Arthroplasty Today 12 (2021) 62–67

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Original research

Does the anatomic design of total knee prosthesis allow for a better component fit than its nonanatomic predecessor? A matched cohort Study

Bartosz M. Maciąg, MD [a, *], Artur Stolarczyk, MD, PhD [a], Grzegorz J. Maciąg, MD [a], Monika Dorocińska, MD [a], Piotr Stępiński, MD [a], Jakub Szymczak, MD [a], Maciej Świercz, MD [a], Krystian Żarnovsky, MD [a], Marcin Łapiński, MD [a], Magda Stolarczyk, MD [b]

[a] Department of Orthopedics and Rehabilitation, Medical University of Warsaw, Warsaw, Poland
[b] 3rd Clinic of Internal Medicine and Cardiology, Medical University of Warsaw, Warsaw, Poland

ARTICLE INFO

Article history:
Received 12 April 2021
Received in revised form
29 August 2021
Accepted 7 September 2021
Available online xxx

Keywords:
Total knee arthroplasty
PERSONA PS
NexGen LPS
Radiological outcomes

ABSTRACT

Background: Total knee arthroplasty (TKA) is considered the most efficient treatment of end-stage osteoarthritis. There is an ongoing debate about proper implant designs and articulation types. One of the considered causes of unsatisfactory outcome and patients' dissatisfaction is femoral or tibial component overhanging, which can lead to chronic knee pain and restricted motion. The aim of this study is to compare radiological outcomes of TKA using an anatomic PERSONA Posterior-Stabilized (PS) knee design with its nonanatomic predecessor, the NexGen LPS.

Methods: A group of 39 patients who received the PERSONA PS system and 33 patients who received the NexGen LPS was included. PERSONA patients were matched to NexGen patients using a 0.1 propensity score threshold with priority given to exact matches. Anteroposterior, lateral, and long-leg radiographs were taken preoperatively and at 6 weeks postoperatively to perform radiological and statistical analysis.

Results: The PERSONA subgroup had statistically higher posterior condylar offset. There is no statistically significant difference in posterior condylar offset ratio. There were less cases of femoral notching, femoral overhang, and placing tibial baseplate in the medial overhang in the PERSONA PS subgroup than in the NexGen subgroup (each statistically significant). Occurrence of tibial underhang was not statistically significant.

Conclusion: Radiological assessment in short-term follow-up showed excellent results for PERSONA knee design with better fit to native femur and tibia. In comparison to its predecessor, it also spares more bone tissue. As the aforementioned parameters are risk factors of lesser clinical outcomes, the PERSONA design gives high hopes for improvement of TKA satisfaction rate.

Introduction

Total knee arthroplasty (TKA) is considered the standard of care for symptomatic end-stage knee osteoarthritis [1,2]. The frequency of TKA is growing worldwide [3,4], and it is estimated that the number of patients electing for TKA will continue to rise [5]. Despite most patients being pleased with their outcomes after TKA, approximately 20% remain unsatisfied [6]. Satisfaction after TKA is correlated with achieving painless functional range of motion [7].

No author associated with this paper has disclosed any potential or pertinent conflicts which may be perceived to have impending conflict with this work. For full disclosure statements refer to https://doi.org/10.1016/j.artd.2021.09.001.

Declaration of interests: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

* Corresponding author. Bursztynowa 2, 04-749 Warsaw, Poland. Tel.: +48 881 568 144.
E-mail address: bmaciag@wum.edu.pl

https://doi.org/10.1016/j.artd.2021.09.001

Arthroplasty surgeons have been unable to achieve the same success rate with knee replacements as they have with hip replacements despite varied implant designs, surgical techniques, and changes in implant alignment [8-10]. Both patient-related and technique-related factors affect the outcome of TKA [11,12]. A combination of the aforementioned factors, one of which is imperfect implant fit, may contribute to the dissatisfaction with the outcome in 20% of patients underging TKA. Femoral and tibial component overhang can result in pain and worse biomechanical outcomes [13]. In the study by Mahoney and Kinsey, it was estimated that nearly 30% of chronic pain cases after TKA were linked with component overhang [14].

Reproducing a patient's native joint mechanics is critical to the success of TKA. An implant that is designed to restore the patient's anatomy may assist in this. It may allow for a better fit of the components and, thus, limit the risk of implant loosening. In addition, it helps sustain a native joint line and avoid implant misalignment which is crucial for restoring the primary knee biomechanics [15,16].

