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Survival of Bicompartmental Knee Arthroplasty at 5 to 23 Years

Sebastien Parratte MD, Vanessa Pauly MS,
Jean-Manuel Aubaniac MD, Jean-Noel A. Argenson MD

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Abstract Recent literature suggests patients achieve substantial short-term functional improvement after combined bicompartmental implants but longer-term durability has not been documented. We therefore asked whether (1) bicompartmental arthroplasty (either combined medial unicompartmental knee arthroplasty (UKA) and femoropatellar arthroplasty (PFA) or medial UKA/PFA, or combined medial and lateral UKA or bicompartmental UKA) reliably improved Knee Society pain and function scores; (2) bicompartmental arthroplasty was durable (survivorship, radiographic loosening, or symptomatic disease progression); (3) we could achieve durable alignment; and (4) the arthritis would progress in the unresurfaced compartment. We retrospectively reviewed 84 patients (100 knees) with bicompartmental UKA and 71 patients (77 knees) with medial UKA/PFA. Clinical and radiographic evaluations were performed at a minimum followup of 5 years (mean, 12 years; range, 5–23 years). Bicompartmental arthroplasty reliably alleviated pain and improved function. Prosthesis survivorship at 17 years was 78% in the bicompartmental UKA group and 54% in the medial UKA/PFA group. The high revision rate, compared with total knee arthroplasty, may be related to several factors such as implant design, patient selection, crude or absent instrumentation, or component malalignment, which can all contribute to the relatively high failure rate in this series.

Level of Evidence: Level III, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.
Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

S. Parratte, V. Pauly, J.-M. Aubaniac, J.-N. A. Argenson (✉)
Service de Chirurgie Orthopediquem, Center for Arthritis Surgery, Aix-Marseille University, Hôpital Sainte Marguerite, 270, Boulevard Sainte-Marguerite, 13009 Marseille, France
e-mail: jean-noel.argenson@ap-hm.fr

Introduction

Surgical treatment of limited arthritis of the knee includes nonprosthetic treatments such as arthroscopic débridement, meniscus transplantation, cartilage repair, high tibial osteotomy (HTO), or tibial tubercle transposition [13, 15, 21, 29, 33, 36]. Arthroplasty solutions include unicompartmental knee arthroplasty (UKA) or conventional TKA [3, 13, 15, 21, 29, 33, 36]. TKA offers high survival and high functional scores when arthritis is affecting the three compartments of the knee; however, TKA does not preserve the bone stock and the ligaments and these points can represent theoretical disadvantages, particularly for young patients with higher demand and higher risk for potential revision [8, 16]. On the other hand, preservation of all the ligaments with facility to tension them accurately from a range of bearing thicknesses and minimal bone excision were the main advantages advocated to originally promote the concept of bicompartmental arthroplasty. Therefore, because bicompartmental arthritis of the knee is not rare, bicompartmental knee arthroplasties have been proposed to bridge the gap between UKA and TKA. UKA is a bone- and ligament-sparing technique that reliably restores knee kinematics and function for arthritis limited to one compartment of the knee [22, 32]. Several authors suggest the functional status of the patient and the survival after UKA are better when the anterior cruciate ligament is intact [3, 6]. Similarly, outcome and kinematic studies suggest maintaining the anterior cruciate ligament in bi- and tricompartmental knee arthroplasty may be advantageous in terms of survivorship [9, 20], stairclimbing ability, patient satisfaction, and joint kinematics [2, 9, 10, 20, 27, 30, 35].

Considering these recent data on UKA and given bicompartmental arthritis of the knee is not rare, there is renewed interest in bicompartmental knee arthroplasties, including combined medial UKA and femoropatellar arthroplasty as well as combined medial and lateral UKA [10, 14, 30]. Smaller implant sizes, less operative trauma, preservation of both cruciate ligaments and bone stock, and a more "physiological" knee are reported advantages over TKA [7, 14, 16–18, 30].

