISMA statement. In February 2022, the following databases were accessed: Pubmed, Web of Science, Google Scholar, Embase. All the randomized clinical trials (RCTs) comparing mobile versus fixed bearing for primary TKA were considered.

Results Data from 74 RCTs (11,116 procedures) were retrieved. The mean follow-up was 58.8 (7.5 to 315.6) months. The MB group demonstrated greater range of motion (ROM) ($P=0.02$), Knee Society Score (KSS) score ($P<0.0001$), and rate of deep infections ($P=0.02$). No difference was found in implant positioning: tibial slope, delta angle, alpha femoral component angle, gamma femoral component angle, beta tibial component angle, tibiofemoral alignment angle, posterior condylar offset, radiolucent lines. No difference was found in duration of the surgical procedure. No difference was found in the following PROMs: Oxford Knee Score (OKS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), visual analogue scale (VAS), function and pain subscales of the KSS score. No difference was found in the rate of anterior knee pain, revision, aseptic loosening, fractures, and deep vein thrombosis.

Conclusion There is no evidence in support that MB implants promote greater outcomes compared to FB implants in primary TKA.

Level of evidence Level I.

Keywords Total knee arthroplasty · Mobile bearing · Fixed bearing

1 Department of Orthopaedic, Trauma, and Reconstructive Surgery, RWTH University Hospital, Pauwelsstraße 30, 52074 Aachen, Germany
2 Department of Medicine, Surgery and Dentistry, University of Salerno, 84081 Baronissi, SA, Italy
3 School of Pharmacy and Bioengineering, Keele University Faculty of Medicine, ST4 7QG Stoke-on-Trent, England
4 Barts and the London School of Medicine and Dentistry, Centre for Sports and Exercise Medicine, Mile End Hospital, Queen Mary University of London, E1 4DG London, England
Introduction

Knee osteoarthritis (OA) is common [6, 94]. Knee OA impairs joint function and quality of life, limiting physical activities and patient independency [71, 73, 115]. Total knee arthroplasty (TKA) is advocated for end-stage knee OA [46, 74, 85]. Both mobile (MB) and fixed (FB) bearing implants are available for primary TKA [1, 49]. FB implants were introduced first, and still represent the most common type of TKA [21, 84]. The polyethylene inlay of FB implants is secured on the tibial plateau. On the other hand, MB implants allow rotation of the polyethylene inlay around its longitudinal axis, miming the physiological kinematics of the knee and promoting a wider range of motion [22, 34, 93]. Previous evidence suggested that MB may promote greater outcomes in functional scores and complications [40, 44, 45, 75, 95]. However, the difference was minimal, and whether mobile bearing provide better outcomes remains controversial [5, 16, 38, 46, 63, 82, 96, 100, 103, 111]. Several randomized clinical trials (RCTs), which have not yet been considered in any previous meta-analyses, have recently been recently published [8, 24, 28, 59, 93, 105, 107, 123]. An update of current evidence could clarify whether MB implants promote greater outcomes to FB in TKA in terms of outcome and complication rate. This meta-analysis compared MB versus FB for primary TKA in terms of implant positioning, patient reported outcome measures (PROMs), and complications. It was hypothesised that MB promotes better outcomes than FB implants in primary TKA.

Materials and methods

Eligibility criteria

All the clinical investigations comparing mobile versus fixed bearing for primary TKA were considered. Only randomized clinical trials (RCTs) with level I to II of evidence, according to Oxford Centre of Evidence-Based Medicine [47], were considered. Only articles in English, German, Italian, French, and Spanish were eligible. Only studies published in peer reviewed journals with accessible full-text article were considered. Only studies which clearly stated the number of included procedures with a minimum of 8 months follow-up were considered. Reviews, opinions, letters, and editorials were not considered. Animals, in vitro, biomechanics, computational, and cadaveric studies were not eligible. All studies investigating the efficacy of experimental rehabilitation protocols were also not included. Studies reporting revision surgeries were also excluded from the analysis.

Search strategy

This meta-analysis was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the 2020 PRISMA statement [89]. The PICODT algorithm was preliminary pointed out:

- P (Population): end-stage knee osteoarthritis;
- I (Intervention): TKA;
- C (Comparison): Mb versus Fb;
- O (Outcomes): implant alignment, surgical duration, range of motion, PROMs, complications;
- D (Design): RCT;
- T (Follow-up): minimum 8 months.

In February 2022, the following databases were accessed: Pubmed, Web of Science, Google Scholar, Embase. The search was limited to RCTs, with no time constrains. The following keywords were used in combination using the Boolean operator AND/OR: knee, osteoarthritis, total, arthroplasty, replacement, prosthesis, implant, mobile bearing, fixed bearing, patient reported outcome measures, PROMs, function, efficacy, complication, revision, reoperation, pain, outcome.