In recent years, surgeons have had high hopes associated with development of the anatomical design of total knee implants.

One of the most recent implants available in the market is PERSONA (Zimmer Biomet, Warsaw, IN). The tibial baseplate is asymmetric and, compared to its predecessor, has more size options on the femoral side. Given the aforementioned differences, this implant is proved to have a lower risk of femoral and tibial component overhang [17,18].

Each femoral component size has both a standard and narrow option, which is 2 mm narrower in the mediolateral dimension. This helps to avoid mediolateral overhang and soft-tissue impingement. The femoral component, with asymmetric posterior condyles, was designed to fit the native anatomy of the tibial plateau. Other differences with this new design as compared to its predecessor include an enhanced locking mechanism of the polyethylene insert into the tibial baseplate and less bone removal from the box in a posterior-stabilized implant than in other commonly used systems [19].

In the study by Dai et al., authors concluded that the anatomical design of the tibial baseplate increases tibial coverage and can restore the shape of tibia more accurately than standard knee designs [20].

The aim of this study was to assess radiological outcomes of TKA using the PERSONA PS at 6 weeks postoperatively and compare them with a matched cohort of patients who underwent TKA with its predecessor, the NexGen LPS (Zimmer Biomet, Warsaw, IN) system.

Material and methods

This study was conducted according to The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement, and an appropriate checklist was presented to the Editors [21]. Informed consent was obtained from all subjects involved in the study.

Patients included in the study were older than 50 years, had osteoarthritis, were undergoing primary TKA with a PS-implant without patellar resurfacing, and had at least 15 degree flexion contracture. Exclusion criteria included 1. patients with prior high tibial osteotomy or other lower limb surgery, 2. patients with rheumatoid arthritis, 3. patients without complete radiographs available for review, 4. patients qualified for cruciate-retaining implants (PCL intact at time of surgery or absent flexion contracture preoperatively).

Thirty-nine patients who underwent PERSONA TKA and thirty-four patients who underwent no gender-specific NexGen LPS TKA met inclusion criteria. All surgeries in both groups were performed between September 2019 and January 2020. For both PERSONA PS and NexGen LPS cohorts, a propensity score based on gathered demographic data of patients (age at surgery, sex, and body mass index) was generated. PERSONA patients were matched to NexGen patients using a 0.1 propensity score threshold with priority given to exact matches (Table 1).

All patients qualified for the TKA have a standard anteroposterior, lateral weight-bearing and long-leg view radiographic examination performed preoperatively at the admission day to the hospital for evaluation of the intraarticular grade of osteoarthritis and assessment of the lower limb alignment. Long-leg view radiographs were performed with 30 cm distance between participant's feet and patella of both limbs directed forward and with 5-7 degrees of tube inclination [22].

All surgeries were performed at a level III academic hospital by two senior authors (A.S., B.M.M.), who are fellowship-trained surgeons: A.S. performed 19 TKA using PERSONA PS and 17 using NexGen LPS, and B.M.M. performed 20 TKA using PERSONA PS and 16 using NexGen LPS. All surgeries were performed using a standard midline incision and medial parapatellar arthrotomy with a tourniquet (average time of 80 minutes) and postoperative drainage for at least 12 hours in all cases. Cruciate sacrificing implants were used beause of the preoperative presence of fixed deficit of 15 degrees of extension or intraoperative diagnosis of PCL insufficiency. Tibial cut was performed first using extramedullary alignment jigs perpendicular to the long axis of the tibia, matching the patient's native slope, unless native slope was less than 3° or greater than 7°. The femur was prepared using an intramedullary alignment tool with a valgus angle between 5° and 7° and external rotation of 3°. Femoral bone cuts were made in the sequence as recommended by the surgical protocol of the PERSONA PS knee system and the NexGen LPS system. After removal of posterior and peripheral osteophytes, soft-tissue balance was assessed using the tibial insert trial. Flexion and extension gaps were balanced. No patella resurfacing was performed. All components were implanted with the use of cement. All liners implanted were PS. The postoperative protocol included chemical and mechanical thromboprophylaxis unless specifically contraindicated. All patients received one dose of parenteral antibiotics at the induction of anesthesia and two further doses postoperatively.

Preoperative as well as 6-week postoperative anteroposterior, lateral and long-leg radiographs were used to assess the radiological parameters.