To confirm the durability of bicompartmental arthroplasty observed in the historical series [20], and considering short-term objective and subjective functional improvements recently reported after combined bicompartmental implants [16, 18, 30], we asked whether (1) bicompartmental arthroplasty (either combined medial unicompartmental knee arthroplasty (UKA) and femoropatellar arthroplasty (PFA) or medial UKA/PFA, or combined medial and lateral UKA or bicompartmental UKA) reliably improved Knee Society pain and function scores; (2) bicompartmental arthroplasty was durable (survivorship, radiographic loosening, or symptomatic disease progression); (3) we could achieve durable alignment; and (4) the arthritis would progress in the unresurfaced compartment.

Materials and Methods

We retrospectively reviewed all 155 patients (177 knees) treated with a bicompartmental knee arthroplasty for bicompartmental osteoarthritis of the knee between April 1972 and December 2000. There were 84 patients (100 knees) having combined medial and lateral UKA (bi-UKA group) and 71 patients (77 knees) having combined medial UKA and PFA (med-UKA/PFA group). The indications for surgery were (1) confirmed diagnosis of bicompartmental osteoarthritis (Ahlback [1] Grade 2 or greater) with a full thickness of the articular cartilage in the lateral compartment in the med-UKA/PFA group and preserved status of the patellofemoral joint (based on clinical evaluation and skyview radiographs) for the bi-UKA group; (2) preoperative range of knee flexion greater than 100° associated with a full range of knee extension; and (3) a clinically stable knee in the frontal and sagittal planes. Patients with the following were considered a contraindication for the procedure: (1) a valgus or a varus deformity greater than 10° as measured on long-leg radiographs; (2) a planned HTO; (3) a planned or previous anterior cruciate ligament reconstruction; or (4) a revision arthroplasty. After 1989, we performed varus and valgus stress radiographs to evaluate the lateral compartment (in the med-UKA/PFA) group and the correction of the deformities (in both groups) [19]. A full loss of cartilage on the lateral compartment or a fixed deformity observed on the stress radiograph was considered a contraindication to surgery after 1989. The minimum followup was 5 years (mean, 11.7 years; range, 5–23 years). In the bi-UKA group, 39 patients (48 knees) and 26 patients (27 knees) in the med-UKA/PFA group died before the final review (at a mean of 12 years postoperatively), but data were available from the last followup before their death (1 year before) and we used these data for the final analysis. Six patients were lost to followup in the bi-UKA group; thus, 94 knees in 78 patients were available for the final analysis in this group. Eight patients were lost to followup in the med-UKA/PFA group; thus, 69 knees in 63 patients were available for the final analysis. Approval of the local ethical committee was obtained.

Age at the time of surgery, body mass index, gender of the patients, and side of the limb were recorded (Table 1). In the bi-UKA group, the etiologies of the osteoarthritis (OA) were primary OA in 92 knees (80%) and posttraumatic OA in eight (8%). In the med-UKA/PFA group, PF arthritis was secondary to patellar instability with a history of patellar dislocation or trochlear dysplasia in 35 knees (45%), posttraumatic arthritis in 15 knees (20%), and primary osteoarthritis in 27 knees (35%). In the med-UKA/PFA group, arthritis of the medial compartment was primary arthritis in all but 15 cases (20% of posttraumatic OA). Grade of arthritis was analyzed preoperatively according to the Ahlback [1] classification (Table 2).

All surgery was performed by the senior authors (JMA, JNA). In the bi-UKA group, the surgical approach was a standard medial parapatellar approach for 70 knees (70%) and a standard subvastus approach in the remaining 30

Table 1. Age, body mass index (BMI), and gender of the patients in each group and side of the knees in each group

Variable	Bi-UKA group	Med-UKA/PFA group	p
Age in years, mean ± SD (range)	65.7 ± 12.4 (32–82)	60.2 ± 9.4 (42–85)	0.09
BMI (kg/m^2), mean ± SD	27 ± 3	26 ± 4	0.54
Gender, number (%)	51 F (51%) 33 M (33%)	43 F (56%) 28 M (44%)	0.34
Side, number (%)	55 right (55%) 45 left (45%)	45 right (59%) 32 left (41%)	0.57

UKA = unicompartmental knee arthroplasty; Bi = bicompartmental; Med = medial; F = female; M = male.