Selection and data collection

Two authors (F.C. and K.E.) independently performed the database search. All the resulting titles were screened and if suitable, the abstract was accessed. The full-text of the abstracts which matched the topic was accessed. A cross reference of the bibliography of the full-text articles were also screened for inclusion. All disagreements between the authors were debated and, if necessary, solved by a third author (NM).

Data items

Two authors (F.C. and K.E.) independently performed data extraction.

The following data at baseline were extracted:

- Generalities of the study: name of the first author, year of publication and journal, length of the follow-up, number of patients, percentage of women (%), body mass index (BMI).

The following data at baseline and at last follow-up were extracted:
- Range of motion (ROM);
- PROMs: Oxford Knee Score (OKS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), visual analogue scale (VAS), Knee Society Score (KSS), and relate function (KSFS and pain (KSPS) subscales.

The following data at last follow-up were collected:
- Implant alignment: tibial slope, delta angle, alpha femoral component angle, gamma femoral component angle, beta tibial component angle, tibiofemoral alignment angle, posterior condylar offset, radiolucent lines;
- Surgical duration;
- Complications: anterior knee pain (AKP), revision, aseptic loosening, fractures, deep vein thrombosis (DVT).

**Study risk of bias assessment**

The risk of bias was valuated using the software Review Manager 5.3 (The Nordic Cochrane Collaboration, Copenhagen). The risk of bias was evaluated, based on the guidelines in the Cochrane Handbook for Systematic Reviews of Interventions [27], by the two reviewers (F.C. and K.E.). The following endpoints were evaluated: selection, detection, performance, attrition, reporting, and other bias. To assess the overall risk of publication bias, the funnel plot of the most commonly reported outcome was performed. The funnel plot charted the standard error (SE) of the Log Odd Ratio (LogOR) versus its OR. The degree of asymmetry of the plot is directly proportional to the degree of bias. To assess the risk of bias of each included studies, the risk of bias graph was performed.

**Statistical analysis and synthesis methods**

The statistical analyses were performed by the main author (F.M.). For descriptive statistics, the IBM SPSS software (version 25) was used. The mean difference and standard deviation were adopted. The $t$ test was performed to assess baseline comparability, with values of $P > 0.1$ considered satisfactory. For the meta-analyses, the software Review Manager 5.3 (The Nordic Cochrane Collaboration, Copenhagen) was used. For continuous data, the inverse variance method with mean difference (MD) effect measure was used. For binary data, the Mantel–Haenszel method with odd ratio (OR) effect measure was used. The confidence interval (CI) was set at 0.95 in all the comparison. Heterogeneity was assessed using $\chi^2$ and Higgins-$I^2$ tests. If $\chi^2 > 0.05$, no statistically significant heterogeneity was found. If $\chi^2 < 0.05$ and Higgins-$I^2 > 60\%$ high heterogeneity was found. A fixed model effect was used as default. In case of high heterogeneity, a random model was used. Overall values of $P < 0.05$ were considered statistically significant.

**Results**

**Study selection**

The literature search resulted in 414 articles. After removal of duplicates ($N = 200$), a further 140 articles were not eligible for the following reasons: study design ($N = 78$), language limitation ($N = 17$), short follow-up ($N = 19$), lacking quantitative data under the endpoints of interest ($N = 26$). Finally, 74 comparative studies were included. The results of the literature search are shown in Fig. 1.

**Risk of publication bias**

The funnel plot of the most commonly reported outcome (revision) was performed to assess the risk of publication bias. The plot evidenced very good symmetry, with optimal distribution of the estimated effects of the included studies. The Egger’s test score was $P = 0.6$, attesting a low risk of publication bias (Fig. 2).

**Study risk of bias assessment**

Given the randomized design of the included studies, the risk of selection bias was low. The risk of detection bias was low to moderate, as was the risk of attrition and reporting biases. The risk of other bias was also low to moderate. Concluding, the quality of the methodological assessment was good. The Cochrane risk of bias graph is shown in Fig. 3.

**Study characteristics and results of individual studies**

Data from 11,116 procedures were retrieved. 69% (7670 of 11,116 patients) were women. The mean follow-up was 58.8 (7.5 to 315.6) months. The mean age was 67.5 ± 5.9 years, the mean BMI was 28.6 ± 2.3 kg/m². Comparability was found at baseline concerning the mean age, mean BMI, female, ROM, KSS, OKS, KSS pain, WOMAC, VAS, and KSS function. Generalities and patient baseline of the included studies are shown in greater detail in Table 1, the baseline comparability between the two groups at baseline in Table 2.