Analysis of the radiographic images was performed using the INFINITT PACS system (INFINITT Healthcare, Seoul, South Korea). The parameters evaluated in the preoperative radiographs included mechanical axis of the limb, angle of valgus/varus deformity of the distal femur (lateral distal femur angle) and proximal tibia (medial proximal tibial angle), posterior condylar offset (PCO), posterior condylar offset ratio (PCOR), and posterior tibial slope. Postoperative radiological analysis consisted of mechanical axis of the limb, coronal and sagittal alignment and position of the

Table 1
Characteristics of participants in the PERSONA PS group and matched NexGen LPS cohort.

Characteristics	Participants characteristics		
	PERSONA PS	NexGen LPS	*P* value
BMI (body mass index, kg/m^2)	30.24 (SD = 4.08)	29.8 (SD = 3.4)	>.05
Age (y)	68.62 (SD = 6.31)	69.5 (SD = 5.7)	>.05
Male:female	13:26	12:21	>.05
Right:left	21:18	19:14	>.05

components (lateral distal femur angle, medial proximal tibial angle), PCO and PCOR, number of implants with tibial overhang or underhang of less or more than 2 mm, potential femoral overhanging or notching, and efficacy of preoperative posterior tibial slope restoration. All radiographs were measured three times by two independent researchers, and mean values of their results were noted. To avoid potential risk of bias, all data concerning participants were blinded. Mean intraobserver and interobserver differences in measurements of femoral and tibial components were calculated for all cases. Intraobserver and interobserver reliability was determined by calculating the intraclass correlation coefficient with a confidence interval of 95%.

Measurements

PCO was defined as the maximum thickness of the posterior femoral condyles, measured on the true lateral view as the distance between the radius corresponding to the margin of the posterior cortex and its tangent parallel to the condyles posteriorly [23].

PCOR was defined as the ratio between PCO and the distance between the radius corresponding to the anterior femoral cortex and its tangent parallel to the posterior condyles [24] (Fig. 1).

In order to assess potential notching or overhang of the femoral component, a line was drawn through the anterior margin of the femoral anterior cortex on the true lateral view knee radiograph, and its relation to the posterior border of the femoral component was analyzed (Fig. 2).

In order to assess the potential overhang or underhang of the tibial component, a line was drawn perpendicular to the tibial line at the border of the tibial plateau on the anterior-posterior and lateral radiographs, and its relation to the borders of the tibial baseplate was analyzed (Fig. 3).

Figure 1. Posterior condylar offset (a) and posterior condylar offset ratio (PCOR) measurements.

Statistical analysis

A statistical analysis of the results was performed. All comparisons were made between continuous variables in independent groups.

Thereafter both t-student and U Mann-Whitney tests were used, according to the normality of distribution tested with the use of Shapiro-Wilk test.

Significance level was set at P value below .05. All statistical analyses were conducted using SAS software, Version 9.4, for Windows (SAS Institute Inc., Cary, NC).

Statement of Human and Animal rights

It is hereby declared that this study was conducted in accordance with the ethical and clinical standards of the Institutional Bioethics Committee.

Results

A total of 39 patients from the PERSONA PS cohort (100%) and 33 patients from the NexGen (97%) matched control cohort completed the assessment at 6 weeks postoperatively. One patient from the NexGen cohort was excluded from the assessment as he did not arrive for the follow-up visit.

Interobserver reliability was high with an ICC of >0.9 for all measurements.

On the preoperative radiographs, the assessment of mechanical axis revealed that 31 knees had varus deformity, 3 had valgus deformity, and 5 were neutral; in the postoperative radiographs, 38 knees were neutral while one limb was left with residual varus.

Postoperative tibial implant slope measured between 3 and 7 degrees in 97.2% of cases. Mean differences between both cohorts were not statistically significant. The PCO was found to be increased after the surgery; the mean difference between preoperative and postoperative values was compared between the NexGen and PERSONA groups. The result was statistically significant and favored the PERSONA group. The PCOR was found to be decreased after the surgery; the mean difference between preoperative and postoperative values was not statistically significant between the analyzed groups (Table 2).

Femoral notching of less than 2 mm occurred in one patient who underwent PERSONA TKA and greater than 2 mm in three patients in the NexGen LPS cohort. The difference was not statistically significant ($P = .3266$). Femoral overhang was observed in a single PERSONA PS and four NexGen LPS femoral implants. The difference was statistically significant ($P = .0398$).