Table 2. Preoperative grade of arthritis according to the Ahlback [1] classification

Ahlback grade	Bi-UKA group, number (%)		Med-UKA/PFA group, number (%)	
	Medial compartment	Lateral compartment	Medial compartment	Patellofemoral compartment
1	0	0	0	0
2	3 (3%)	30 (30%)	20 (26%)	0
3	92 (92%)	65 (65%)	55 (71%)	77 (100%)
4	5 (5%)	5 (5%)	2 (3%)	0

UKA = unicompartmental knee arthroplasty; Bi = bicompartmental; Med = medial.

cases (30%). In the med-UKA/PFA group, the surgical approach was a standard medial parapatellar approach for 42 knees (55%). A subvastus approach was performed in the 35 knees (45%) with a history of patellar dislocation or trochlear dysplasia to manage the external retinaculum release without compromising the patellar blood supply. All UKA components were cemented on the tibial and the femoral side. Between 1972 and 1989, Zimmer Condylar 2 (Zimmer, Warsaw, IN) or Alpina (Biomet, Bridgend, UK) were used as UKA implants either in the medial or the lateral compartment. After 1989, Miller-Galante UKA (Zimmer) were systematically used and performed with modern dedicated instrumentation, including tibial and femoral cutting guides. In the med-UKA/PFA group, all patients had an autocentric patellofemoral prosthesis (DePuy, Warsaw, IN) with a cemented polyethylene (PE) patella and a Co-Cr femoral component cemented in 40% of the cases. The design characteristics and the surgical technique of this device have been previously described [4, 5] (Fig. 1).

Postoperative rehabilitation protocols included immediate weightbearing protected by crutches during the first 2 or 3 weeks according to patient tolerance, and exercises were focused on passive flexion immediately and then active recuperation of flexion and extension. All patients received routine prophylaxis with fractionated heparin in the 1970s and 1980s and later this protocol was changed to low-molecular-weight heparin pre- and postoperatively for 21 days.

All patients were evaluated clinically preoperatively, at 3 months postoperatively, at yearly intervals postoperatively, and at last followup by one observer (SA) not involved in the treatment using the Knee Society knee and function score [23]. For the patients operated on in the 1970s and 1980s, the data collected on the standardized knee sheet used in the department during this period were used to calculate the Knee Society score [23]. We recorded the arc of knee flexion preoperatively, during followup, and at the final evaluation.

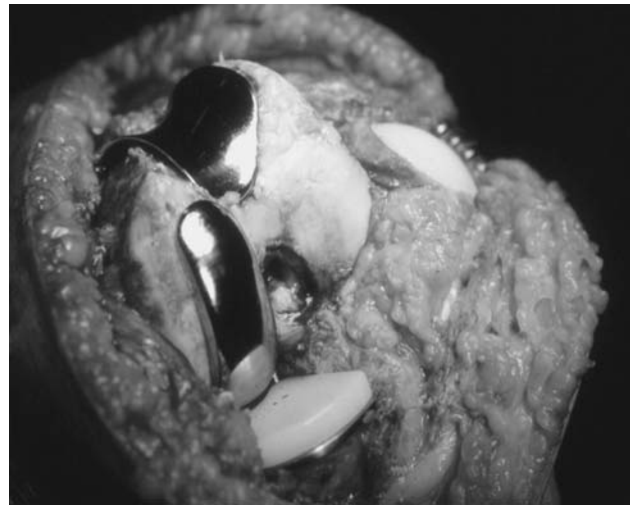

Fig. 1 The final operative view of a combined a medial UKA with a patellofemoral arthroplasty performed in 1985 is shown. UKA = unicompartmental knee arthroplasty.

