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SYSTEMATIC REVIEW

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"Anatomic patella design versus medialized dome design in the modern posterior stabilized (ATTUNE) total knee arthroplasty: a systematic review and meta-analysis"

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Abstract

Background Patellar component design in total knee arthroplasty (TKA) can influence patellofemoral kinematics and clinical outcomes. The medialized dome design (MDD) aligns the patella apex more medially, while the anatomic patella design (APD) aims to replicate the native patella's shape and tracking. Although biomechanical studies suggest potential benefits of APD, clinical evidence remains inconclusive.

Methods A systematic review and meta-analysis following PRISMA guidelines was conducted to compare the clinical outcomes of MDD and APD in a modern posterior-stabilized TKA (ATTUNE system). We searched PubMed, Scopus, Embase, and Web of Science on January 10, 2025, without language or date restrictions. Eligible studies included randomized controlled trials (RCTs) and comparative cohort designs evaluating patient-reported outcome measures (PROMs), revisions, complications, range of motion (ROM), and radiologic measures of patellar stability. Risk of bias was assessed using RoB-2 for RCTs and ROBINS-I for cohort studies. Pooled effect sizes were calculated using Hedges's g and random-effects modeling.

Results Seven studies, including three RCTs and four cohort studies, with a total of 1,069 patients and 1,113 knees (507 APD vs. 606 MDD), were included. The meta-analysis demonstrated no significant difference in PROMs (Hedges's g = 0.09; 95% CI [–0.04 to 0.22]; $P = 0.17$) or ROM (Hedges's g = 0.02; 95% CI [–0.21 to 0.26]; $P = 0.83$) between APD and MDD. While revision rates and complications were higher for APD, the differences were not statistically significant compared to MDD (14 vs 9). Radiographic measures showed inconsistencies and did not definitively favor either design.

Conclusions Current evidence suggests that APD offers no clear clinical advantage over MDD in the ATTUNE posterior-stabilized TKA. Both designs yield broadly comparable PROMs and knee function outcomes. Larger RCTs with extended follow-up are warranted to clarify the safety of APD.

Level of evidence III.

Keywords Patellar resurfacing, Anatomic patella, Medialized dome, Total knee arthroplasty

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Introduction

Optimal outcomes in total knee arthroplasty (TKA) depend on precise component selection and surgical technique [1]. A modern posterior-stabilized ATTUNE knee system, with a modified trochlear groove that more accurately replicates the natural trochlea-patella anatomy, has demonstrated superiority over the traditional press-fit condylar design. This superiority is evident in its biomechanical and clinical performance, including improved patellar tracking, reduced contact pressure, greater patient-reported outcome measures (PROMs), and lower patellofemoral complication rates [2–4].

The ATTUNE system currently has two options for patellar resurfacing: the Anatomic Patellar Design (APD) and the Medialized Dome Design (MDD). The MDD aligns the patella apex closer to the native anatomic position, minimizing the risk of femoral impingement. The APD incorporates dome medialization and adds a lateral facet contour to replicate the natural patella shape [5]. This design aims to improve patellofemoral tracking, particularly at higher flexion angles [2, 5, 6] (Fig. 1).

Biomechanical investigations have suggested that the APD may offer advantages such as greater patellofemoral flexion ranges, more closely resembling native knee patella tracking, a greater weight-bearing range of motion (ROM), and improved extensor mechanism strength. However, conclusions regarding the relative performance of the MDD versus APD in clinical settings remain inconclusive [5, 7–12].

This study aims to analyze clinical data comparing MDD and APD within the ATTUNE system. Specifically, we evaluate RPOMs, knee function, implant survivorship, complication rates, and radiologic measures for patellar stability to determine whether the proposed kinematic benefits of APD result in tangible clinical improvements.

Methods

This systematic review and meta-analysis comply with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [13]. We registered the protocol of the study in PROSPRO (CRD42024621087). In addition; the study protocol was registered and approved by Iran National Committee for Ethics in Biomedical Research; (Reference Number: IR.SBMU.MSP.REC.1403.688).

Search strategy

A literature search was conducted across four major databases—PubMed, Scopus, Embase, and Web of Science—using tailored keywords and Boolean operators. The search was performed on January 10, 2025, and results were exported without applying language or publication date restrictions. Complete search strings for each database are provided in the Appendix A.

Eligibility criteria

We employed the PICOS framework to formulate the eligibility criteria. The population (P) of interest included patients who underwent TKA using the ATTUNE knee system with patellar resurfacing. The APD was considered the intervention (I), while the MDD served as the control (C) group. We focused on clinical outcomes, with PROMs, revisions, and complications as the primary outcomes, and ROM and radiologic measures of patellar stability as secondary outcomes (O). Eligible study designs (S) included randomized controlled trials (RCTs) and non-randomized comparative studies with at least 6 months of clinical follow-up. Studies that did not meet these criteria, or those comparing outcomes of other patella designs or prosthesis systems, were excluded. Cross-sectional and case series studies were also excluded.

Specifically, for PROMs, we gathered data from reliable and valid questionnaires [14–22], including: EQ-5D (EuroQol-5 Dimension); KOOS (Knee Injury and Osteoarthritis Outcome Score); JKOM (Japanese Knee Osteoarthritis Measure); WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index); OKS (Oxford Knee Score); KSS (Knee Society Score); PKIP (Patellar Kinematic Inverse Prediction); and HSS (Hospital for Special Surgery Score); Feller, and Kujala scores.