**Results of syntheses**

Eighteen studies (3827 procedures) were included in the comparison of ROM [4, 9, 10, 12, 14, 18, 23, 25, 41, 54, 59, 60, 62, 70, 75, 118]. The MB group demonstrated greater ROM (MD 1.58; 95% CI 0.22 to 2.93; $P = 0.02$; Fig. 4).
Thirty-one studies (5094 procedures) were included in the comparison of the KSS score [4, 10, 12, 13, 17, 18, 25, 32, 33, 39, 41, 42, 48, 54, 57, 59, 60, 62, 66, 70, 75, 83, 87, 91, 95, 96, 104, 106, 107, 110, 118]. The MB evidenced greater KSS score (MD 1.23; 95% CI 0.85 to 1.61; \( P < 0.0001 \); Fig. 5).

Thirty-two studies (6489 procedures) were included in the comparison of rate of deep infection [4, 7, 13, 14, 17, 23, 25, 32, 33, 39, 41, 42, 48, 54, 57, 59, 60, 62, 66, 70, 75, 83, 87, 91, 95, 96, 104, 106, 107, 110, 118].
The MB group evidenced a greater rate of deep infections (OR 1.64; 95% CI 1.07 to 2.52; \(P\) = 0.02; Fig. 6).

No difference was found in implant positioning: tibial slope, delta angle, alpha femoral component angle, gamma femoral component angle, beta tibial component angle, tibiofemoral alignment angle, posterior condylar offset, radiolucent lines.

No difference was found in duration of the surgical procedure.

No differences were found in the following PROMs: OKS, WOMAC, VAS, function and pain subscales of the KSS score.

No difference were found in the rate of the following complications: AKP, revision, aseptic loosening, fractures, DVT.

![Funnel plot](Fig. 2 Funnel plot)

![Methodological quality assessment](Fig. 3 Methodological quality assessment)
**Table 1** Generalities and patient baseline of the included studies

| Author, year | Journal | Follow-up (months) | Bearing | Procedures ($n$) | Mean age | Mean BMI | Women (%) |
|--------------|---------|--------------------|---------|-----------------|----------|----------|-----------|
| Abdel et al., 2018 [2] | Bone Joint J | 120.1 | APE FB, Metal backed FB, MB | 50, 66, 53 | 67, 67, 67 | | |
| Aggarwal et al., 2013 [4] | J Arthroplasty | 66 | MB, FB | 29, 27 | 60, 54.6 | 27.4, 25.3 | 83, 85 |
| Aglietti et al., 2005 [5] | J Arthroplasty | 36 | MB, FB | 103, 107 | 71, 69.5 | 27.5, 27.5 | 86, 81 |
| Amaro et al., 2016 [7] | Knee Surg Sports Traumatol Arthrosc | 24 | MB, FB | 32, 32 | 65.2, 65.2 | 31.1, 31.1 | 75, 75 |
| Amaro et al., 2019 [8] | J Knee Surg | 24 | MB, FB | 32, 32 | 65.2, 65.2 | 31.1, 31.1 | 75, 75 |
| Artz et al., 2015 [9] | J Arthroplasty | 24 | FB, MB | 102, 104 | 61.6, 61.7 | | 47, 55 |
| Bailey et al., 2014 [10] | Knee Surg Sports Traumatol Arthrosc | 24 | MB, FB | 161, 170 | 69.2, 70.1 | 30.4, 31.6 | 69, 70 |
| Baktir et al., 2016 [11] | Acta Orthop Traumatol Turk | 72 | MB, FB | 47, 46 | 64.9, 64.7 | 33.3, 32.2 | 87, 89 |
| Ball et al., 2011 [12] | J Arthroplasty | 48 | MB, FB | 51, 42 | 64.9, 64.0 | 31.0, 31.0 | 56, 56 |
| Beard et al., 2007 [13] | Knee | 36 | MB, FB | 33, 33 | 73.1, 73.1 | | 60, 60 |
| Bhan et al., 2005 [14] | J Bone Joint Surg | 54 | MB, FB | 32, 32 | 63, 63 | | 69, 69 |
| Breeman et al., 2013 [17] | Bone Joint J | 60 | MB, FB | 276, 263 | 69, 69 | 29.5, 30.3 | 16, 59 |
| Breugem et al., 2008 [18] | Clin Orthop Relat Res | 12 | MB, FB | 53, 47 | 68.9, 71.2 | 29.1, 28.4 | 64, 65 |
| Breugem et al., 2012 [19] | Knee Surg Sports Traumatol Arthrosc | 94.8 | MB, FB | 40, 29 | 80, 78 | | 65, 65 |
| Chaudhry et al., 2018 [23] | J Orthop Traumatol | 90 | MB, FB | 60, 50 | 57.6, 58.7 | 25.1, 25.7 | 72, 71 |
| Choi et al., 2010 [25] | J Bone Joint Surg | 24 | MB, FB | 85, 85 | 70.1, 71.1 | 26.6, 26.5 | 93, 97 |
| Feczko et al., 2017 [31] | BMC Musculoskeletal Disord | 60 | MB, FB | 48, 42 | 69, 28.7 | | 30.1, 28.7 |
| Ferguson et al., 2014 [32] | Knee | 24 | MB, FB | 163, 163 | 69.8, 70.2 | 29.7, 31.1 | 53, 53 |
| Fransen et al., 2015 [33] | J Arthroplasty | 72 | MB, FB | 77, 69 | 65.7, 63.8 | 30.2, 30.2 | 68, 72 |
| Garling et al., 2005 [35] | Acta Orthop | 24 | MB, FB | 21, 21 | 66, 66 | 27.0, 27.0 | 50, 50 |
| Goe et al., 2009 [36] | J Bone Joint Surg | 24 | MB, FB | 176, 136 | 71.79, 72.62 | 31.9, 31.5 | 2, 4 |
| Hansson et al., 2005 [38] | Knee | 24 | MB, FB | 25, 27 | 74, 75 | | 48, 52 |
| Hansch et al., 2010 [39] | Int Orthop | 24 | MB, FB | 55, 50 | 69.4, 70 | 29.9, 29.7 | 40, 60 |
| Harrington et al., 2009 [41] | J Arthroplasty | 24 | MB, FB | 72, 68 | 63.3, 63.7 | 34.2, 34.2 | 69, 59 |
### Table 1 (continued)