Radiographic evaluation was performed by one observer (SP) on long-leg radiographs and on anteroposterior (AP), lateral, and skyline radiographs of the knee obtained postoperatively and at last followup. The lower-limb alignment was assessed on long-leg radiographs performed using a standardized protocol in which the patient stood with the patella facing anteriorly. On these long-leg radiographs, pre- and postoperatively, the femoral angle (CH: condylar axis to hip center), the tibial angle (PA: plateau axis to ankle), and the articular deformation (CP: condylar axis and plateau axis) were calculated [11, 12]. Then the hip-knee-ankle (HKA) angle was calculated as the sum of the three previously defined angles (HKA = CH + PA + CP) considering CP as positive in case of lateral convergence [11, 12]. We assessed postoperative alignment of the femoral and tibial components as well as the postoperative alignment of the limb on long-leg radiographs with the same standardized protocol used preoperatively [11, 12] (Fig. 2). We examined full tangential AP and lateral radiographs and skyline radiographs to detect the presence, extent, and progression of femoral, tibial, or patellar radiolucencies; we considered lucencies greater than 1 mm, irregular, or progressive between two radiographic examinations as relevant according to the Knee Society roentgenographic score [23]. The restoration of the mechanical axis was also analyzed postoperatively and at final followup according to the Kennedy classification, which considers the alignment correct when the mechanical axis is in Zone 2 or C (central) [25]. This classification divides the knee into fives zone: Zone 0 is medial to the medial part of tibial plateau, Zone 1 is the medial half of the medial plateau, Zone 2 is the lateral-half of the tibial plateau, Zone C is the area of the tibial spines,

Fig. 2 Long-leg radiograph reveals a well-functioning bi-UKA at 10 years followup. bi-UKA = UKA = bicompartmental unicompartmental knee arthroplasty.

and Zone 3 is the medial part of the lateral plateau [25]. Furthermore, progression of OA was evaluated in the nonresurfaced compartment on AP radiographs and in the patellofemoral joint on skyline radiographs [8]. The Ahlback classification was used to evaluate OA progression in the medial or femoropatellar compartment [1].

Patient demographics were described using means and standard deviations or medians and ranges for continuous variables and counts (percent) for categorical variables. A descriptive report of the radiographic outcomes was performed using means and standard deviations to describe pre- and postoperative alignment. Survival analysis was performed using the Kaplan-Meier technique (with 95% confidence intervals) for all patients considering revision for any reason or radiographic loosening as the end point [24]. Analysis was performed using SPSS software (Version 12; SPSS Inc, Chicago, IL). All calculations assumed two-tailed tests.

Results

Bicompartmental arthroplasty reliably alleviated pain and improved the Knee Society knee and function scores, respectively, improved from 44 ± 6 (range, 25–64) to 88 ± 2 (range, 65–100) and from 38 ± 8 (range, 14–65) to 84 ± 10 (range, 59–100) in the bi-UKA group and in the med-UKA/PFA group; and from 42 ± 8 (range, 17–59) to 88 ± 2 (range, 58–100) and from 35 ± 9 (range, 10–57) to 79 ± 15 (range, 58–100). In the bi-UKA group, the mean active knee flexion improved from 112° ± 5° (range, 100°–145°) preoperatively to 136° ± 4° (range, 117°–149°) at final followup. In the med-UKA/PFA group, the mean active knee flexion improved from 118° ± 9° (range, 100°–150°) preoperatively to 134° ± 6° (range, 120°–153°) at final followup.

Bicompartmental arthroplasty demonstrated mixed results in regard to durability with a 17-year survival to revision, radiographic loosening, or disease progression of 78% (95% confidence interval, 0.73–0.83) in the bi-UKA group and 54% (95% confidence interval, 0.47–0.61) in the med-UKA/PFA group (Fig. 3A–B). Twenty-five knees (15.5%) showed radiolucencies (less than 1 mm) at the tibial bone-cement interface without any sign of progression after 5 years of followup. No femoral radiolucencies were observed.

The mechanical axis of the lower limb was correct and stable at last followup (Table 3). At last followup, the mean AP axis of the tibial component was 89° ± 3° (range, 85°–90°) on the medial side and 90° ± 2° (range, 88°–93°) on the lateral side. Mean tibial slope was 3° ± 4° (range, 0°–8°). The mean AP femoral axis was 92° ± 7° (range, 86°–94°).

At last followup, 14 knees were asymptomatic (without any change in the clinical score) OA progression in the patellofemoral compartment in the bi-UKA group and six knees presented isolated asymptomatic OA progression in the lateral compartment in the med-UKA/PFA group.