Fig. 1 Anteroposterior and lateral views of two patellar component designs: (**a**) Medialized Dome Design (MDD) and (**b**) Anatomic Patella Design (APD). This figure is reproduced from *Shon et a*'s [7] article: *"The Design of the Patellar Component Does Not Affect the Patient-Reported Outcome Measures in Primary Posterior-Stabilized Total Knee Arthroplasty: A Randomized Prospective Study"*. Permission is granted under the CC-BY licenses specified in the original article. *Journal of Clinical Medicine*, Mar 2022; ISSN: 2077–0383; https://doi.org/10.3390/jcm11051363

Study selection

Following the manual elimination of duplicate entries, two independent reviewers (OB, MH) screened the titles and abstracts of the remaining articles to identify potentially eligible studies. The full texts of the shortlisted articles were then thoroughly evaluated to determine their compliance with the predetermined inclusion criteria. Any disagreements that arose during the selection process were resolved through discussion. In cases where consensus could not be reached, a third reviewer (SH) was consulted to make the final decision.

Data collection process

A data extraction sheet created in Microsoft Excel was used to systematically collect information from the included studies. All extracted data were independently gathered by two evaluators, with any discrepancies resolved through discussion. The extracted data included the lead author, year of publication, study design, follow-up duration, demographic details (total patients and knees, women percent, number of knees in MDD and APD, age, and body mass index [BMI] and bearing design) presented in Table 1, and outcomes, PROMs, knee function, complications or revisions, and radiologic measures in Table 2. Additionally, raw data used in the meta-analysis were provided in Appendix B for transparency and reproducibility.

For studies reporting sub-scores, overall scores were calculated to facilitate meta-analysis [11, 12]. In the case of the study by Ahearn et al. [11], which did not report standard deviations, we estimated the mean SD using data from other studies with similar sample sizes and scores. During the preparation of the manuscript, the authors used "ChatGPT" only for grammar correction. After using this service, the authors reviewed and edited the content as needed.

Risk of bias assessment

Two independent authors assessed the quality of studies utilizing the Cochrane ROBINS-I tool for non-randomized studies to evaluate biases related to confounding, selection, and intervention classification [23]. Similarly, RCTs were evaluated using the Cochrane RoB-2 tool [24]. addressing randomization, deviations from intended interventions, missing data, outcome measurement, and reporting biases. Disagreements between the two assessors were resolved through discussion. The Robvis tool was used to visualize bias assessments, providing graphical summaries [25].

Data analyses

Effect estimates were calculated using Hedges's g to address outcome heterogeneity and small sample sizes. Effect sizes were classified as small (< 0.2), moderate (0.2–0.5), or large (> 0.5). A random-effects model was applied to account for inter-study variability, and analyses were performed using Comprehensive Meta-Analysis (CMA) v3.3, with significance set at $p < 0.05$.

Heterogeneity was evaluated using the I^2 statistic, with thresholds of 25, 50, and 75% indicating low, moderate, and high heterogeneity, respectively. Insufficient data for pooling were narratively summarized, and funnel plots were used to assess publication bias when at least 10 studies contributed to a meta-analysis. All pooled results were reported with 95% confidence intervals (CIs) for clarity and transparency.

Table 1 Study and patient characteristics

Study, Year	Study Design / LoE	Total Cases (women %)	Knees (APD / MDD)	Mean Age (APD / MDD)	Mean BMI (APD / MDD)	Tibial Bearing Design
Ahearn 2021 [11]	prospective cohort/II	100 (63)	50/50	71/69	31.2/31.7	-
Kleeman-Forsthuber 2024 [8]	retrospective cohort/III	200 (70)	100/100	66/66	26.2/26.2	MB
Mannen 2019 [12]	retrospective cohort/III	27 (69)	16/16	62.5/65.2	25.6/27.6	MB
Mochizuki 2021 [10]	RCT/I	48 (93)	24/24	74.3/73.0	27.1/28.1	FB
Shon 2022 [7]	RCT/I	98 (90)	49/49	71.33/71.92	27.69/27.11	FB
Sobhi 2024 [5]	prospective cohort/II	505 (-)	212/323	67.85/66.9	30.63/31.23	MB
Kim 2023 [9]	RCT/I	91 (86)	47/44	69.36/70.62	26.73/26.87	FB
Total	3 RCT/4 Cohort	1069 (86)	507/606	68.5/67.5	28.7/28.95	

APD Anatomic patellar design, *MDD* Medialized dome design, *RCT* Randomized controlled trial, *LoE* Level of evidence, *BMI* Body mass index, *FB* Fixed bearing, *MB* Mobile bearing