| Author, year | Journal | Follow-up (months) | Bearing | Procedures (n) | Mean age | Mean BMI | Women (%) |
|--------------|---------|--------------------|---------|----------------|----------|----------|------------|
| Hasegawa et al., 2008 [42] | Knee Surg Sports Traumatol Arthrosc | 40 | MB | 25 | 73 | 25.2 | 88 |
| | | | FB | 25 | 73 | 25.2 | 88 |
| Henrikson et al., 2006 [43] | Clin Orthop Relat Res | 24 | MB | 26 | 72 | |
| | | | FB | 26 | 72 | |
| Jacobs et al., 2011 [48] | Knee Surg Sports Traumatol Arthrosc | 12 | MB | 46 | 67.6 | 71 |
| | | | FB | 46 | 66.7 | 70 |
| Jolles et al., 2012 [50] | J Bone Joint Surg | 60 | MB | 26 | 67.1 | 29.6 | 69 |
| | | | FB | 29 | 70.2 | 27.9 | 48 |
| Kalisvaart et al., 2012 [51] | J Bone Joint Surg | 60 | FB (polyethylene) | 75 | 67 | 32.1 | 69 |
| | | | FB (modular-metal-backed) | 76 | 67.1 | 30.5 | 70 |
| Kim et al., 2007 [56] | J Bone Joint Surg | 67.2 | MB | 174 | 67 | 26.7 | 64 |
| | | | FB | 174 | 67 | 26.7 | 64 |
| Kim et al., 2007 [64] | J Bone Joint Surg | 158.4 | FB | 146 | 69.8 | 27.5 | 94 |
| | | | MB | 146 | 69.8 | 27.5 | 94 |
| Kim et al., 2008 [63] | Clin Orthop Relat Res | 24 | FB | 92 | 69.5 | 27.8 | 92 |
| | | | MB | 92 | 69.5 | 27.8 | 92 |
| Kim et al., 2009 [57] | J Arthroplasty | 24 | FB | 61 | 48.3 | 26.8 | 74 |
| | | | MB | 61 | 48.3 | 26.8 | 74 |
| Kim et al., 2009 [55] | Knee Surg Sports Traumatol Arthrosc | 24 | FB | 66 | 70 | 26.0 | 97 |
| | | | MB | 66 | 70 | 26.0 | 97 |
| Kim et al., 2011 [54] | Knee Surg Sports Traumatol Arthrosc | 30 | MB | 37 | 68 | 27.3 | 95 |
| | | | FB | 36 | 66 | 27.1 | 98 |
| Kim et al., 2017 [60] | J Arthroplasty | 134.4 | FB | 92 | 61.5 | 26.2 | 82 |
| | | | MB | 92 | 61.5 | 26.2 | 82 |
| Kim et al., 2012 [58] | J Bone Joint Surg | 201.6 | MB | 108 | 45 | 25.6 | 77 |
| | | | FB | 108 | 45 | 25.6 | 77 |
| Kim et al., 2014 [62] | J Bone Joint Surg | 144 | MB | 444 | 66.5 | 29.6 | 93 |
| | | | FB | 444 | 66.5 | 29.6 | 93 |
| Kim et al., 2018 [61] | J Arthroplasty | 156 | MB | 164 | 63 | 28.0 | 87 |
| | | | FB | 164 | 63 | 28.0 | 87 |
| Kim et al., 2020 [59] | J Arthroplasty | 315.6 | MB | 291 | 58 | 27.0 | 77 |
| | | | FB | 291 | 58 | 27.0 | 77 |
| Killen et al., 2019 [53] | J Clin Orthop Trauma | 144 | FB | 19 | 76.79 | 76 |
| | | | MB | 28 | 76.57 | 60 |
| Lädermann et al., 2007 [66] | Knee | 36 | FB | 52 | 79 | 29.9 | 77 |
| | | | MB | 50 | 72 | 29.6 | 60 |
| Lädermann et al., 2008 [67] | Rev. Chir. Orthop. Reparatrice Appar. Mot | 85.2 | FB | 48 | 69.8 | 29.9 | 77 |
| | | | MB | 44 | 72 | 29.6 | 60 |
| Lizaur-Utrilla et al., 2012 [70] | J Arthroplasty | 24 | MB | 61 | 74.6 | 31.3 | 77 |
| | | | FB | 58 | 73.9 | 32.6 | 81 |
| Mahoney et al., 2012 [72] | Clin Orthop Relat Res | 24 | MB | 178 | 66 | 31.0 | 67 |
| | | | FB | 183 | 66 | 31.0 | 61 |
| Marques et al., 2014 [75] | Knee Surg Sports Traumatol Arthrosc | 48 | FB | 45 | 68.9 | 28.7 | 75 |
| | | | MB | 42 | 69.4 | 30.4 | 70 |
| Matsuda et al., 2010 [76] | Knee Surg Sports Traumatol Arthrosc | 70.8 | FB | 31 | 76 | 78 |
| | | | MB | 30 | 73 | 77 |
| Author, year | Journal | Follow-up (months) | Bearing | Procedures \((n)\) | Mean age | Mean BMI | Women (%) |