The tibial baseplate was overhanging more than 2 mm in one PERSONA PS tibial implant and four NexGen tibial implants ($P = .0398$). In the NexGen group, two cases of tibial underhang of more than 2 mm both on the medial and lateral sides were observed, while in the PERSONA group, there was only one on the medial side ($P = .425$) (Table 3).

Discussion

Despite the ongoing development of newer knee joint implants that better fit the native bone morphology, the proportion of patients unsatisfied with their TKA remains constant. There are several known risk factors of dissatisfaction including patient-

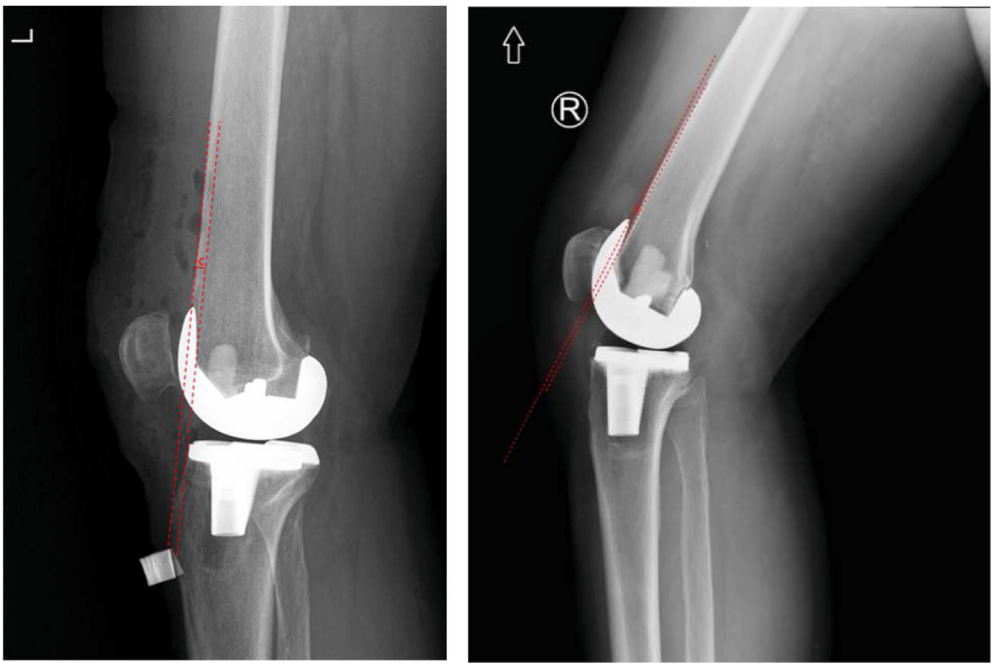

Figure 2. Femoral notching (left) and femoral overhang (right) measurement.

related, surgical technique-related, and implant-related issues [7,25].

The aim of this study was to assess the radiological outcome of TKA with the use of PERSONA PS knee design after the first 6 postoperative weeks and compare it with a matched cohort of patients who underwent TKA with the use of PERSONA's predecessor, NexGen LPS system.

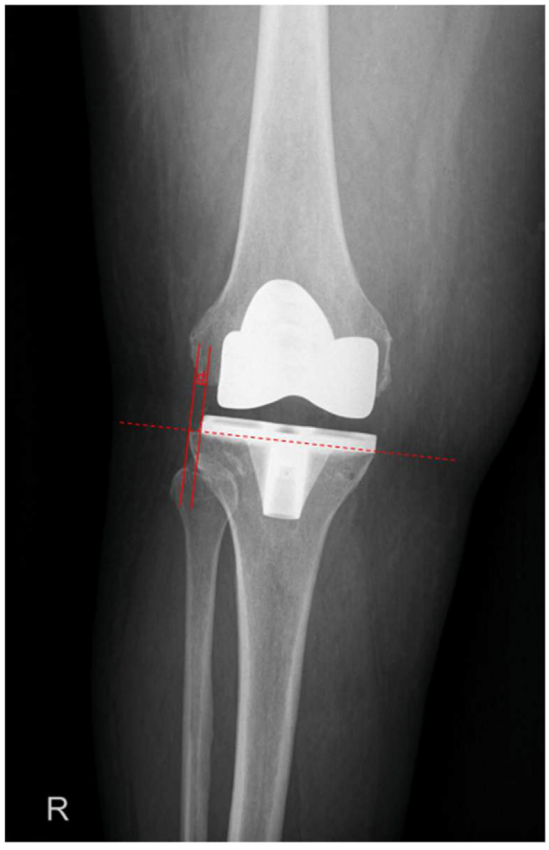

Figure 3. Tibial underhang measurement.