Table 2 Study outcomes

Study, Year	Follow Up (months)	PROMs		Revision or Complication		ROM		Radiologic Measures	
		Measure	**Results**	**Measure**	**Results**	**Measure**	**Results**	**Measures and Method**	**Results**
Ahearn 2021 [11]	12	EQD5. KOOS	APD had superior scores for (Mobility, Activity and Anxiety) for EQ5D And KOOS Function	-	-	-	-	-	-
Kleeman-Forsthuber 2024 [8]	28 for APD 73 for MDD	-	-	Revisions (no. and cause) CKE and AKP rate	APD: 7 (3 for patella failure) MDD: 3 (no patella failure) APD had more CKE and AKP rates (18 APD/2 MDD)	n-WB ROM	NS	Merchant and lateral views SPPF, LPD, PTA, Insall-Salvati ratio	APD: had greater PTA, and LPD values and SPPF rates
Mannen 2019 [12]	9	KSS, KOOS, PKIP	NS	-	-	WB, n-WB FF	NS	Measured during full ROM ERA and IRA, LPD measured during full ROM	APD had lower ERA
Mochizuki 2021 [10]	12	JKOM	NS	Revisions or Complications	0	n-WB ROM	NS	Merchant and lateral and anterior views at 30, 60, 90, 120 degree of knee flexion IRA, PTA	NS
Shon 2022 [7]	3, 6, 12	KOOS, WOMAC, Feller, Kujala	NS	Revisions or Complications	0	n-WB FF, FC at 3,6,12 m	APD at 6 m had greater FF	Merchant view PTA, LPD	APD had lower PTA angles
Sobhi 2024 [5]	1, 12	OKS	NS	Reoperations (Revision no.)	APD: 7 (0) MDD: 6 (2 ongoing pain)	n-WB ROM	NS	Merchant and lateral views PTA, RLL, LPD	APD: more RLLs for lateral femur view and greater PTA MDD: more RLLs for axial patella view and greater LPD
Kim 2023 [9]	24	KSS, WOMAC, Kujala, HSS	NS	Revision or Complication	0	n-WB ROM, FF, FC	NS	Merchant and lateral views PTA, PTA outliers Blackburne-Peel ratio	NS PTA outliers (APD: 11 and MDD: 5%)

Abbreviations: PROMs Patient-Reported Outcome Measures, *MDD* Medialized dome design, *APD* Anatomic patellar design, *EQ-5D* EuroQol-5 Dimension, *KOOS* Knee Injury and Osteoarthritis Outcome Score, *JKOM* Japanese Knee Osteoarthritis Measure, *WOMAC* Western Ontario and McMaster Universities Osteoarthritis Index, *OKS* Oxford Knee Score, *RLL* Radiolucent Lines, *KSS* Knee Society Score, *HSS* Hospital for Special Surgery, *PKIP* Patellar Kinematic Inverse Prediction, *WB* Weight-Bearing, *n-WB* no Weight-Bearing, *LPD* Lateral Patellar Displacement, *PTA* Patellar Tilt Angle, *ERA* External Rotation Angle, *IRA* Internal Rotation Angle, *CKE* Chronic Knee Effusion, *AKP* Anterior Knee Pain, *ROM* Range of Motion, *SPPF* Superior Patellar Pole Fragmentation, *FF* Flexion, *FC* Flexion Contracture

Results

Study selection and study characteristics

The electronic search yielded 2,069 articles. After removing duplicates, 1,060 articles underwent title and abstract screening. Of these, 30 studies were selected for full-text evaluation. Following a thorough review, seven studies met the inclusion criteria (Fig. 2).

The seven included studies comprised three RCTs [7, 9, 10], two prospective cohort studies [5, 11], and two retrospective cohorts [8, 12]. A total of 1,069 patients and 1,113 knees were analyzed, with 507 knees in the APD group and 606 knees in the MDD group. The mean age was 68.5 years for APD patients and 67.5 years for MDD patients, with a mean BMI of 28.7 and 28.95, respectively. Three RCTs [7, 9, 10] utilized fixed-bearing (FB) tibial designs, while three cohort studies employed mobile-bearing (MB) designs [5, 8, 12]. Ahearn et al. [11] did not report the type of tibial bearing (Table 1).

Quality assessment

Using the RoB-2 tool, the two RCTs were rated as having a low risk of bias. And the one RCT had some concerns. Similarly, under the ROBINS-I tool, one study was rated as low risk, while the remaining three were deemed moderate risk due to concerns related to patient selection and confounding factors (Figs. 3 and 4).

Outcomes

Patient reported outcome measures

Six studies (three RCTs and three cohort studies) evaluated PROMs between both groups [5, 7, 9–12]. Among the RCTs, all reported comparable outcomes between the two groups. Shon et al. [7] evaluated KOOS, WOMAC, Feller, and Kujala scores at 3, 6, and 12 months postoperatively and found no statistical differences between groups. Mochizuki et al. [10] reported comparable JKOM scores at 12 months postoperatively. Similarly, Kim