|-------------|---------|-------------------|---------|------------------|----------|---------|-----------|
| Minoda et al., 2014 [83] | Knee Surg Sports Traumatol Arthrosc | 24 | MB | 46 | 74.3 | 26.3 | 89 |
| | | | FB | 48 | 75.7 | 25.5 | 87 |
| Nieuwenhuijse et al., 2013 [83] | J Bone Joint Surg | 70 | LPS-Flex MB | 16 | 66.8 | 25.9 | 79 |
| | | | LPS-Flex FB | 12 | 72.2 | 26.5 | 70 |
| | | | LPS MB | 14 | 68.7 | 29.0 | 100 |
| | | | LPS FB | 19 | 68.5 | 27.6 | 76 |
| Nutton et al., 2012 [87] | J Bone Joint Surg | 12 | FB | 40 | 69.8 | 29.8 | 53 |
| | | | MB | 36 | 68.3 | 29.1 | 50 |
| Okamoto et al., 2014 [88] | J Arthroplasty | 12 | MB | 20 | 76 | 25.0 | 90 |
| | | | FB | 20 | 78 | 27.0 | 80 |
| Park et al., 2018 [91] | Knee Surg Sports Traumatol Arthrosc | 24 | MB | 70 | 69.5 | 26.0 | 93 |
| | | | FB | 70 | 68.9 | 25.6 | 96 |
| Pijls et al., 2012 [92] | J Bone Joint Surg | 120 | MB | 21 | 64 | 27.0 | 86 |
| | | | FB | 21 | 66 | 27.0 | 76 |
| Poirier et al., 2015 [93] | Orthop Traumatol Surg Res | 108 | MB | 31 | 72 | 27.0 | 58 |
| | | | FB | 30 | 70 | 27.0 | 53 |
| Powell et al., 2018 [95] | Bone Joint J | 60 | MB | 46 | 65.5 | 29.7 | 44 |
| | | | FB | 39 | 65.5 | 29.7 | 44 |
| Price et al., 2003 [96] | J Bone Joint Surg | 12 | FB | 19 | 73.1 | 29.0 | 60 |
| | | | MB | 21 | 73.1 | 29.0 | 60 |
| Radetzki et al., 2013 [97] | Acta Orthop | 120 | MB | 22 | 65.5 | 24.4 | 60 |
| | | | FB | 17 | 66.5 | 24.1 | 53 |
| Rahman et al., 2010 [98] | J Arthroplasty | 43 | MB | 24 | 62.6 | 31.5 | 58 |
| | | | FB | 27 | 62 | 31.4 | 67 |
| Roh et al., 2012 [102] | Knee Surg Sports Traumatol Arthrosc | 30 | MB | 42 | 69.8 | 26.5 | 95 |
| | | | MB | 44 | 71 | 26.4 | 93 |
| Sappey-Marinier et al., 2019 [104] | Knee Surg Sports Traumatol Arthrosc | 60 | FB | 64 | 71 | 29.0 | 58 |
| | | | MB | 65 | 71 | 30.0 | 60 |
| Sappey-Marinier et al., 2020 [105] | Knee Surg Sports Traumatol Arthrosc | 120 | MB | 50 | 71 | 29.0 | 58 |
| | | | MB | 56 | 71 | 30.0 | 60 |
| Schotanus et al., 2016 [106] | Knee Surg Sports Traumatol Arthrosc | 24 | MB | 20 | 62.7 | 29 | 48 |
| | | | FB | 22 | 67.3 | 29.4 | 41 |
| Schotanus et al., 2017 [107] | Eur J Orthop Surg Traumatol | 24 | MB | 20 | 61.9 | 29.4 | 40 |
| | | | FB | 21 | 67.1 | 29.9 | 43 |
| Scuderi et al., 2012 [109] | J Arthroplasty | 48 | MB | 152 | 63.7 | 29.6 | 55 |
| | | | FB | 141 | 63.4 | 29.4 | 62 |
| Shemanski et al., 2012 [110] | Knee Surg Sports Traumatol Arthrosc | 72 | MB | 150 | 70 | 26.9 | 68 |
| | | | MB | 150 | 68 | 26.9 | 60 |
| Tiwari et al., 2019 [113] | Knee Surg Sports Traumatol Arthrosc | 24 | MB | 260 | 69.7 | 26.9 | 94 |
| | | | FB | 133 | 69.7 | 26.7 | 98 |
| Tjornild et al., 2015 [114] | Acta Orthop | 24 | MB | 23 | 66 | 30.0 | 46 |
| | | | FB | 23 | 66 | 27.0 | 65 |
| Urwin et al., 2014 [116] | Knee | 9 | FB | 8 | 59.3 | 31.9 | 38 |
| | | | MB | 8 | 59.6 | 31.9 | 38 |
| Van hammersfeld et al., 2018 [117] | Acta Orthop | 72 | MB | 16 | 68 | 30.1 | 70 |
| | | | MB | 12 | 67.5 | 29.8 | 83 |
| Vasdev et al., 2009 [118] | J Orthop Surg | 42 | MB | 60 | 63 | 63 | 50 |
Discussion

