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Review

Outcome of simultaneous bi-unicompartmental knee arthroplasty: a systematic review

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Abstract. *Background and aim*: Simultaneous medial and lateral tibiofemoral osteoarthritis (OA) could be treated with bi-unicompartmental knee arthroplasty (Bi-UKA) as an alternative to total knee arthroplasty (TKA). The present systematic review aims to assess if simultaneous Bi-UKA is a feasible option for treating medial and lateral tibiofemoral OA. *Materials* and Methods: A comprehensive search of PubMed, MEDLINE, Cochrane Library, and Google Scholar was performed to find studies that reported on the outcome of simultaneous Bi-UKA for both medial and lateral tibiofemoral OA. *Results*: Seven studies were considered eligible for inclusion in the present systematic review. Intraoperative fractures occurred 8 times. Overall, there were 22 revisions of the prosthetic components for any reason with a survival rate that ranged from 83 to 100%. Of these, 16 revisions were for the aseptic loosening of the prosthetic components. Out of 302 surgeries, three were revised due to symptomatic OA progression in the patello-femoral joint. All clinical scores improved at the latest follow-up compared to preoperative values. Moreover, there were no differences in clinical scores of Bi-UKA compared to unicompartmental knee arthroplasty (UKA), or medial UKA plus patello-femoral prosthesis. Whereas, compared to TKA, Bi-UKA patients had comparable or superior scores. Finally, the Bi-UKA group had a significantly shorter hospital stay compared to the TKA group. *Conclusions*: The use of simultaneous Bi-UKA is a valid option to address bicompartmental knee OA in selected patients with low intraoperative fracture rate, low revision rate, satisfactory clinical outcome, and fast recovery. (www.actabiomedica.it)

Key words: bi-unicompartmental knee arthroplasty, total knee arthroplasty, unicompartmental knee arthroplasty, patellofemoral arthroplasty, osteoarthritis, clinical outcome

Introduction

Simultaneous medial and lateral tibiofemoral osteoarthritis (OA) could be treated with bi-unicompartmental knee arthroplasty (Bi-UKA) as an alternative to total knee arthroplasty (TKA) (1, 2). It is a minimally invasive procedure that results a shorter stay in the hospital (2, 3). Inclusion criteria for Bi-UKA include simultaneous medial and lateral tibiofemoral OA, an asymptomatic patello-femoral joint (arthritis less than or equal to Alback grade II), a varus deformity of less than 10°, a flexion deformity of less than 10°, a body-mass index lower than 35, no clinical evidence of anterior cruciate ligament (ACL) laxity, and a pre-operative range of movement more than 90° (2, 4). Active inflammatory arthritis, knee instability, severe coronal or sagittal deformity, and tibial bone defect larger than 12 mm, on the other hand, are contraindications to this procedure (4).

The patient's bone stock and all intraarticular ligaments are preserved in Bi-UKA, theoretically leading to more normal knee kinematics and enhanced function (2). Banks et al. (5) found that retaining both cruciate ligaments in Bi-UKA preserves certain

essential characteristics of normal knee kinematics, such as posterior translation of the femoral condyles and tibial internal rotation during flexion. Fuchs et al. (6) demonstrated that Bi-UKA, which preserves all ligamentous structures, mimics the biomechanics of an intact knee more precisely than TKA. Romangoli et al. (7) show that Bi-UKA outperforms TKA in replicating a gait pattern similar to that of healthy knees. Computer-assisted Bi-UKA surgery was developed recently, allowing the surgeon to control limb alignment and ligament balance throughout the entire process (8).

In a prospective randomized controlled trial (RCT), Banger et al. (9) found that, compared to a mechanically aligned TKA, the robotic-assisted cruciate-sparing Bi-UKA preserves better the natural anatomy of the knee in the coronal, sagittal, and axial planes at 3 months postoperatively, and may thus maintain normal joint kinematics. Wada et al. (10) conducted a systematic review of the literature on the clinical results of both simultaneous and staged Bi-UKA and found a favorable clinical outcome for this procedure. To the best of the authors' knowledge, this is the first systematic review to assess if simultaneous Bi-UKA is a feasible option for treating medial and lateral tibiofemoral OA of the knee. Hence, the present systematic review aims to evaluate the intraoperative fracture rate, revision rate of the prosthetic components for any reason, revision rate for symptomatic OA progression of the patellofemoral joint (PFJ), the clinical outcome and the hospital stay of patients treated with simultaneous Bi-UKA for both medial and lateral tibiofemoral OA.

