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KNEE ARTHROPLASTY

Functional outcome after bicompartmental knee replacement for medial and patellofemoral osteoarthritis

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Abstract

Introduction Total knee arthroplasty (TKA) is used for tricompartmental knee osteoarthritis, while unicompartmental knee arthroplasty (UKA) is preferred for unicompartmental knee osteoarthritis. Bicompartmental knee arthroplasty (BKA) aims to address 2 knee compartments by combining 2 UKA's or 1 UKA with a patellofemoral replacement. This study examines the clinical outcomes of BKA, focusing on pain alleviation and knee function. The aim of this study is to report the functional outcome of BKA and see if this aligns with BKA outcomes from literature in terms of patient reported outcome measurements (PROMs) and range of motion (ROM) after a 2-year follow-up. Additionally, radiographic alignment, implant survivorship, adverse events and length of stay are secondary outcomes.

Methods This is a cohort study of 21 patients who underwent BKA for medial and patellofemoral osteoarthritis. The patients had follow-up for at least 2 years postoperatively. PROMs were assessed using the Knee injury and Osteoarthritis Outcome Score (KOOS), Knee Society Score (KSS), Oxford Knee Score, Western Ontario and McMaster University Osteoarthritis index (WOMAC) and the Visual Analogue Scale (VAS). ROM was measured using a goniometer. Pre- and postoperative radiographic coronal alignment was measured using standard full leg radiographs. Patient demographics, implant survivorship, length of stay and adverse events were recorded.

Result Twenty-one patients (23 knees) were included, with a mean follow-up of 41 months (standard deviation [SD] 12 months; range 24–59 months). Patient-reported outcome measures (PROMs) demonstrated significant improvements, with 80% achieving good to excellent OKS and KSS scores. KOOS scores were similar to scores found in literature. The WOMAC score was higher in our results compared to other authors. Which indicates worse outcome. The mean preoperative hip-knee-ankle angle (HKAA) was 2.4 degrees varus (SD 1.9 degrees; range 1.2 degrees valgus − 6.1 degrees varus), while the mean postoperative HKAA was 0.3 degrees valgus (SD 2.8 degrees; range 4.6 degrees valgus − 5.6 degrees varus) ($p < 0.001$). Postoperative range of motion averaged 117 degrees (SD 10 degrees; range 98–132).

Conclusions BKA shows promise in alleviating pain and improving knee function in patients with medial and patellofemoral osteoarthritis. Challenges include the risk of revision and technical difficulties during surgery. Comparative studies suggest similar outcomes between BKA and TKA, with potential advantages for younger, more active patients. Further research, particularly randomized trials with larger cohorts, is necessary to elucidate the long-term benefits and drawbacks of BKA compared to other knee arthroplasty options.

Keywords Knee arthroplasty · Bicompartmental knee replacement · Patient reported outcome · Radiographic outcome

Introduction

Unicompartmental knee arthroplasty (UKA) is the preferred treatment in cases of isolated unicompartmental osteoarthritis, whereas total knee arthroplasty (TKA) is a commonly employed therapeutic approach for tricompartmental knee osteoarthritis. UKA preserves native knee kinematics and proprioception more effectively compared to total knee replacement and is considered a bone-sparing intervention

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with greater potential for future revisions [1]. When osteoarthritis affects two out of the three knee compartments, the conventional choice has been total knee replacement. Nevertheless, there is ongoing debate among surgeons regarding whether the patellofemoral joint can be disregarded in such cases [2, 3].

The most frequently affected compartments are the medial and patellofemoral compartments, with the lateral compartment being affected less frequently [4]. Recently, a growing interest has emerged in the concept of combining two unicompartmental knee replacements to selectively address the medial, lateral and patellofemoral compartments. Differences in outcomes have been observed, depending on the use of modular or monolithic implants. Monolithic implants encompass a single femoral component that replaces both the medial and patellofemoral joint surfaces, posing challenges in component orientation [5]. In contrast, modular implants employ separate components, permitting the independent replacement of the medial femoral surface and the trochlear surface [5]. These bicompartmental knee arthroplasties (BKA) hold the potential to spare both cruciate ligaments, theoretically retaining proprioception and native knee kinematics.

Early clinical results have shown promise in terms of pain alleviation, knee function improvement, and the restoration of knee alignment [6]. The objective of our study is to present clinical and functional outcomes following medial and patellofemoral bicompartmental knee arthroplasty, with a minimum follow-up period of two years.

Materials and methods

Between January 2018 and December 2021, a total of 21 patients (23 knees) underwent bicompartmental knee arthroplasty (BKA) for the treatment of medial and patellofemoral osteoarthritis. These procedures were carried out by an experienced senior surgeon specializing in unicondylar and patellofemoral joint arthroplasty. Ethical approval was granted by the local ethics committee for the implementation of this single center descriptive cohort study.