In four cases in the bi-UKA group, avulsion of the anterior tibial spine was observed intraoperatively, requiring intraoperative fixation using nonabsorbable suture without adverse effects on the final outcome. No other intraoperative complications were observed. Twelve patients had postoperative deep venous thromboses and were treated with a therapeutic dose of fractioned heparin in the 1970s and 1980s and with low-molecular-weight heparin later. In the bi-UKA group, 17 knees underwent a revision at a mean of 6.5 years (range, 9 months to 12 years), 16 for aseptic loosening and one for a symptomatic progression of OA in the patellofemoral compartment. Among the 16 aseptic loosening cases, eight involved loosening of both the medial and lateral implant, five of the medial implant and three of the lateral one. The failures were related to polyethylene wear and loosening of the tibial plateau for all the cases in the lateral and in the medial sides. Most of the revised patients (13 of 16) were operated on before 1989. Ten knees were revised using a conventional posterostabilized TKA with a tibial stem and eight knees with a hinged prosthesis. One knee was revised for progression of OA in the patellofemoral compartment at 10 years by addition of a patellofemoral implant with a good result at final followup of 15 years. In the med-UKA/PFA group, 28 knees underwent revision, 27 for aseptic loosening at a mean of 7.9 years (range, 11 months to 22 years) and one knee for septic loosening at 4 months. Among the 27 aseptic loosening cases, 20 knees had an isolated loosening of the patellofemoral implant and seven knees had loosening of the medial UKA related to PE wear and loosening of the tibial plateau. Among the 20 loosening of the patellofemoral implant, 15 were uncemented PFA performed before 1989 and five were cemented. Revisions were performed using a conventional postero-stabilized TKA with tibial stem and augments when required (Fig. 4A–D). The knee with septic loosening required a two-stage revision.

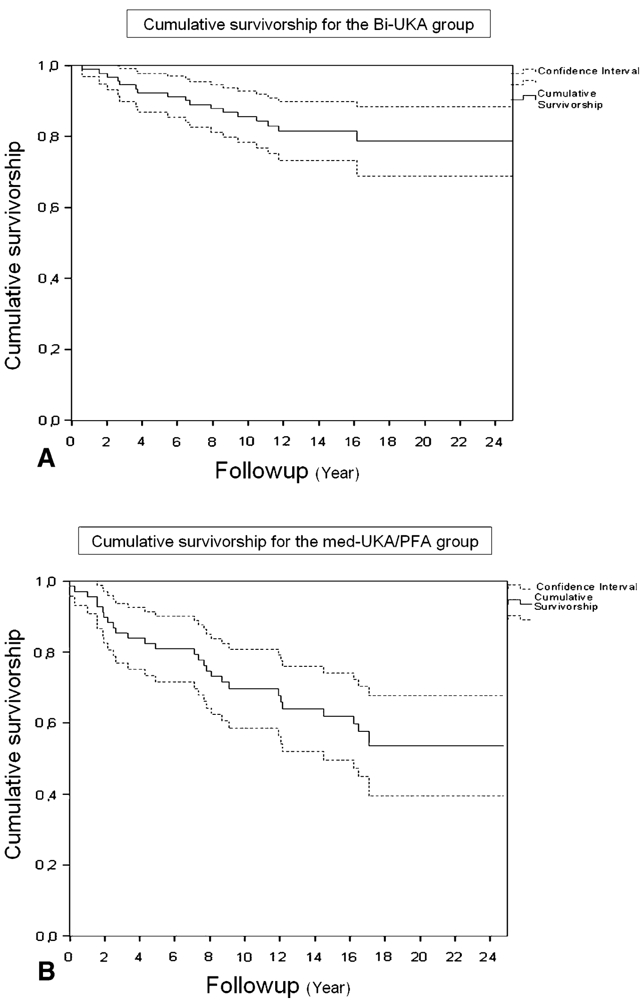

Fig. 3A–B Kaplan-Meier survivorship analysis curves with revision for any reason as the end point are shown. (**A**) The 17-year survivorship was 0.78 (95% confidence interval, 0.73–0.83) in the bi-UKA group and (**B**) 0.58 (95% confidence interval, 0.47–0.61) in the med-UKA/PFA group. UKA = unicompartmental knee arthroplasty; bi = bicompartmental; med = medial.