Materials and methods

The guidelines for Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) were followed (11). A thorough search of PubMed, MEDLINE, Cochrane Library, and Google Scholar was conducted up to the 15th of August 2023 to find studies that reported on the outcome of patients treated with simultaneous Bi-UKA for both medial and lateral tibiofemoral OA. The following search strategy was used: "(Knee) AND (arthroplasty OR replacement) AND (bi-unicompartmental OR bi-unicondylar). Two reviewers independently assessed the titles and abstracts of all identified studies to determine their suitability for this systematic review. Furthermore, each reference list from the identified studies was manually checked to ensure that no relevant articles were overlooked. In vitro studies, case reports, kinematic studies, surgical technique papers, studies with the addition of patellofemoral arthroplasty, staged Bi-UKA studies, studies with missing clinical data, and those not published in English were excluded. Furthermore, each study was examined in terms of the following variables: the number of patients, the patient's age at the time of surgery, and the length of follow-up.

The included studies were also assessed in terms of intraoperative fractures, revision of the prosthetic components for any reason, and revision for symptomatic OA progression of PFJ. Finally, the survival rate of the prosthetic components was collected.

Results

The PRISMA flowchart for study selection is shown in Figure 1.

The initial search identified 412 studies that were evaluated for eligibility. After removing duplicates and examining the titles and abstracts, the full-text versions of ten studies (1-4, 12-17) were evaluated. Through cross-referencing, nine more articles (18-26) were identified. Twelve articles were excluded. Of these, eight (14, 17-23) had partial or missing clinical outcome data and four (1, 15, 16, 26) reported the outcome of staged Bi-UKA. As a result, seven studies (2-4, 12, 13, 24, 25) were considered eligible for inclusion in the present systematic review. Six studies (2-4, 13, 24, 25) were retrospective and one study (12) was a prospective RCT. In the 7 studies included, the data of 284 patients who received 302 Bi-UKA was recorded. They had a mean age at surgery of 65 years. The patients were evaluated at a minimum follow-up of 2 months and a maximum follow-up of 276 months (Table 1).

Intraoperative fractures occurred 8 times, requiring surgical treatment in all cases. Overall, there were 22 revisions of the prosthetic components for any reason with a survival rate that ranged from 83 to 100%.