Patients included in the study were selected retrospectively and exhibited a diagnosis of both medial and patellofemoral osteoarthritis, characterized by typical medial and anterior knee pain, as well as radiographic confirmation of medial and patellofemoral osteoarthritis graded at level 3 or 4 according to the Kellgren-Lawrence classification on standard knee x-rays (AP, lateral, Rosenberg, Skyline view). Patients were required to have a range of motion exceeding 90 degrees of knee flexion and a fixed flexion contracture of less than 10 degrees. Furthermore, they should not display coronal or sagittal instability based on clinical examination and radiographic alignment should exhibit less than 10 degrees of varus with no varus thrust during gait. Importantly, patients should not display radiographic evidence of lateral compartment osteoarthritis or experience lateral tenderness or painful symptoms. There were no age restrictions for inclusion.

All surgical procedures were performed with a medial parapatellar approach. During the operation, thorough examination of the patellofemoral joint was conducted and only in cases with clear cartilage loss on the trochlear side was the bicompartmental arthroplasty pursued. In instances of isolated patellar cartilage loss with an intact trochlea, a medial unicondylar arthroplasty without patellofemoral replacement was performed. Routine exploration of the lateral compartment was avoided to prevent a more extensive release required for lateral compartment access.

Consistency was maintained across all procedures by using the same implants. The Zimmer Biomet Oxford Partial Knee system (Zimmer Inc., Warsaw, IN) was used for the medial tibiofemoral compartment, while the Zimmer Biomet Gender Solution Patello-Femoral Joint System (Zimmer Inc., Warsaw, IN) was applied to address the patellofemoral compartment. Postoperatively, patients received similar physiotherapy regimens, focusing on knee mobilization, gait rehabilitation and strengthening of the surrounding muscle envelope, which was administered by a physiotherapist of the patient's choice.

Demographic information for all patients was collected retrospectively through a review of patient records. The following data were documented: date of birth, gender, procedure date, body mass index, ASA score and any prior knee surgeries. Data pertaining to adverse events related to the operation, such as wound complications, infections, thromboembolism and revision procedures, were extracted from patient records. Clinical follow-up assessments were conducted at 6 weeks postoperatively. Additionally, patient-reported outcomes were collected prospectively beyond the two-year follow-up period. Several standardized assessment tools, including the Knee Society Score (KSS), Oxford Knee Score (OKS), Knee Osteoarthritis Outcome Score (KOOS), Western Ontario and McMaster University Osteoarthritis Index (WOMAC) and Visual Analog Scale (VAS) were administered during an additional clinic appointment. Radiographs, including anteroposterior and lateral views, as well as weight-bearing full-leg views, were obtained at the 6-week postoperative mark and assessed for indicators of loosening, implant position and coronal leg alignment, measured by the HKAA on full leg x-rays. Patient reported outcome and range of motion were studied as our primary outcome with pre- and postoperative coronal alignment, complication rate and length of stay as secondary outcomes.

Table 1 Demographics

Demographics	Study group
Age [Mean ± SD (range)]	56.7 ± 8.4y (45-75y)
Sex	23 (100%)
Male (n, %)	9 (39.1%)
Female (n, %)	14 (60.9%)
Side (n, %)	23 (100%)
Right (n, %)	14 (60.9%)
Left (n, %)	9 (39.1%)
BMI [Mean ± SD (range)]	29.8 ± 5.0 (23–39)
ASA grade	23 (100%)
1 (n, %)	13 (56.5%)
2 (n, %)	9 (39.1%)
3 (n, %)	1 (4.3%)
Previous Knee surgery (n, %)	11 (47.8%)
Follow-up [Mean ± SD (range)]	41 months ± 12 (24-59y)

Statistics were carried out with SPSS version 29 (IBM SPSS statistics). Descriptive statistics were performed for demographic data and outcome scores. Paired-samples T-test was performed to check for statistical significance between post- and preoperative values. Inter- and intrarater variability was determined with Fleiss Kappa test. Statistical significance was defined as p-values < 0.05.

Results

Demographic characteristics

A total of 21 patients, corresponding to 23 knees (including two cases with bilateral bicompartmental knee replacements conducted at different instances), were enrolled in the study. The mean duration of follow-up was 41 months (standard deviation [SD] 12 months; range 24–59 months) and the average age of the participants was 57 years (SD 8 years; range 45–75 years). A comprehensive summary of demographics is presented in Table 1.