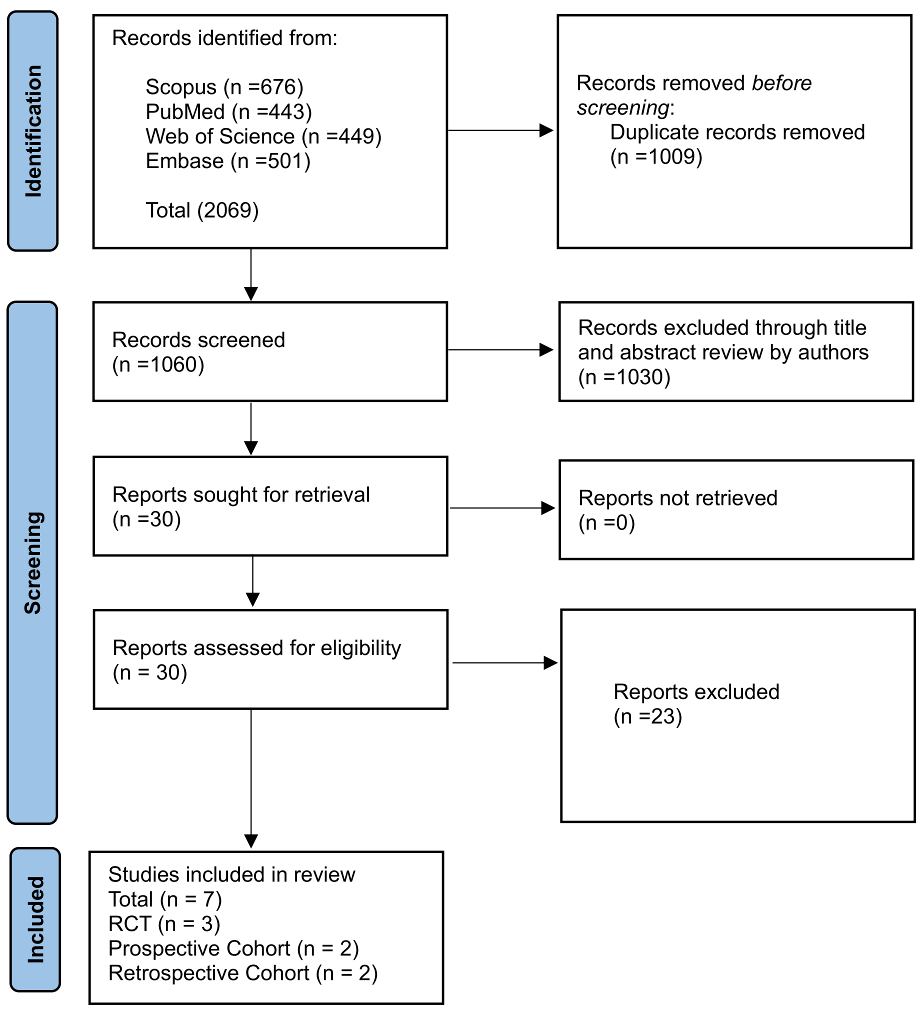


Fig. 2 Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flow diagram, Illustrating the study selection process, including the number of records identified, screened, assessed for eligibility, and included in the final analysis

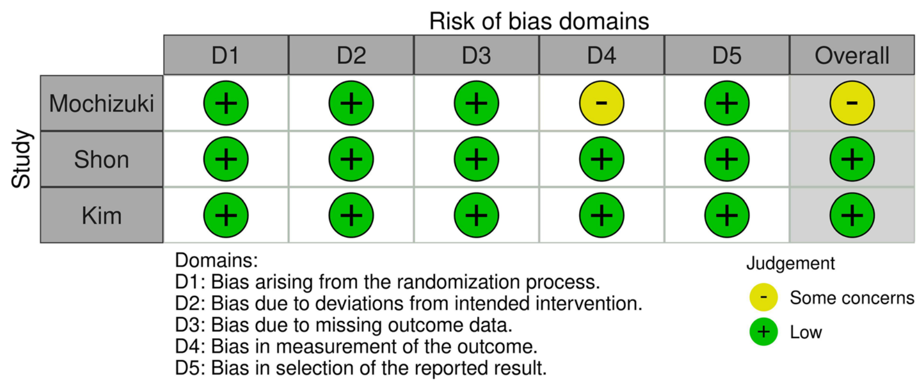


Fig. 3 The risk of bias assessment for included randomized controlled trials

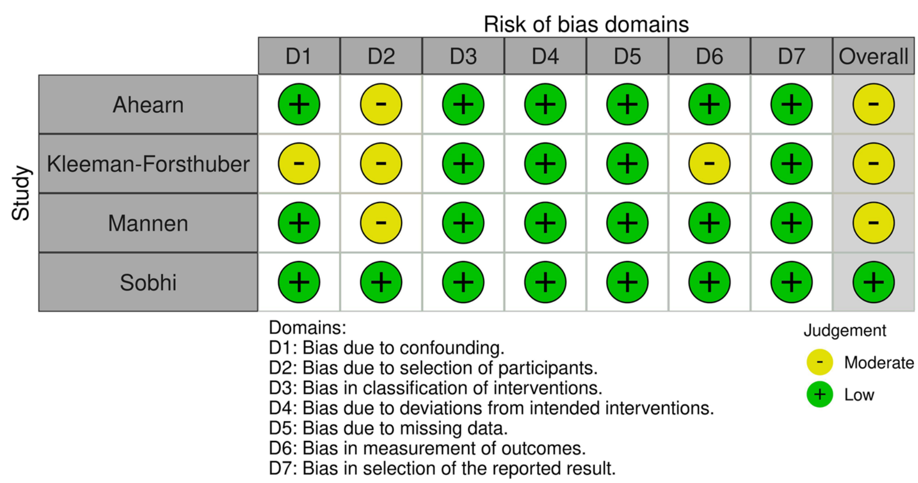


Fig. 4 The risk of bias assessment for included non-randomized studies

et al. [9] found no significant differences for KSS, HSS, WOMAC, or Kujala scores at 24 months postoperatively.

Three cohort studies evaluated PROMs for both designs [5, 11, 12]. Overall, the cohort studies demonstrated a trend toward superior PROMs for APD, with one study showed significantly greater outcomes for APD. Sobhi et al. [5] in a prospective cohort study, reported no significant differences in OKS at the 1- and 12-month marks. Mannen et al. [12] found no significant differences between groups for KSS, KOOS and PKIP subgroups in patients who had at least 9 months of follow-up. In contrast, Ahearn et al. [11] in a prospective cohort study, reported significantly superior KOOS "Function" scores and EQ-5D sub-scores for "Mobility", "Activity", and "Anxiety" in the APD group (Table 2).

We included six studies in our meta-analysis, which were heterogeneous in terms of the PROMs questionnaires used. These included three studies reporting KOOS, one reporting KSS, one reporting JKOM, and one reporting OKS. To address this variability and provide a more precise estimation, we used Hedges's g as the effect size. The meta-analysis demonstrated no significant difference between groups at the last follow-up endpoint (Hedges's $g = 0.09$; 95% CI [−0.04 to 0.22]; $P = 0.17$; $I^2 = 0$) (Fig. 5).