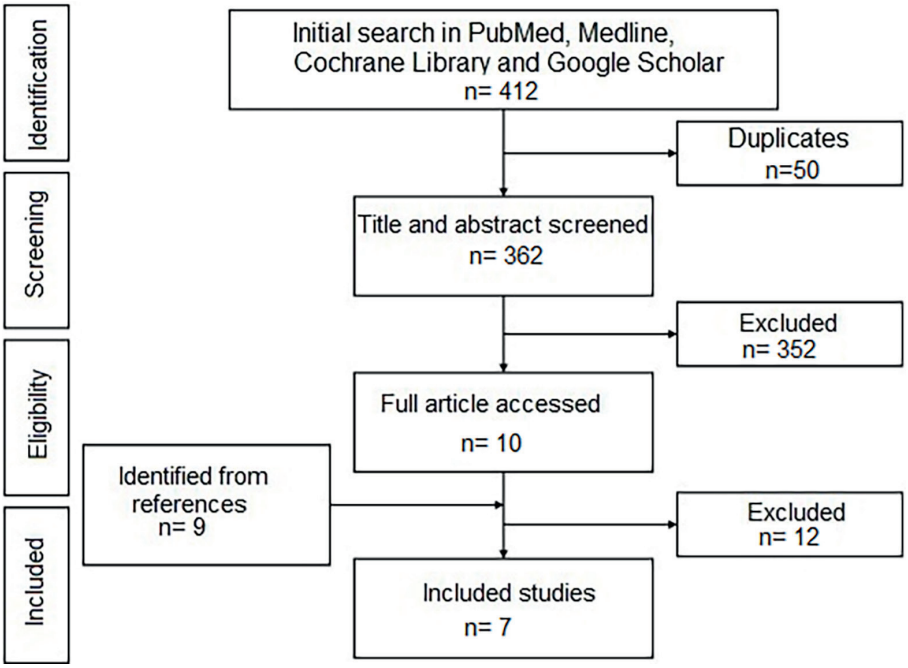

Figure 1. Flowchart of the systematic review.

Table 1. Demographic data.

Study	Participants	Type of Study	Patients (knees)	Age at surgery, years	Follow-up, months
Fuchs et al. (24)	Bi-UKA vs UKA	Retrospective	15 (15) vs 17 (17)	67.4 vs 62.5	26.7
Parratte et al. (13)	Bi-UKA vs medial UKA plus PFA	Retrospective	78 (94) vs 63 (69)	65.7 vs 60.2	144
Biazzo et al. (2)	Bi-UKA vs TKA	Retrospective	19 (19) vs 18 (18)	59.7 vs 61.2	180
Confalonieri et al. (3)	Bi-UKA vs TKA	Retrospective	22 (22) vs 22 (22)	60.4 vs 60.7	48[a]
Romagnoli et al. (4)	Bi-UKA	Retrospective	101 (103)	65.2	112.8
Blyth et al. (12)	Bi-UKA vs TKA	Prospective RCT	34 (34) vs 42 (42)	68.7 vs 70.4	12
Fuchs et al. (25)	Bi-UKA vs TKA	Retrospective	15 (15) vs 15 (15)	67.4 vs 68.1	29.3

Age at surgery and follow-up are expressed as mean. [a] Follow-up expressed as minimum. Abbreviations: Bi-UKA: bi-unicompartmental knee arthroplasty; UKA: unicompartmental knee arthroplasty; PFA: patello-femoral arthroplasty; TKA: total knee arthroplasty; RCT: randomized controlled trial.

Of these, 16 revisions were for the aseptic loosening of the prosthetic components. Other causes of revision of the prosthetic components include one case of resorption of the anterior tibial spine, one case of medial polyethylene wear, one case of fracture of the medial tibial plateau, two cases of anteroposterior instability, and one case of persistent postoperative pain. Out of 302 surgeries, three were revised due to symptomatic OA progression in the PFJ with the addition of a patellofemoral arthroplasty (PFA) (Table 2).

Clinical outcome of patients treated with Bi-UKA was evaluated with Knee Society Score (KSS), Knee Society Knee Score (KSKS), Knee Society Function Score (KSFS), Italian Orthopaedic UKR Users Group score (GIUM), Western Ontario and McMaster University Osteoarthritis Index (WOMAC), Visual Analogue Scale (VAS), Oxford Knee Score (OKS), EuroQol five-Dimension three-Level questionnaire (EQ-5D-3L), Forgotten Joint Score (FJS), University of California, Los Angeles (UCLA), Hospital for

Table 2. Details on the type of implants and intra and postoperative complications of Bi-UKA.

Study	Type of Bi-UKA implants	Intraoperative fractures of the anterior tibial spine	Revision of the prosthetic components	Symptomatic OA progression of the patellofemoral joint	Survival rate %
Fuchs et al. (24)	Metal backed	None	None	None	100
Parratte et al. (13)	Metal backed	4	16	1	83
Biazzo et al. (2)	All poly and Metal backed	2	1	None	94.7
Confalonieri et al. (3)	All poly	2	None	None	100
Romagnoli et al. (4)	Metal backed	None	4	2	96.1
Blyth et al. (12)	Metal backed	None	1	None	97
Fuchs et al. (25)	Metal backed	None	None	None	100

Abbreviations: Bi-UKA: bi-unicompartmental knee arthroplasty; OA: osteoarthritis.