Outcome analysis

Radiographic assessments were independently conducted by two investigators. No indications of progressive radiolucent lines, loosening or component subsidence were identified. Component positioning was deemed satisfactory in all instances by the investigators. One patient did not have full leg radiographs taken. The mean preoperative hip-knee-ankle angle (HKAA) was 2.4 degrees varus (SD 1.9 degrees; range 1.2 degrees valgus − 6.1 degrees varus), while the mean postoperative HKAA was 0.3 degrees valgus (SD 2.8 degrees; range 4.6 degrees valgus − 5.6 degrees varus). Statistical analysis revealed a significant difference between pre- and postoperative values ($p < 0.001$). Intrarater variability was deemed poor for preoperative HKAA measurements (kappa = 0.010) and fair for postoperative measurements (kappa = 0.193. Interrater variability was considered poor for both pre- and postoperative measurements (kappa = 0.009 and kappa = 0.058).

Table 2 PROM outcome scores

Variable	Mean ± SD (range)
KSS knee	85.5 ± 12.4 (51–99)
KSS functional	77.2 ± 20.6 (26–94)
OKS	38.8 ± 10.3 (12–46)
KOOS	75.5 ± 20.4 (18–92)
WOMAC	17.3 ± 22.9 (0-85.4)
VAS pain	2.8 ± 1.9 (1.0-6.5)

The mean postoperative range of motion was 117 degrees (SD of 10 degrees; range 98–132). The average length of hospital stay was 2.8 days (SD of 1.4 days; range 0–7 days). Notably, 80% of Oxford Knee Score (OKS) and Knee Society Score (KSS) knee/function scores fell within the categories of good to excellent. An average VAS score of 2.8 (SD 1.9; range 1.0-6.5) shows the patients to have limited to no pain 2 years postoperatively. A detailed summary of Patient-Reported Outcome Measure (PROM) scores is provided in Table 2.

No instances of deep infection, superficial wound complications or deep venous thrombosis were documented. A single patient necessitated tibial tuberosity transfer for patella baja and was later revised to a total knee replacement because of ongoing anterior knee pain.

Discussion

As partial knee arthroplasty gains traction within the orthopedic community globally, an increasing number of surgeons are exploring the feasibility of bicompartmental knee replacement. Our study aimed to delineate the outcomes of a case series involving 21 patients (23 knees) who underwent medial and patellofemoral modular unlinked bicompartmental replacement, demonstrating good to excellent postoperative Knee Society Score (KSS), Oxford Knee Score (OKS) in 80% of our study population. Knee Injury and Osteoarthritis Outcome Score (KOOS) and Visual Analog Scale (VAS) pain scores were comparable to findings by other authors, yet WOMAC score was higher in our group indicating worse outcome [7]. One patient performed considerably worse over all outcome scores. The difference between this patient and other patients was especially high in the WOMAC score which could be an explanation to the higher mean WOMAC score in our study compared to work from other authors as our other outcome scores do align with previously published results. Pre- and posteroperative HKA axis inter- and intrarater variability was deemed poor

to fair in our study which is in contradiction with literature [8]. A possible explanation could be the different level of experience between the investigators (1 senior resident, 1 junior resident). The quality of full leg x-rays was also very low which makes it more difficult to measure the HKA in a reproducible way.

The literature presents varied revision rates for bicompartmental knee replacements. Historically, monolithic femoral components were utilized, exhibiting significantly higher revision rates compared to modular systems [6]. The increased revision rates with monolithic implants primarily stem from challenges in aligning the implant to fit the distal femoral and trochlear joint surfaces simultaneously. The variability in distal femoral morphology complicates sizing and alignment with off-the-shelf implants, leading to malalignment and potential complications, as evidenced in a study by Rolston et al., where 42 monolithic bicompartmental knee replacements exhibited a 12% revision rate and 25% incidence of anterior knee pain during short-term follow-up [9]. A recent study by Beckmann et al. reports promising outcomes with custom monolithic femoral components, showing significant improvements in functional scores and a 97.3% implant survivorship at 2.6 years of follow-up [10].

In contrast, our study employed modular implants, enabling optimal positioning and sizing, ideally contributing to more favorable outcomes. Several other authors have also reported positive outcomes following bicompartmental knee replacement. Heyse et al. found postoperative KSS knee scores averaging 92 ± 10 and KSS function scores averaging 83 ± 18 [11]. Argenson et al. observed an increase in range of motion from 107° preoperatively to 121° postoperatively ($p = 0.004$), while Kamath et al. reported similar improvements in PROM scores and an increase in range of motion from 122° to 133° ($p = 0.001$), with 97% of knees achieving a range of motion greater than 120° [7, 12].

However, challenges exist, as demonstrated by Parratte's series of 77 knees treated with combined medial UKA and patellofemoral arthroplasty (PFA), where 27 knees required revision at a mean follow-up of 8 years, primarily due to aseptic loosening of the trochlear and tibial components [13]. Our study encountered one case necessitating revision to total knee replacement due to persistent patellofemoral pain and maltracking, without radiographic evidence of loosening or polyethylene wear. However due to short follow-up it is difficult to make a meaningful comparison between our study and previous publications regarding implant survival.