In the study by Benazzo et al., it was stated that the PERSONA knee design not only provides excellent clinical and functional outcome but also helps achieve excellent radiological outcome and its reproducibility [26]. However, their results were not compared to any other knee design [26]. In our study, the PERSONA cohort was compared to its predecessor, and a significant improvement in implant fit on both tibial and femoral sides was demonstrated radiographically.

Previous studies have evaluated differences between cruciate retaining PERSONA and NexGen implants, but this is the first to evaluate the difference between these two posterior stabilized implants [27-29]. There is still a lack of studies, especially randomized-controlled studies comparing the outcome of PERSONA PS design to that of NexGen LPS.

The paramount finding of this study was that the use of PERSONA knee system allowed to increase the PCO and to decrease the incidence of both tibial and femoral overhang in comparison to the matched cohort treated with the NexGen system.

The evaluation of PCO showed a mean increase in this parameter in both groups with higher values for the PERSONA cohort. It is believed that a decrease in this value of 2 mm might decrease the

Table 2
Radiographic parameters comparison between groups.

Radiographic parameter	PERSONA, N = 39	NexGen, N = 33	*P* value
PTS between 3°-7° (% of knees)	97.4	97.0	>.05
Mean difference between preoperative and postoperative PCO	5.89 (SD = 6.3)	1.31 (SD = 9.23)	**.0206**
Mean difference between preoperative and postoperative PCOR	0.0323 (SD = 0.2)	0.0112 (SD = 0.240)	.6882

PTS, posterior tibial slope.
Bold values are statistically significant, with *P*-value <.05.

Table 3
Radiographic parameters comparison between groups.

Radiographic parameter	PERSONA, N = 39	NexGen, N = 33	*P* value
No. of femoral notching	1	3	.3266
No. of femoral overhang	0	3	**.0398**
No. of tibial overhang	1	4	**.0398**
No. of tibial underhang	1	2	.425

Bold values are statistically significant, with *P*-value <.05.

postoperative flexion by 12.2° [22]. Maintaining higher values of PCO not only improves the postoperative flexion but also allows for less bone resection, which might be crucial in case of possible future revision surgery. With the use of PCL sacrificing design, it also allows to achieve greater stability in mid- and full-flexion [30,31].

Femoral notching was detected only in one case in the PERSONA cohort, and it was less than 2 mm. Femoral notching of more than 2-3 mm has been shown to be a risk factor of periprosthetic fractures of the femur. The availability of a vast array of sizes of PERSONA sizes improves its femoral fit [20,32].

A crucial aspect of the proper baseplate orientation is to cover the tibial plateau as closely to the native bone area as possible. With the asymmetric PERSONA tibial baseplate, the tibial plateau coverage is maximized, especially in the posterolateral area, which minimizes medial overhang. This asymmetric design also allows for proper external rotation of the baseplate to enhance patellar tracking and limit anterior knee pain related to maltracking [33,34]. In vivo studies showed that the PERSONA knee design has the lowest risk of overhanging and is inclined to underhang on the medial aspect of the tibia as compared to other popular primary tibial baseplates [17]. However, there is a lack of studies examining the potential negative effects of the tibial component underhanging. In the study by Liu et al., authors reported higher tibial bone resorption [35].

One potential limitation of the study is the fact that this is a retrospective matched-cohort study, not a randomized-controlled one. What is more, no gender-specific NexGen knee design was used, as this would potentially resolve the femoral overhang issue. Other limitations may be that the study was conducted in a single institution, and there is no comparison of clinical results with other hospitals or surgeons and also that not many patients were enrolled in the study. However, despite the small number of participants, several outcomes were found to be significant.

Conclusions

Radiological assessment in the short-term follow-up showed excellent results of PERSONA anatomic knee design with better fit to native femur and tibia. In comparison to its predecessor, it also allows to spare more bone. As the aforementioned parameters are risk factors of lesser clinical outcomes, the PERSONA knee design gives hopes for improvement in TKA satisfaction rate. Future studies should further explore if this new implant design can improve clinical outcomes after TKA.