Special Surgery score (HSS), Patellar Score (PS) and Tegner activity score. All clinical scores improved at the latest follow-up compared to preoperative values. Moreover, there were no differences in clinical scores of Bi-UKA compared to unicompartmental knee arthroplasty (UKA) (24), or medial unicompartmental knee arthroplasty (MUKA) plus PFA (13). Whereas, compared to TKA, Bi-UKA patients had comparable scores except for KSS, WOMAC function and stiffness in two studies (2, 3, 25) (Table 3).

Finally, the Bi-UKA group had a significantly shorter hospital stay, with an average of 6.31 days compared to 7.9 in the TKA group (2, 3).

Discussion

The most important findings of the present study were that the use of Bi-UKA for treating both medial and lateral tibiofemoral OA was associated with a low intraoperative fracture rate, a low revision rate of the prosthetic components for any reason, a low revision rate for symptomatic OA progression of the PFJ, an improvement in clinical outcome at latest follow-up compared to preoperative values, a comparable clinical outcome compared to UKA or MUKA plus PFA, and a comparable or better clinical outcome and faster recovery compared to TKA.

Bi-UKA is not widely used since concurrent medial and lateral tibiofemoral OA account for only 5% (2.9 – 6.3%) of the knee OA population as demonstrated in a recent meta-analysis of 16 studies (*27*). In the literature, few authors have described the clinical outcome of simultaneous Bi-UKA for the management of medial and lateral tibiofemoral OA.

Intraoperative fractures of the anterior tibial spine during implantation of Bi-UKA

Excessive intra-operative tension on the ACL as a result of unbalanced extension/flexion space or inability to reestablish the joint line might result in an intraoperative fracture of the anterior tibial spine. In the present review, an intraoperative fracture rate of 2.6% (8 out of 302) of the anterior tibial spine during implantation of the prosthesis has been observed. Both, Biazzo et al. (2) and Confalonieri et al. (3) observed two intraoperative fractures treated with internal fixation. While Parratte et al. (13) observed four cases treated with nonabsorbable sutures. This complication was shown to be successfully resolved with computer-assisted Bi-UKA (8).

Revision of the prosthetic components of Bi-UKA

In this study, there was a revision rate of 7.3% (22 out of 302) of the prosthetic components for any reason. Moreover, a revision rate of 5.3% (16 out of 302) for aseptic loosening of the prosthetic components was observed. With early Bi-UKA, unsatisfactory

Table 3. Clinical outcomes.

Study	Participants	KSS		KSKS		KSFS		GIUM		Womac pain		WOMAC function		WOMAC stiffness		VAS		VAS stiffness		OKS		EQ-5D-3L VAS		EQ-5D-3L INDEX		FJS		UCLA activity scale		HSS		PS		Tegner activity score	
		PO	FU	PO	FU	PO	FU	PO	FU	PO	FU	PO	FU	PO	FU	PO	FU	PO	FU	PO	FU	PO	FU	PO	FU	PO	FU	PO	FU	PO	FU	PO	FU	PO	FU
Fuchs et al. (24)	Bi-UKA vs UKA	NS	169.7 vs 169.3														8.5 vs 6.9													NS	80.4 vs 85.2	NS	26.8 vs 25.7		
Parratte et al. (13)	Bi-UKA vs MUKA+ PFA			44 vs 38	88 vs 84	42 vs 35	88 vs 79																												
Biazzo et al. (2)	Bi-UKA vs TKA			43.7 vs 42.7	78.3 vs 75.1	48.5 vs 47.7	80.5 vs 75.5	NS	77.4 vs 74.8	NS	4 vs 4.2	NS	7.2 vs 8.7[a]	NS	1.7 vs 2.5[a]																				
Confalonieri et al. (3)	Bi-UKA vs TKA			44 vs 43.4	80 vs 77.9	48 vs 47.2	82.2 vs 77.3	NS	78.5 vs 75.2	NS	4 vs 4.2	NS	7.8vs 9.2[a]	NS	1.5 vs 2.3[a]																				
Romagnoli et al. (4)	Bi-UKA			67.07	91	58.02	88.04									8[a]	1[a]																		
Blyth et al. (12)	Bi-UKA vs TKA	102 vs 99[a]	156 vs 159[a]	42 vs 41[a]	48 vs 51.5[a]	56 vs 52[a]	102.5 vs 109.5[a]									6.6 vs 7.0	1.6 vs 1.9	6.9 vs 6.6	2.4 vs 2.1	19 vs 18.5[a]	39 vs 37[a]	72.2 vs 69.8	74.9 vs 78.9	0.44 vs 0.45	0.73 vs 0.76	NS	19 vs 20.5[a]	3 vs 3[a]	5.5 vs 5[a]						
Fuchs et al. (25)	Bi-UKA vs TKA	NS	169 vs 123													N.S	8.5 vs 5.8													NS	80 vs 70	NS	26.8 vs 19	NS	2 vs 1.2