Bicompartmental knee replacement for medial and patellofemoral osteoarthritis offers theoretical advantages over total knee replacement, preserving both cruciate ligaments and the lateral compartment. However, studies report varying survivorship rates, with short-term survivability appearing similar between total knee arthroplasty and bicompartmental knee arthroplasty [6]. Long-term outcomes remain debatable, with reported survival rates ranging from 54 to 100% at 12–17 years [11, 13]. TKA in contrary had revision rates around 9% at 19 years [14]. Lower survivability of bicompartmental knee arthroplasty may be attributed to its application in a younger, more active population, potentially leading to higher revision rates due to increased activity levels, fractures, loosening, and wear. Revision of BKA to TKA is usually possible with primary implants and has the same issues difficulties as UKA to TKA revision. In case of significant bone loss during BKA removal, conversion to a revision-type implant is necessary.

Another possible treatment for patients with medial and patellofemoral arthritis is medial UKA. The Oxford group explored the patellofemoral joint in 824 knees and discovered full thickness cartilage loss in 16% of these knees. They found that clinical outcomes were not affected by the severity of cartilage loss, concluding that osteoarthritis of the medial facet of the patella was no contraindication for medial UKA [2]. Similarly, Lu et al., in their meta-analysis, determined that medial and lateral facet PFOA was not a contraindication for medial UKA. They also found that progression of PFOA did not increase the risk of failure in patients who received a medial UKA with pre-existing asymptomatic patellofemoral arthritis, attributing this to the frequent asymptomatic nature of patellofemoral osteoarthritis [3]. In our series all patients exhibited patellofemoral symptoms in addition to degenerative changes in the patellofemoral joint on radiographs, complicating the decision to leave the PFJ untreated.

Comparative analysis between TKA and BKA patient reported outcomes reveals similar scores, with some studies reporting comparable improvements in patient-reported outcomes [15, 16]. In a prospective study conducted by Goh et al., comprising 26 bicompartmental knee arthroplasties and 22 total knee arthroplasties, no significant disparities were noted between TKA and BKA groups in outcome scores at both 5-year and 10-year follow-up periods. Remarkably, both cohorts exhibited excellent outcomes, with a 100% satisfaction rate reported in both groups. Furthermore, 95% of patients who underwent BKA reported their expectations being met [17]. In a recent investigation conducted by Deng et al., a comparison was made between the return to sport among 25 cases of modular bicompartmental knee arthroplasty and 50 cases of total knee arthroplasty. The study revealed a notably higher rate of return to sports in the BKA group (71.64% versus 56.45%, $p = 0.039$). Notably, the sports typically engaged in by these patients were of low to medium impact [18]. This study is particularly noteworthy as it appears to be the sole investigation of its

kind, especially considering the trend of a younger population undergoing knee arthroplasty, where the ability to resume sporting activities postoperatively holds significant importance.

Analysis of surgical time and blood loss during the procedures indicated longer surgical durations for bicompartmental knee replacements compared to TKA, although there was less blood loss in the former [15]. The technical difficulties of BKA, attributed to the placement of two separate femoral components, contributes to the prolonged duration of surgery. However, due to fewer bone cuts required, BKA procedures are associated with reduced intraoperative blood loss, thereby contributing to their relatively less invasive nature.

Limitations of our study include its retrospective nature, relatively small sample size, descriptive statistics, lack of a comparison group and absence of pre- and postoperative value comparisons beyond coronal alignment. Due to the short follow-up we couldn't make meaningful conclusions regarding implant survival. For 8 patients the 2 year follow-up PROMs were not collected, which is a high drop-out number. While our postoperative outcomes align with those reported in the literature, this cannot be statistically confirmed.

In summary, bicompartmental knee replacement for medial and patellofemoral arthritis emerges as a viable alternative to total knee replacement. While the advantages of preserving both cruciate ligaments and the lateral compartment remain uncertain in clinical practice, there appears to be no significant inferiority compared to total knee replacement, despite conflicting findings in the literature. Further investigation is warranted, particularly through randomized prospective studies with large sample sizes, to delineate the advantages and disadvantages of bicompartmental versus total knee replacement comprehensively.

Conclusion

In conclusion, we present a series comprising 23 cases of medial and patellofemoral bicompartmental knee replacements, demonstrating comparable postoperative patient reported outcome scores to various other studies. Bicompartmental knee replacement emerges as a valuable alternative for patients with bicompartmental knee osteoarthritis, alongside total knee replacement. The biggest concern remains implant survival. Therefore, further prospective randomized studies on large patient populations with long follow-up are imperative to thoroughly explore the advantages of this kinematic-preserving approach to knee replacement.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00402-024-05543-8.

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