References

[1] Bourne RB, McCalden RW, MacDonald SJ, Mokete L, Guerin J. Influence of patient factors on TKA outcomes at 5 to 11 years follow up. Clin Orthop Relat Res 2007;464:27. https://doi.org/10.1097/blo.0b013e318159c5ff.

[2] Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charron KDJ. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? Clin Orthop Relat Res 2010;468:57. https://doi.org/10.1007/s11999-009-1119-9.

[3] Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR). Hip, knee & shoulder arthroplasty: 2019 annual report. Adelaide: AOA; 2019.

[4] Ben-Shlomo Y, Blom A, Boulton C, et al. The National Joint Registry 17th annual report 2020. London: National Joint Registry; 2020.

[5] Maradit Kremers H, Larson DR, Crowson CS, et al. Prevalence of total hip and knee replacement in the United States. J Bone Joint Surg Am 2015;97(17):1386. https://doi.org/10.2106/JBJS.N.01141.

[6] Kahlenberg CA, Nwachukwu BU, McLawhorn AS, Cross MB, Cornell CN, Padgett DE. Patient satisfaction after total knee replacement: a systematic review. HSS J 2018;14(2):192.

[7] Gunaratne R, Pratt DN, Banda J, et al. Patient dissatisfaction following total knee arthroplasty: a systematic review of the literature. J Arthroplasty 2017;32(12):3854. https://doi.org/10.1016/j.arth.2017.07.021.

[8] Dall'Oca C, Ricci M, Vecchini E, et al. Evolution of TKA design. Acta Biomed 2017;88(2S):17. https://doi.org/10.23750/abm.v88i2-S.6508.

[9] Sheth NP, Husain A, Nelson CL. Surgical techniques for total knee arthroplasty: measured resection, gap balancing, and Hybrid. J Am Acad Orthop Surg 2017;25(7):499. https://doi.org/10.5435/JAAOS-D-14-00320.

[10] Rivière C, Lazic S, Boughton O, Wiart Y, Villet L, Cobb J. Current concepts for aligning knee implants: patient-specific or systematic? EFORT Open Rev 2018;3(1):1. https://doi.org/10.1302/2058-5241.3.170021.

[11] Jacobs CA, Christensen CP, Karthikeyan T. Patient and intraoperative factors influencing satisfaction two to five years after primary total knee arthroplasty. J Arthroplasty 2014;29(8):1576. https://doi.org/10.1016/j.arth.2014.03.022.

[12] Schwartz FH, Lange J. Factors that affect outcome following total joint arthroplasty: a review of the recent literature. Curr Rev Musculoskelet Med 2017;10(3):346. https://doi.org/10.1007/s12178-017-9421-8.

[13] Bonnin MP, Schmidt A, Basiglini L, Bossard N, Dantony E. Mediolateral oversizing influences pain, function, and flexion after TKA. Knee Surg Sports Traumatol Arthrosc 2013;21(10):2314. https://doi.org/10.1007/s00167-013-2443-x.

[14] Mahoney OM, Kinsey T. Overhang of the femoral component in total knee arthroplasty: risk factors and clinical consequences. J Bone Joint Surg Am 2010;92(5):1115. https://doi.org/10.2106/JBJS.H.00434.

[15] Babazadeh S, Dowsey MM, Swan JD, Stoney JD, Choong PF. Joint line position correlates with function after primary total knee replacement: a randomised controlled trial comparing conventional and computer-assisted surgery. J Bone Joint Surg Br 2011;93(9):1223. https://doi.org/10.1302/0301-620X.93B9.26950.

[16] Shetty GM, Mullaji A, Bhayde S. Computer guided restoration of joint line and femoral offset in cruciate substituting total knee arthroplasty. Knee 2012;19(5):611. https://doi.org/10.1016/j.knee.2011.11.004.

[17] Jin C, Song EK, Prakash J, Kim SK, Chan CK, Seon JK. How much does the anatomical tibial component improve the Bony coverage in total knee arthroplasty? J Arthroplasty 2017;32(6):1829. https://doi.org/10.1016/j.arth.2016.12.041.

[18] Schnurr C, Csecsei G, Nessler J, Eysel P, Konig DP. How much tibial resection is required in total knee arthroplasty? Int Orthop (Sicot) 2011;35(7):989. https://doi.org/10.1007/s00264-010-1025-5.