[a] values are expressed as median. Abbreviations: NS: Not Specified; PO: PostOperative; FU: Follow-Up; Bi-UKA: bi-unicompartmental knee arthroplasty; UKA: unicompartmental knee arthroplasty; PFA: patello-femoral arthroplasty; TKA: total knee arthroplasty; KSS: Knee Society Score; KSFS: Knee Society Function Score; KSKS: Knee Society Knee Score ; GIUM: Italian Orthopaedic UKR Users Group score; WOMAC: Western Ontario and McMaster University Osteoarthritis Index; VAS: Visual Analogue Scale; OKS: Oxford Knee Score; EQ-5D-3L: EuroQol five-Dimension three-Level questionnaire; FJS: Forgotten Joint Score; UCLA: University of California, Los Angeles; HSS: Hospital for Special Surgery score; PS: Patellar Score.

results have been found. Parratte et al. (13) performed a retrospective study to present the long-term results of 94 knees (78 patients) that had Bi-UKA at a minimum follow-up of 5 years (mean, 12 years; range, 5–23 years). Sixteen knees underwent revision of the prosthetic components at a mean of 6.5 years (range, 9 months-12 years), due to polyethylene wear and tibial plateau loosening with a survival rate of 83%. All of them needed to be converted to TKA. The authors attributed the low survival rate to the design and instrumentation of the prostheses used, as well as fixation issues since most of the revised patients (13 of 16) were operated on before 1989.

On the other hand, the outcome with modern Bi-UKA appears promising with no more revisions for aseptic loosening due to improved fixation. In a long-term follow-up, Biazzo et al. (2) found a case of resorption of the anterior tibial spine 7 years after surgery that needed conversion to a TKA with a survival rate of 94.7%. The authors theorized that it was due to a lack of knee balance. Romagnoli et al. (4) conducted research in which they reported on the results of 103 Bi-UKA in 101 patients. At a mean follow-up of 9.45 years (range, 2–20 years), four knees required further surgeries, producing an overall survival rate of 96.1%. Of these, one knee had medial polyethylene (PE) wear 16.7 years after the index operation. Both the tibial component and the PE were revised with others, leaving the remaining prosthetic components in situ. One patient fractured the medial tibial plateau after a fall 3.2 years after the index procedure, and another patient developed anteroposterior instability due to an ACL lesion 13.2 years after surgery. Both patients were treated with a mobile-bearing primary TKA. Finally, 8.8 years after surgery, one patient with poliomyelitis in the operative limb exhibited antero-posterior instability, so the Bi-UKA was revised with a hinged TKA. Blyth et al. (12) had a revision surgery of one Bi-UKA with a survival rate of 97%. This was converted to TKA in less than 3 months because of pain caused by a small osteochondral defect at the medial trochlea, which the authors related to an incorrect indication. Finally, Confalonieri et al. (3), Fuchs et al. (24), and Fuchs et al. (25) did not report any revisions of the prosthetic components with a 100% survival rate. In all these studies, there was no evidence of aseptic loosening or subsidence of the implants or signs of osteolysis.