Discussion

Bicompartmental arthroplasty has been advocated as an alternative to TKA for limited arthritis of the knee to preserve bone stock and restore more normal kinematics [14, 16–18]. As a result of these potential advantages over TKA, there is a renewed interest for combined compartmental implants, including combined medial UKA and femoropatellar arthroplasty and combined medial and lateral UKA [14, 16–18]. To confirm the durability of bicompartmental arthroplasty observed in the historical series [20], and considering short-term objective and subjective functional improvements recently reported after combined bicompartmental implants [16, 18, 30], we asked whether (1) bicompartmental arthroplasty (either combined medial UKA and femoropatellar arthroplasty or combined medial and lateral UKA) reliably improved Knee Society pain and function scores; (2) bicompartmental arthroplasty was durable (survivorship with the end points of revision, radiographic loosening, or symptomatic disease progression); and (3) we could achieve durable alignment; and (4) whether arthritis would progress in the unresurfaced compartment.

Table 3. Pre- and postoperative radiologic results in the two groups

Variable	Bi-UKA group		Med-UKA/PFA group	
	HKA angle (mean ± SD, range)	Kennedy classification	HKA angle (mean, range)	Kennedy classification
Preoperative evaluation	176° ± 5° (170°–180°)	NA	178° ± 4 (174°–181°)	NA
Postoperative evaluation at 1 year	178° ± 3° (174°–181°)	Kennedy 2: 36	179° ± 4° (177°–182°)	Kennedy 2: 31
		Kennedy C: 64		Kennedy C: 46
Postoperative evaluation at last followup	178° ± 4° (175°–182°)	Kennedy 2: 36	179° ± 4° (175°–182°)	Kennedy 2: 31
		Kennedy C: 64		Kennedy C: 46

UKA = unicompartmental knee arthroplasty; Bi = bicompartmental; Med = medial; HKA = hip-knee-ankle angle; SD = standard deviation; NA = not applicable.

Fig. 4A–D (**A**) One-year postoperative long-leg radiograph reveals a well-functioning right knee with a combined medial-UKA and PFA. (**B**) A 12-year postoperative long-leg radiograph confirms the well-functioning status of the same combined medial-UKA and PFA. (**C**) Anteroposterior radiograph shows substantial wear and loosening of the medial-UKA requiring a revision at 22-year followup. (**D**) Revision was performed using a conventional posterostabilized TKA with a tibial stem. UKA = unicompartmental knee arthroplasty.

We note some limitations in our study design. First, we included different types of implants performed during a long time period with a major evolution in both the instrumentations and the implants over that time. These data include patients in whom we used relatively crude techniques and early-generation components no longer in use. Second, we did not match our patients with patients operated for a TKA during the study period to directly compare the results of TKA and those of bicompartmental arthroplasty. Third, we were also unable to perform a contemporary evaluation of the functional results including a subjective evaluation using a knee-related quality-of-life questionnaire (such as the Knee Osteoarthritis Outcomes Score) [28, 31] and an objective functional evaluation tool such as gait laboratory analysis or three-dimensional fluoroscopy because most of these methods of evaluation were not available at the time of the early operations [7, 16–18, 27]. Despite these limitations, we report a relatively homogenous and continuous series of patients operated on in the same department for either a combined medial and lateral UKA or a combined medial UKA and patellofemoral arthroplasty by the same two senior authors (JMA, JNA) using a cemented metal-backed implant for the UKA and the same patellofemoral implant.

One of the primary aims of bicompartmental arthroplasty is to restore more normal knee kinematics and function by preserving the bone and the ligaments of the patient [7, 10, 16–18, 30]. In fact, this bone and ligament-sparing technique can be considered minimally invasive surgery, not only for the skin and the muscular tissue, but also for the structures inside the knee [7, 10, 16–18, 30]. This is confirmed by our data observed in the series of bicompartmental arthroplasty reported in the literature (Table 4) [7, 10, 14, 17, 20, 34]. According to kinematic and gait studies, knees with biunicondylar arthroplasty can provide excellent functional outcomes in appropriately selected patients close to those observed with UKA. One study [20] suggests results are better for patients with preserved cruciate ligaments, and in our series, preserved cruciate ligaments was one of the most important criteria to