The main finding of the present study was that the MB implants performed in a similar fashion to FB implants for TKA. The analyses evidenced greater KSS, ROM, and rate of the deep infection in MB implants. However, though statistically significant, their clinical relevance is likely limited. Concerning the KSS score, its overall difference between the two implants does not overcome their minimal clinically important difference (MCID), which has been estimated between 6/100 and 9/100 [40, 52, 68, 69, 112]. A formal MCID for the ROM has not yet been estimated. However, given its minimal difference, the clinical relevance of these findings was dubious. A slight improvement of PROMs was not necessarily associated with a functional advantage [15]. The minimal functional improvement may be explained by greater axial rotation promoted by the MB implants [29, 53, 99]. Amaro et al. [8] evaluating kinematic differences in 64 patients, found that axial rotation was higher in the MB group after 1 year, but disappeared at 2-year follow-up. A histological study showed the development of fibrotic tissue in the synovial membrane and infrapatellar fat pad after a TKA [3]. This produces a hardening effect that may minimize the kinematic differences between the MB and FB groups [8]. MB actively corrects the rotational femoral offset while standing, improving stepping and squatting [46]. However, this difference is not clinically relevant [88]. Moreover, different types of MB implants have different kinematics during stepping and squatting [46], and the final clinical outcome of MB can be influenced by the brand. A long-term study comparing different types of MB and FB implants could be useful to further understand the real benefits of different type of prostheses.