[19] Graceffa A, Indelli PF, Basnett K, Marcucci M. Analysis of differences in bone removal during femoral box osteotomy for primary total knee arthroplasty. Joints 2014;2:76.

[20] Dai Y, Scuderi GR, Bischoff JE, Bertin K, Tarabichi S, Rajgopal A. Anatomic tibial component design can increase tibial coverage and rotational alignment accuracy: a comparison of six contemporary designs. Knee Surg Sports Traumatol Arthrosc 2014;22(12):2911. https://doi.org/10.1007/s00167-014-3282-0.

[21] Von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. BMJ 2007;335(7624):806. https://doi.org/10.1136/bmj.39335.541782.AD.

[22] Hsu RW, Himeno S, Coventry MB, Chao EY. Normal axial alignment of the lower extremity and load-bearing distribution at the knee. Clin Orthop Relat Res 1990;255:215.

[23] Bellemans J, Banks S, Victor J, Vandenneucker H, Moemans A. Fluoroscopic analysis of the kinematics of deep flexion in total knee arthroplasty. Influence of posterior condylar offset. J Bone Joint Surg Br 2002;84(1):50. https://doi.org/10.1302/0301-620x.84b1.12432.

[24] Johal P, Hassaballa MA, Eldridge JD, Porteous AJ. The posterior condylar offset ratio. Knee 2012;19(6):843. https://doi.org/10.1016/j.knee.2012.03.017.

[25] Scott CE, Howie CR, MacDonald D, Biant LC. Predicting dissatisfaction following total knee replacement: a prospective study of 1217 patients. J Bone Joint Surg Br 2010;92(9):1253. https://doi.org/10.1302/0301-620X.92B9.24394.

[26] Benazzo F, Ghiara M, Rossi SMP, Pruneri E, Tiwari V, Perelli S. Clinical and radiological analysis of a personalized total knee arthroplasty system design. Int Orthop (Sicot) 2019;43:1113. https://doi.org/10.1007/s00264-018-4095-4.

[27] Rajgopal A, Aggarwal K, Kumar S. A five-Year Comparative functional and clinical evaluation of two contemporary cruciate-retaining knee implants. Arthroplast Today 2020;6(3):369. https://doi.org/10.1016/j.artd.2020.05.009.

[28] Song SJ, Park CH, Bae DK. What to know for selecting cruciate-retaining or posterior-stabilized total knee arthroplasty. Clin Orthop Surg 2019;11(2):142. https://doi.org/10.4055/cios.2019.11.2.142.
[29] Galea VP, Botros MA, Madanat R, Nielsen CS, Bragdon C. Promising early outcomes of a novel anatomic knee system. Knee Surg Sports Traumatol Arthrosc 2019;27:1067. https://doi.org/10.1007/s00167-018-5248-0.
[30] Kim JH. Effect of posterior femoral condylar offset and posterior tibial slope on maximal flexion angle of the knee in posterior cruciate ligament sacrificing total knee arthroplasty. Knee Surg Relat Res 2013;25(2):54. https://doi.org/10.5792/ksrr.2013.25.2.54.
[31] Matziolis G, Brodt S, Windisch C, Roehner E. Changes of posterior condylar offset results in midflexion instability in single-radius total knee arthroplasty. Arch Orthop Trauma Surg 2017;137(5):713. https://doi.org/10.1007/s00402-017-2671-5.
[32] Morris WZ, Gebhart JJ, Goldberg VM, Wera GD. Implant size availability affects reproduction of distal femoral anatomy. J Knee Surg 2016;29(5):409. https://doi.org/10.1055/s-0035-1564727.
[33] Panni AS, Ascione F, Rossini M, et al. Tibial internal rotation negatively affects clinical outcomes in total knee arthroplasty: a systematic review. Knee Surg Sports Traumatol Arthrosc 2018;26(6):1636. https://doi.org/10.1007/s00167-017-4823-0.
[34] Abdelnasser MK, Adi MM, Elnaggar AA, Tarabichi S. Internal rotation of the tibial component in total knee arthroplasty can lead to extension deficit. Knee Surg Sports Traumatol Arthrosc 2020;28(9):2948. https://doi.org/10.1007/s00167-019-05695-w.
[35] Liu C, Zhao G, Chen K, et al. Tibial component coverage affects tibial bone resorption and patient-reported outcome measures for patients following total knee arthroplasty. J Orthop Surg Res 2021;16(1):134. https://doi.org/10.1186/s13018-021-02250-7.