Symptomatic OA progression of the patellofemoral joint in patients with Bi-UKA

One of the concerns of this procedure is the symptomatic OA progression of the PFJ. Hence, rigorous inclusion criteria must be followed. In the present review, only 1% (3 out of 302) of the knees were revised for symptomatic OA progression in the PFJ. Romagnoli et al. (4) observed two knees with OA progression in the PFJ, as a result, a PFA was added 4.1 and 10.3 years after the index operation. Parratte et al. (13) revised one knee at 10 years by the addition of a PFA with a favorable result at the 15-year follow-up. The authors assumed that this low rate of symptomatic OA progression of the PFJ is most likely due to appropriate pre-operative screening excluding patients with symptomatic PFJ with OA more than Alback grade II.

Clinical outcome of Bi-UKA vs UKA and MUKA plus PFA

Clinical scores improved at the latest follow-up in all the studies included in the present review when compared to preoperative values. Moreover, the results of patients treated with Bi-UKA were equivalent to those of UKA (24) and MUKA plus PFA (13). Fuchs et al. (24), in a retrospective study, found no significant differences in clinical results between patients with unicondylar and bicondylar sledge prostheses of the knee, concluding that implantation of bicondylar sledge prostheses retaining both cruciate ligaments achieves functional results comparable to UKA. Parratte et al. (13) conducted a retrospective analysis to describe the mid and long-term results of 94 Bi-UKA (78 patients) and 69 MUKA plus PFA (63 patients) at a mean of 12 years (5–23 years). They found that both the Bi-UKA and MUKA plus PFA groups had similar Knee Society knee and function scores at the latest follow-up. On the other hand, Bi-UKA can produce equivalent or better clinical results than TKA in patients with OA involving both the medial and lateral tibio-femoral compartments.

Clinical outcome of Bi-UKA vs TKA

Mercurio et al. (28) found in a recent systematic review and comparative meta-analyses, evaluating the outcomes of Bi-UKA and TKA for the treatment of medial and lateral knee OA, that TKA reported better neutral alignment than Bi-UKA, in the absence of differences in pain between the two surgical procedures probably because the mean postoperative hip-knee-ankle angles reported for both TKA and Bi-UKA resulted within the safe zone of 177° to 183°. Whereas, it was observed that Bi-UKA showed a better KSS and WOMAC function and stiffness, probably because, compared with a mechanically aligned TKA, Bi-UKA maintains the natural anatomy of the knee better in the coronal, sagittal, and axial planes and may therefore preserve normal joint kinematics and maintain knee proprioception (9, 25).

Hospital stay after Bi-UKA vs TKA

In patients with OA in both the medial and lateral tibio-femoral compartments, Bi-UKA had a quicker recovery time than TKA as demonstrated by Biazzo et al. (2) and Confalonieri et al. (3) who observed that the hospital stay in the Bi-UKA group was statistically shorter than in the TKA group, with a mean of 6.31 days compared to 7.9 in the TKA group. Whereas, Blyth et al. (12) did not find any differences in the groups.

Limitations

This systematic review is limited by the small number of studies and the low duration of follow-up, due to the recent development and utilization of Bi-UKA implants. Moreover, the number of patients in all but two studies (4, 13) was low. The level of evidence of studies included in this review was low. In fact, except for the study by Blyth et al. (12), all were retrospective and not randomized. Another limitation was that the Bi-UKA implants utilized were not homogeneous. More prospective, randomized controlled studies with a large number of patients and a long follow-up time are needed in the future to demonstrate the advantages of this technique before it can be recommended for routine use in the treatment of bicompartmental OA. Despite the limitations mentioned previously, to the best of the authors' knowledge, this is the first systematic review to report on the intraoperative fractures rate, revision rate of the prosthetic components for any reason, revision rate for symptomatic OA progression of the PFJ, and clinical outcome of simultaneous Bi-UKA that could help surgeons better understand the benefits of this type of surgery.

Conclusions

The results observed in the present systematic review suggest that the use of Bi-UKA is a valid option to address OA in the medial and lateral tibiofemoral compartments in selected patients with low intraoperative fracture rate, low revision rate, satisfactory clinical outcome, and fast recovery.

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Authors contribution: All Authors; data curation and analysis: IA; writing original draft preparation: IA, HZ; reviewed the manuscript for important intellectual content and editing: IA, HZ, MD; all authors have read and approved the final version of the manuscript.

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