Revisions and complications

Five studies reported revisions and complications. Overall, the studies found no significant differences between both groups. All three RCTs reported no revisions or complications during the follow-up [7, 9, 10]. Sobhi et al. [5] in a prospective cohort study, reported higher reoperation rates in the APD group (3.2 vs. 1.8%), though the difference was not statistically significant. Similarly, Kleeman-Forsthuber et al. [8] in a retrospective cohort study, reported more revisions in the APD group (7 vs. 3%), with three cases of isolated patella failure in the APD group compared to one case of traumatic patella failure

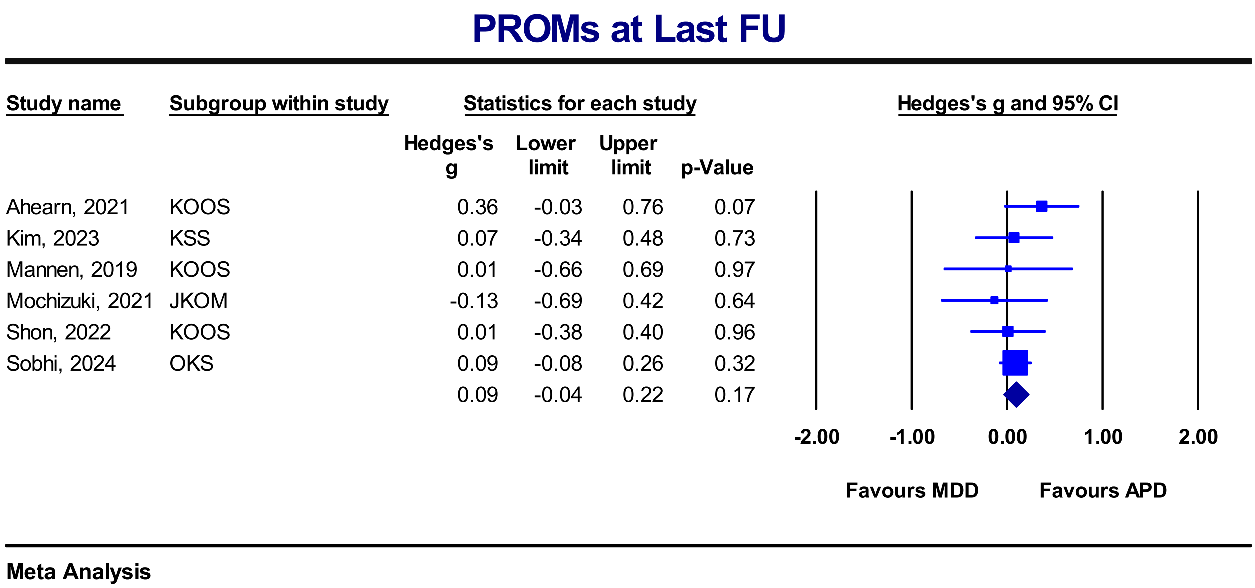


Fig. 5 Forest plot of patient reported outcome measures last follow-up. The Pooled Hedges's g indicates non-significant patient reported outcome measures difference for both anatomic patella design and medialized dome design groups

in the MDD group. However, this difference was also not statistically significant. In Addition, the APD group demonstrated significantly higher rates of anterior knee pain (AKP) and chronic knee effusions (CKE) compared to the MDD group (Table 2). We did not perform a meta-analysis for this domain due to the scarcity of data.

Radiographic measures of patellar stability

Five studies compared patellar tilt angle (PTA) in the Merchant view [5, 7–10]. Two studies reported significantly higher PTA in the APD group [5, 8], two found no significant differences [9, 10], and one reported lower PTA in the APD group [7]. Kim et al. [9] also reported PTA outliers (PTA > 5°), with APD showing a higher outlier rate (11 vs. 5%), although the difference was not statistically significant.

Lateral patellar displacement (LPD) was evaluated in four studies [5, 7, 8, 12]. Three used the Merchant view, while Mannen et al. [12] measured LPD during full ROM. Among the three studies, one reported significantly greater LPD in the APD group [8], another reported significantly greater LPD in the MDD group [7], and the third found no significant differences [5]. Mannen et al. [12], reported that LPD during weight bearing showed no significant differences between groups.

Two studies assessed patellar height using Insall-Salvati and Blackburne-Peel ratios, finding comparable results between groups [8, 9]. Two studies evaluated patellar rotation angles, including internal (IRA) and external (ERA) rotation, during different flexion angles and full ROM [10, 12]. Both reported no significant differences in IRA, while one found significantly lower ERA in the APD group during weight-bearing ROM.

Sobhi et al. [5] evaluated the radiolucent lines (RLLs) in lateral and Merchant views, with higher rates observed in the lateral femur view for the APD group and in the axial patella view for the MDD group. Additionally, Kleeman-Forsthuber et al. [8] reported significantly higher rates of superior patellar pole fragmentation (SPPF) in the APD group (Table 2). We could not perform a meta-analysis for this domain due to the scarcity and heterogeneity of reported data.