The rate of deep infection was strongly influenced by the study by Breeman et al. [17], which weighted 17.6% on the final effect. Indeed, when conducting the analyses without those data [17], the rate of deep infection is similar between the two groups. Nevertheless, the authors evidenced no difference between the two implants in terms of infections in their study [17]. Indeed, a deep infection was present in 12 of 276 patients in the MB group, and in 6 of 263 patients in the FB group [17]. Some limitations that may have influence

Table 1 (continued)

| Author, year         | Journal               | Follow-up (months) | Bearing | Procedures (n) | Mean age | Mean BMI | Women (%) |
|----------------------|-----------------------|--------------------|---------|----------------|----------|----------|-----------|
| Watanabe et al., 2005 | Int Orthop            | 96                 | MB      | 22             | 59.6     | 96       |           |
| Wohlrab et al., 2005 | Z Orthop              | 35                 | FB      | 30             | 65.5     | 24.4     | 62        |
| Woolson et al., 2011 | J Arthroplasty        | 120                | FB      | 30             | 77.9     | 29.2     |           |
| Wylde et al., 2008   | J Bone Joint Surg     | 24                 | FB      | 120            | 67.6     | 64       |           |
|                      |                       |                    | MB      | 108            | 68.9     | 68       |           |

MB: mobile bearing; FB: fixed bearing

Table 2 Baseline comparability of the two groups

| Endpoint         | FB (n = 5517) | MB (n = 5599) | P values |
|------------------|---------------|---------------|----------|
| Mean age         | 67.5 ± 61     | 67.3 ± 5.6    | n. s.    |
| Mean BMI         | 28.7 ± 2.3    | 28.6 ± 2.3    | n. s.    |
| Women (%)        | 1.7 ± 8.9     | 1.5 ± 6.9     | n. s.    |
| ROM              | 104.9 ± 24.5  | 105.0 ± 24.1  | n. s.    |
| KSS              | 39.7 ± 17.0   | 40.5 ± 17.1   | n. s.    |
| OKS              | 33.1 ± 10.9   | 33.3 ± 10.9   | n. s.    |
| KSS pain         | 25.3 ± 26.5   | 21.1 ± 25.7   | n. s.    |
| WOMAC            | 59.9 ± 8.5    | 59.2 ± 8.3    | n. s.    |
| VAS              | 32.8 ± 36.0   | 32.5 ± 33.0   | n. s.    |
| KSS function     | 43.3 ± 12.8   | 43.5 ± 12.7   | n. s.    |

No statistically significant difference was detected

MB: mobile bearing; FB: fixed bearing; MD: mean difference; ROM: range of motion; OKS: Oxford Knee Score; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; VAS: visual analogue scale; KSS: Knee Society Score; n. s.: not significant
our results should be discussed. The authors conducted a multicentre study involving 116 surgeons [17, 99]. Surgeon experience and approaches, implants design and post-operative protocols were not considered.

No differences in radiographic alignment were shown in the present study. Only one study showed a radiographic difference in patellar translation [104]. A tendency to increase patellar translation in the MB group was also evidenced in the present study. In MB implants, the rotation of the tibial component and the variable position of the tibial relative to the femoral implant can affect patellar tracking [90]. However, other meta-analyses comparing patellar translation did not evidence any differences between MB and FB implants [86, 111].

The MB design has been introduced to better simulate knee kinematics, reducing contact stresses, aseptic loosening, and polyethylene wear [20]. The self-alignment promoted by the MB implants compensates the physiological tibial and the femoral component offset [30]. The latter has been hypothesized to improve the conformity between femoral component and mobile insert during stepping and squatting, thus reducing contact pressure and loosening of polyethylene wear [46]. However, this study was unable to identify differences between the two implants, in contest with previous evidence [59, 62, 105]. Though there is less wear at the femoral condyle interface in MB than in FB implant, the former produce additional wear at the surface of metallic tibial implant, which may explain the similarity in the rate of overall wear [105]. Only one study [37] showed a higher rate of aseptic loosening in the MB group. The risk was higher only in certain models. In the MB implants, the geometry of tibial component is such that the shortening of the keel and the under-face texture increase the risk for micromotion and aseptic loosening [26, 53, 65, 101, 104, 108].

This study certainly has limitations. The analyses were conducted irrespective of the surgical exposure and approach. In the present study, both minimally and standard invasive techniques were included. Surgical exposure may influence outcomes, and minimally invasive surgery performed by experienced surgeon may offer short- and mid-term clinical and functional benefits over the conventional exposure [78]. Moreover, the surgical approach may influence the clinical outcomes. A recent network meta-analysis demonstrated that the mini-subvastus approach outperformed all other approaches (mini-medial paratellar, midvastus, quadriceps sparing) [77]. Patellar retaining or resurfacing has not been investigated, and may represent a further limitation [80]. Different inlay designs (posterior stabilized, cruciate/bicruciate retaining) were not considered as separate. A previous meta-analysis demonstrated no difference in the outcome between the posterior stabilized versus cruciate retaining [81], while no study which compared MB versus FB using bicruciate retaining implants.

![Forest plot of the comparison: ROM (IV: inverse variance; CI: confidence interval). The square represents the effect of each single study. The horizontal line represents the confidence interval of each study. The vertical line “0” represent the no effect threshold. The diamond represents the final effect of the overall analysis.](image_url)
were included in the present study. The manufacturer of the implants was often biased. MB implants are more sensitive to soft tissue release and optimal gap balancing over flexion and extension. Differently, in FB implants planned resection following the anatomical landmarks (anteroposterior and trans-epicondylar axis) can be performed [79]. Few authors appropriately described the surgical protocol, and further subgroups comparisons were not possible. This may generate bias and increase heterogeneity. The conclusion of the present meta-analysis should be considered with these limitations. Results of the present study indicated that bearing in TKA, whether mobile or fixed, does not influence the clinical outcome.