Table 4. Results of the different series of bicompartmental arthroplasty in the literature

Study	Number of implants	Type of implant	Methods of evaluation	Clinical results	Followup mean (minimum to maximum)	Survivorship (number of revisions)
Goodfellow and O'Connor [20] (1986)	114	Combined medial and lateral UKA	Clinical and radiographic	Pain relief = 90% Flexion = 90°	49 months 2 to 6 years	88.5% at 6 years (8)
Stewart and Newton [34] (1992)	156	Combined medial and lateral UKA	Clinical and radiographic	NA	NA 1 to 13 years	43% at 12 years (34)
Fuchs et al. [17] (2003)	15	Combined medial and lateral UKA	Clinical and proprioceptive analysis	KSS = 169.7	31.9 months 7 to 70 months	100 at 31.9 months (0)
Banks et al. [7] (2005)	5	Combined medial and lateral UKA	Fluoroscopic 3-D Gait analysis	Dynamic flexion = 123°	NA	NA
Engh [14] (2007)	NA	Monobloc combined medial UKA and PFA	NA	NA	NA	NA
Confalonieri et al. [10] (2008)	22	Combined medial and lateral UKA	Clinical and radiographic	KSKS = 80 points KSFS = 83 points	42 months 36 to 48 months	100 at 48 months (0)
Parratte et al. [current study]	100 bi-UKA 77 medial-UKA/PFA	Three designs of UKA and one design of PFA	Clinical and radiographic	Bi-UKA KSKS = 88 KSFS = 84 Medial-UKA/PFA KSKS = 88 KSFS = 79	12 years 5 to 23 years	78% at 17 years (17) 54% at 17 years (28)

UKA = unicompartmental arthroplasty; mi = bicompartmental; 3-D = three-dimensional; NA = not applicable; KSS = Knee Society Score; KSKS = Knee Society Knee Score, KSFS = Knee Society Function score.

confirm the indication of bicompartmental arthroplasty. Our data and that in the literature confirm that bicompartmental arthroplasties could be proposed as an alternative to TKA [10]. To date, there are limited outcome data to our knowledge reporting the short-, mid-, or long-term outcomes of bicompartmental arthroplasty and no report of combined medial UKA with patellofemoral implant. The concept of a new monobloc bicompartmental implant combining a medial UKA and a patellofemoral implant has been recently described but there are no outcome data available yet [14, 30].

Survivorship to revision at 17 years was lower than observed for TKA or UKA in both groups. We observed a relatively high revision rate, particularly concerning the med-UKA/PFA group. This high revision rate may be related to early generations of implants. The results may be improved with enhanced instrumentation and techniques, better PE, and contemporary designs. Furthermore, at the beginning of the experience, no instrumentation was available for surgical guidance. In case of failure, bone stock was preserved and revision considered easier than a revision performed after TKA. In the med-UKA/PFA group, failure was related to the patellofemoral implant for 20 knees of 27 revised for aseptic loosening. Improvement in implant design and fixation may improve these results in the future, particularly concerning the patellofemoral joint. In our study, only one patient in the bi-UKA group underwent revision for symptomatic OA progression in the patellofemoral compartment. This relatively low rate of symptomatic OA progression is probably related to proper preoperative screening, particularly concerning the patellofemoral compartment. If careful clinical screening and stressed radiography remain the key points for patient selection, quantitative evaluation of the cartilage status using modern dedicated tools such as T2 mapping may be helpful in the future to optimize patient selection [26].

Due to renewed interest in bicompartmental arthroplasty, we report our mid- and long-term results of combined medial and lateral UKA and combined medial UKA and patellofemoral arthroplasty. Our data suggest this concept improves function and restores limb alignment restoration for moderate deformities. A relatively high revision rate was observed compared to TKA series and these failures may be related to early generation of implant and limited instrumentation. In contrast, we observed few cases of progressive OA confirming the indication for bicompartmental arthroplasty in case of bicompartmental arthritis of the knee. We believe partial knee replacement with less bone loss and the potential for greater function an important concept. The concept with new implants and appropriate instrumentation will require confirmation using contemporary objective tools to confirm its usefulness.

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