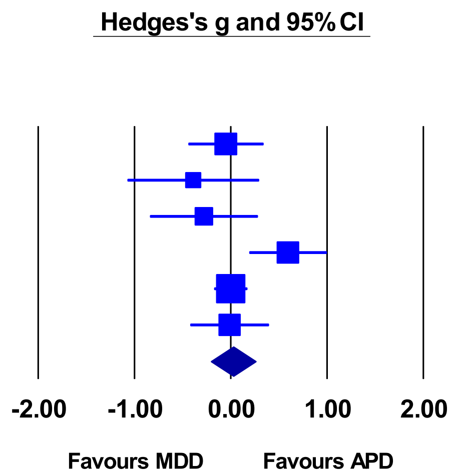
Knee function

Six studies (three RCTs and three cohort studies) evaluated knee function at the seated position [5, 7–10, 12]. Three studies reported only ROM [5, 8, 10], Kim et al. [9] reported ROM alongside further flexion (FF) and flexion contracture (FC). Shon et al. [7] reported FC and FF. In addition, Mannen et al. [12] evaluated FF in seated position and wight bearing positions. All studies found no significant differences between groups. However, Shon et al. [7] reported significantly greater FF for APD at the 6-month follow-up, with no differences observed at the 3- or 12-month time points (Table 2).

We included six studies in a meta-analysis for ROM. Hedges's g was used to calculate pooled outcomes, as two studies reported FF instead of ROM. The meta-analysis confirmed no significant differences in ROM between the two designs (Hedges's $g = 0.02$; 95% CI [−0.21 to 0.26]; $P = 0.83$; $I^2 = 53\%$) (Fig. 6).

ROM at Last FU

Study name	Hedges's g	Lower limit	Upper limit	p-Value
Kleeman-Forsthuber, 2024	-0.05	-0.44	0.34	0.80
Mannen, 2019	-0.39	-1.07	0.29	0.26
Mochizuki, 2021	-0.28	-0.84	0.28	0.33
Shon, 2022	0.59	0.19	1.00	0.00
Sobhi, 2024	0.00	-0.17	0.17	1.00
Kim, 2023	-0.01	-0.42	0.40	0.96
	0.02	-0.21	0.26	0.83



Meta Analysis

Fig. 6 Forest plot of range of motion last follow-up. The pooled Hedges's g demonstrates comparable range of motion outcomes for both anatomic patella design and medialized dome design groups

Discussion

This review compared the clinical outcomes of MDD and APD designs for the ATTUNE TKA system. Overall, the two designs yielded comparable clinical results, in terms of PROMs and ROM with inconclusive findings for revisions, complications and radiological measures.

The meta-analysis demonstrated non-significant PROMs difference between both designs; aligning with results of most studies that evaluated multiple PROM scores at different time points and reported non-significant outcomes between both groups [5, 7, 9, 10, 12]. Due to its favorable patellofemoral joint kinematics, the APD design theoretically offers advantages by better replicating natural patellar flexion and providing a more efficient patellofemoral lever. Specifically, similar to the natural knee, APDs exhibit a patellofemoral contact point that migrates from inferior to superior during knee flexion [26], whereas MDDs maintain a relatively more superior contact point throughout flexion. This migration pattern in APD enhances the efficiency of the extensor mechanism [12], and improves patellofemoral tracking [2, 26]. Despite the promising theoretical biomechanical benefits, our findings did not reveal any significant improvements in patients' subjective or objective outcomes during short-term follow-up. One major challenge was the high heterogeneity in PROMs reporting across various questionnaires, which restricts the generalizability of the meta-analysis results. Several biomechanical, population-related, and methodological factors may contribute to the nonsignificant differences observed between the two designs.

The superior kinematic characteristics of APD are primarily observed during maximum flexion, weight-bearing, and high-demand activities [12, 26, 27]. However, the advanced age of patients in the included studies likely limited their ability to engage in such activities, potentially rendering the kinematic benefits of APD less apparent in this population. Future research should prioritize younger and more active patients who are likely to push the knee to its functional limits. Additionally, none of the included studies evaluated "joint awareness" using the Forgotten Joint Score (FJS), a valuable metric that could offer deeper insights into patient experiences and outcomes [28].

Other kinematic factors are likely influential, as patellofemoral and tibiofemoral joint kinematics are interdependent [6, 29, 30]. Thus, tibial and femoral component positioning and tibial component design can significantly affect knee kinematics and, subsequently, PROMs [6]. In an in vivo study, Smith et al. [27] compared four cohorts comparing different bearings and patellar designs—MB-APD, FB-APD, MB-MDD, and FB-MDD—and found that while lateral contact positions at full extension were similar, kinematic differences emerged during flexion. The MB-APD group showed more consistent lateral condylar rollback compared to FB-APD, which demonstrated more anterior sliding. Axial rotation was most pronounced in the

MB-APD group, while the FB-APD group exhibited the least rotation and more variability. Overall, MB-APD showed more natural and consistent kinematics, including greater lateral translation, axial rotation, and range of motion, whereas MDD designs showed less variability. These differences may help explain the non-significant findings in the included trials using FB designs in our study.

The meta-analysis for ROM revealed no significant differences between the groups. Pooled effect sizes showed wide confidence intervals and moderate inconsistency, which reduced the certainty of the findings in this domain. Additionally, the meta-analysis included only ROM measurements taken in seated positions. While, in vivo studies reported that APD demonstrates greater ROM under weight-bearing conditions [12, 27]. Future research should prioritize weight-bearing kinematics to provide a more comprehensive understanding of these differences.

Current evidence indicates no significant differences in survival between the groups. The RCTs exhibited no revisions or complications within two years of follow-up [7, 9, 10]. However, retrospective studies with larger sample sizes raised concerns about APD's safety, showing a trend towards higher rates of patella failure, reoperation, and AKP for APD [5, 8]. Historically, APDs have been associated with higher complication rates and a greater susceptibility to failure in TKAs with misaligned femoral or patellar components [31–34]. These issues may stem from the unique morphology of APD, which can lead to greater patellar strain when variations in patellar resection angles occur [8, 9]. Larger RCTs with extended follow-up periods are required to better evaluate these findings.