![Forest plot of the comparison: KSS score (IV: inverse variance; CI: confidence interval). The square represents the effect of each single study. The horizontal line represents the confidence interval of each study. The vertical line “0” represent the no effect threshold. The diamond represents the final effect of the overall analysis.](image-url)
**Conclusion**

There is no evidence to support that MP implants promote better outcomes compared to FB implants in primary TKA. The analyses evidenced greater KSS, ROM, and greater rate of the deep infection in MB implants. However, though statistically significant, their clinical relevance is limited. Further clinical trials are required.

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**Fig. 6** Forest plot of the comparison: rate of deep infection (M–H: Mantel–Haenszel; CI: confidence interval). The square represents the effect of each single study. The horizontal line represents the confidence interval of each study. The vertical line “0” represents the no effect threshold. The diamond represents the final effect of the overall analysis.

| Study or Subgroup                  | Weight | Odds Ratio M–H, Fixed, 95% CI | Odds Ratio M–H, Fixed, 95% CI |
|-----------------------------------|--------|-------------------------------|-------------------------------|
| Aggarwal et al. 2013              |        |                               |                               |
| Amaro et al. 2016                 |        |                               |                               |
| Beard et al. 2007                 | 7.4%   | 0.19 [0.01, 4.07]             |                               |
| Bhan et al. 2005                  | 1.4%   | 3.10 [0.12, 78.87]            |                               |
| Breeman et al. 2013               | 17.6%  | 1.95 [0.72, 5.27]             |                               |
| Chaudhry et al. 2018              |        |                               |                               |
| Choi et al. 2010                  | 3.0%   | 1.00 [0.06, 16.25]            |                               |
| Fransen et al. 2015               | 1.5%   | 2.73 [0.11, 68.01]            |                               |
| Garling et al. 2005               | 1.4%   | 3.15 [0.12, 81.74]            |                               |
| Go et al. 2009                    | 3.3%   | 2.35 [0.24, 22.89]            |                               |
| Hanusch et al. 2010               | 1.3%   | 10.74 [0.56, 204.74]          |                               |
| Harrington et al. 2009            | 2.9%   | 1.06 [0.06, 17.28]            |                               |
| Hasegawa et al. 2008              |        |                               |                               |
| Jacobs et al. 2011                | 1.4%   | 5.22 [0.24, 111.88]           |                               |
| Kim et al. 2007                   | 1.5%   | 5.06 [0.24, 106.12]           |                               |
| Kim et al. 2007 (2)               | 3.0%   | 1.00 [0.06, 16.14]            |                               |
| Kim et al. 2008                   | 5.9%   | 0.49 [0.04, 5.55]             |                               |
| Kim et al. 2009                   | 2.9%   | 1.00 [0.06, 16.36]            |                               |
| Kim et al. 2011                   |        |                               |                               |
| Kim et al. 2012                   | 3.0%   | 1.00 [0.06, 16.20]            |                               |
| Kim et al. 2014                   | 6.0%   | 1.00 [0.14, 7.13]             |                               |
| Kim et al. 2018                   | 5.9%   | 1.00 [0.14, 7.19]             |                               |
| Kim et al. 2020                   | 5.9%   | 1.00 [0.14, 7.15]             |                               |
| Lizaur-Utrilla et al. 2012        | 1.4%   | 3.18 [0.13, 79.96]            |                               |
| Lädermann et al. 2007             | 1.5%   | 2.90 [0.12, 72.65]            |                               |
| Mahoney et al. 2012               | 5.8%   | 1.55 [0.26, 9.40]             |                               |
| Matsuda et al. 2010               | 1.4%   | 3.20 [0.13, 81.78]            |                               |
| Powell et al. 2018                | 1.5%   | 6.36 [0.32, 126.95]           |                               |
| Sappey-Mamarier et al. 2020       | 1.5%   | 2.73 [0.11, 68.54]            |                               |
| Tiwari et al. 2019                | 5.9%   | 0.17 [0.01, 4.19]             |                               |
| Tjornild et al. 2015              | 1.4%   | 3.13 [0.12, 81.00]            |                               |
| Wyld et al. 2008                  | 4.2%   | 0.37 [0.01, 9.11]             |                               |

**Total (95% CI)** 100.0% 1.64 [1.07, 2.52]

Heterogeneity: Chi² = 11.64, df = 26 (P = 0.99); I² = 0%

Test for overall effect: Z = 2.25 (P = 0.02)
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Declarations

Conflict of interest The authors declare that they have no competing interests for this article.

Ethical approval This study complies with ethical standards.

Consent to publish Not applicable.

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