Although concerns remain regarding revision rates and implant safety, the ATTUNE system is widely considered a safe option for total knee arthroplasty. A recent systematic review and meta-analysis by Choudhury et al. [3] compared the ATTUNE knee system with the traditional PFC Sigma design and found that the ATTUNE system significantly improved KSS relative to the PFC Sigma. Moreover, the ATTUNE prosthesis was associated with fewer patellofemoral complications, including reductions in anterior knee pain and crepitus. Overall, the study concluded that modern implant designs, as exemplified by the ATTUNE system, offer clear clinical advantages over traditional designs.

Radiological measures yielded inconsistent findings across studies. For PTA, LPD, RLLs results were heterogenous and unconvincing to make a solid conclusion. Although, APD has demonstrated higher but non-significant PTA outlier rates in one study [9]. The incidence of PTA outlier TKAs may be a more valuable measure compared to average PTA to predict inferior PROMs [9, 35]. In addition, APD demonstrated higher SPPF rates in one study, which is a concerning finding in terms of longevity of patellar component [8]. The results were heterogenous to make a solid conclusion. Future studies are needed to further investigate the safety of APD design.

Limitations

Most of the included studies are characterized by short follow-up durations, typically spanning only one to two years, which precludes the evaluation of long-term outcomes. Additionally, the small sample sizes observed in these studies significantly reduce their statistical power, thereby limiting the ability to detect subtle differences or trends. The meta-analysis was further constrained by the limited availability of data on revisions and radiological outcomes, hindering the pooling of these critical endpoints. Moreover, the heterogeneity in the reporting of PROMs prevented the individual pooling of each PROMs score. Finally, as this study focused solely on patellar resurfacing within the ATTUNE system, the applicability of the findings to broader patient populations or alternative implant designs is limited.

Conclusion

Based on current literature, APD offers no significant clinical advantage over MDD. Both designs demonstrate comparable clinical outcomes, with slight differences in PROMs that may favor APD in specific scenarios. Future studies with extended follow-up durations are essential to better assess the safety and longevity of APD. Surgeons may choose between these designs based on personal preference and patient-specific factors.

Abbreviations

TKA	Total Knee Arthroplasty
PROMs	Patient-Reported Outcome Measures
APD	Anatomic Patellar Design
MDD	Medialized Dome Design
ROM	Range of Motion
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analysis
RCT	Randomized Controlled Trial
EQ-5D	EuroQol-5 Dimension
KOOS	Knee Injury and Osteoarthritis Outcome Score
JKOM	Japanese Knee Osteoarthritis Measure
WOMAC	Western Ontario and McMaster Universities Osteoarthritis Index
OKS	Oxford Knee Score
KSS	Knee Society Score
PKIP	Patellar Kinematic Inverse Prediction
HSS	Hospital for Special Surgery Score
BMI	Body Mass Index
CMA	Comprehensive Meta-Analysis
FB	Fixed-Bearing
MB	Mobile-Bearing
AKP	Anterior Knee Pain
CKE	Chronic Knee Effusions
PTA	Patellar Tilt Angle
LPD	Lateral Patellar Displacement
IRA	Internal Rotation
ERA	External Rotation

RLLs	Radiolucent Lines
SPPF	Superior Patellar Pole Fragmentation
FF	Further Flexion
FC	Flexion Contracture

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

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Authors' contributions
"Sina Hajiaghjani" contributed to the conceptualization of the study, methodology development, data curation, and drafting of the original manuscript. "Amir Mehrvar" served as the project supervisor, conducted formal analysis and investigation, and participated in drafting the manuscript. "Omid Bahrami" played a key role in refining the methodology, contributed to data curation, and reviewing and editing the manuscript. "Mohammadhossein Hefzosseheh" provided essential resources, contributed to data curation, and data visualizations. "Maryam Alaei" managed project administration and assisted in reviewing and editing the manuscript. "Mohammad Poursalehian" participated in reviewing and editing the manuscript.

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Data availability
All data generated or analyzed during this study are included in this published article and its supplementary files (Appendices A–B). The full data extraction spreadsheets, risk-of-bias assessments, and meta-analysis output files (Comprehensive Meta-Analysis v3.3) are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the [Iran National Committee for Ethics in Biomedical Research] (Reference Number: [IR.SBMU.MSP.REC.1403.688]). And PROSPERO with the registration code of: CRD42024621087.

Consent for publication
Not applicable.

Competing interests
The authors have no relevant financial or non-financial interests to disclose.

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References

1. Sharkey PF, et al. Why are total knee arthroplasties failing today–has anything changed after 10 years? J Arthroplasty. 2014;29(9):1774–8.
2. Sharma A, et al. In Vivo Three-Dimensional Patellar Mechanics: Normal Knees Compared with Domed and Anatomic Patellar Components. J Bone Joint Surg Am. 2017;99(5): e18.
3. Choudhury AK, et al. Modern implants in total knee arthroplasty are more patellofemoral joint friendly compared to their traditional design: a systematic review and meta-analysis. Arch Orthop Trauma Surg. 2023;143(9):5873–89.
4. Minoda Y, et al. Impingement of the patellar component against the tibial post depends on the design of the post-cam mechanism: Comparison between 12 posterior stabilized total knee prostheses. Knee. 2018;25(4):676–81.
5. Sobhi S, et al. Medialized Dome and Anatomic Onlay Patella Designs in the Modern Posterior Stabilized Rotating Platform Total Knee Arthroplasty Demonstrate No Clinical or Radiological Differences at One Year. J Arthroplasty. 2024;39(1):87–95.
6. Roussot MA, Haddad FS. The evolution of patellofemoral prosthetic design in total knee arthroplasty: how far have we come? EFORT Open Rev. 2019;4(8):503–12.
7. Shon OJ, Kim GB. The Design of the Patellar Component Does Not Affect the Patient-Reported Outcome Measures in Primary Posterior-Stabilized Total Knee Arthroplasty: A Randomized Prospective Study. J Clin Med. 2022;11(5):1363.
8. Kleeman-Forsthuber LT, et al. Clinical and Computational Evaluation of an Anatomic Patellar Component. J Arthroplasty. 2024;39(8):S70-s79.
9. Kim SE, et al. Anatomic Patellar Design Has No Clinical Superiority Over Dome Patellar Design in Total Knee Arthroplasty: A Randomized Clinical Trial. J Arthroplasty. 2023;38(9):1742–7.
10. Mochizuki T, et al. Difference in patient-reported outcomes of various patellar component designs in total knee arthroplasty: A randomized clinical study. J Orthop Surg (Hong Kong). 2021;29(1):2309499021996068.
11. Ahearn N, et al. Conforming patellar button design improves outcome of total knee arthroplasty. Knee. 2021;29:399–404.
12. Mannen EM, et al. Influence of Component Geometry on Patellar Mechanics in Posterior-Stabilized Rotating Platform Total Knee Arthroplasty. J Arthroplasty. 2019;34(5):974–80.
13. Page MJ, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372: n71.
14. Phatama KY, et al. Knee Injury and Osteoarthritis Outcome Score: Validity and Reliability of an Indonesian Version. Ochsner J. 2021;21(1):63–7.
15. Culliton SE, et al. Validity and Internal Consistency of the New Knee Society Knee Scoring System. Clin Orthop Relat Res. 2018;476(1):77–84.
16. Tuğay BU, et al. Oxford Knee Score: cross-cultural adaptation and validation of the Turkish version in patients with osteoarthritis of the knee. Acta Orthop Traumatol Turc. 2016;50(2):198–206.
17. Ali AA, et al. Validation of predicted patellofemoral mechanics in a finite element model of the healthy and cruciate-deficient knee. J Biomech. 2016;49(2):302–9.
18. Narin S, et al. Cross-cultural adaptation, reliability and validity of the Turkish version of the Hospital for Special Surgery (HSS) Knee Score. Acta Orthop Traumatol Turc. 2014;48(3):241–8.
19. Lewis S, et al. Development of a Scale to Assess Performance Following Primary Total Knee Arthroplasty. Value in Health. 2014;17(4):350–9.
20. Obradovic M, Lal A, Liedgens H. Validity and responsiveness of EuroQol-5 dimension (EQ-5D) versus Short Form-6 dimension (SF-6D) questionnaire in chronic pain. Health Qual Life Outcomes. 2013;11:110.

21. Akai M, et al. An outcome measure for Japanese people with knee osteoarthritis. J Rheumatol. 2005;32(8):1524–32.
22. Thumboo J, Chew LH, Soh CH. Validation of the Western Ontario and Mcmaster University osteoarthritis index in Asians with osteoarthritis in Singapore. Osteoarthritis Cartilage. 2001;9(5):440–6.
23. Sterne JA, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ. 2016;355: i4919.
24. Sterne JAC, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ. 2019;366: l4898.
25. McGuinness LA, Higgins JPT. Risk-of-bias VISualization (robvis): An R package and Shiny web app for visualizing risk-of-bias assessments. Research Synthesis Methods. 2021;12(1):55–61.
26. Ali AA, et al. In vivo comparison of medialized dome and anatomic patellofemoral geometries using subject-specific computational modeling. J Orthop Res. 2018;36(7):1910–8.
27. Smith LA, et al. Anatomic vs Dome Patella: Is There a Difference Between Fixed- vs Mobile-Bearing Posterior-Stabilized Total Knee Arthroplasties? J Arthroplasty. 2021;36(11):3773–80.
28. Carlson VR, et al. When Does the Knee Feel Normal Again: A Cross-Sectional Study Assessing the Forgotten Joint Score in Patients After Total Knee Arthroplasty. J Arthroplasty. 2018;33(3):700–3.
29. Varadarajan KM, et al. Relationship between three-dimensional geometry of the trochlear groove and in vivo patellar tracking during weight-bearing knee flexion. J Biomech Eng. 2010;132(6): 061008.
30. Merican AM, et al. The effect of femoral component rotation on the kinematics of the tibiofemoral and patellofemoral joints after total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2011;19(9):1479–87.
31. Buechel FF, Pappas MJ, Makris G. Evaluation of contact stress in metal-backed patellar replacements. A predictor of survivorship. Clin Orthop Relat Res. 1991;273:190–7.
32. Lombardi AV Jr, et al. Fracture/dissociation of the polyethylene in metal-backed patellar components in total knee arthroplasty. J Bone Joint Surg Am. 1988;70(5):675–9.
33. Bayley JC, Scott RD. Further observations on metal-backed patellar component failure. Clin Orthop Relat Res. 1988;236:82–7.
34. Groeneveld HB. Combined femoro-tibial-patellar endoprosthesis of the kneejoint preserving the ligaments. Acta Orthop Belg. 1973;39(1):210–5.
35. Narkbunnam R, et al. Suboptimal patellofemoral alignment is associated with poor clinical outcome scores after primary total knee arthroplasty. Arch Orthop Trauma Surg. 2019;139(2):249–54.

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