The Journal of Arthroplasty xxx (2017) 1–8

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Mid-Term Clinical, Functional, and Radiographic Outcomes of 105 Gender-Specific Patellofemoral Arthroplasties, With or Without the Association of Medial Unicompartmental Knee Arthroplasty

Sergio Romagnoli, MD, Matteo Marullo, MD *

Joint Replacement Department, IRCCS Istituto Ortopedico Galeazzi, Milano, Italy

ARTICLE INFO

Article history:
Received 18 August 2017
Received in revised form
10 October 2017
Accepted 13 October 2017
Available online xxx

Keywords:
patellofemoral osteoarthritis
patellofemoral replacement
bicompartmental replacement
knee osteoarthritis
knee replacement
anterior cruciate ligament sparing surgery

ABSTRACT

Background: The purpose of this study is to evaluate clinical and radiographic outcomes after gender-specific patellofemoral arthroplasty (PFA) either isolated or combined with unicompartmental knee arthroplasty (UKA).

Methods: A total of 105 PFAs in 85 patients were reviewed: 64 knees had isolated patellofemoral osteoarthritis and received an isolated PFA, and 41 knees with bicompartmental osteoarthritis were treated with medial UKA and PFA. Preoperative and postoperative clinical and functional assessment included knee range of motion, Knee Society Score, University of California Los Angeles Activity Score, Tegner Activity Level Scale, and visual analogue scale pain. Preoperative and postoperative radiographs were evaluated for patellofemoral and tibiofemoral compartment osteoarthritis, trochlear dysplasia, changes in patellar height, and signs of osteolysis.

Results: At a mean follow-up of 5.5 ± 1.6 years, both groups showed improvement in knee joint range of motion ($P < .001$), clinical and functional Knee Society Score ($P < .001$), University of California Los Angeles Activity Score ($P < .001$ in the PFA group and $P = .004$ in the UKA + PFA group), and visual analogue scale pain ($P < .001$). There were no statistically significant postoperative differences between the 2 groups. No signs of osteolysis or subsidence were recorded. Survivorship of these 105 implants was 95.2%.

Conclusion: Excellent clinical and radiographic outcomes were achieved after PFA with a gender-specific implant both as isolated replacement and when combined with medial UKA. Bicompartmental replacement with small implants can be considered in patients with bicompartmental osteoarthritis and intact anterior cruciate ligament.

The treatment of patellofemoral osteoarthritis (OA) remains challenging. The early implant designs of patellofemoral arthroplasty (PFA) prostheses were burdened by suboptimal clinical outcomes and relatively high failure rates [1,3]. With the extended knowledge of patellofemoral biomechanics and development of more anatomical PFA designs, better clinical results and survival rates are now achieved [4–10]. Ultimately, PFA may replace total knee arthroplasty (TKA) in the treatment of isolated end-stage patellofemoral OA. Yet, TKA remains the preferred solution in end-stage bicompartmental disease of the knee. TKA offers reliable and long-lasting results in more than 85% of patients, although their satisfaction does not always meet expectations [11]. TKA sacrifices healthy compartments of the knee and one or both of the cruciate ligaments, altering normal knee kinematics and proprioception [12]. These theoretical disadvantages are particularly critical for younger, active, high-demand patients who wish to return to their previous levels of activity and who are at higher risk for potential knee joint revision surgery.

With the renewed interest in PFA, there is also a growing focus on bicompartmental knee arthroplasty (BKA) for treating end-stage medial or lateral tibiofemoral OA and patellofemoral OA with a

Funding: This work was supported by the National Institute of Health [codice progetto RC L2034/2015].

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to https://doi.org/10.1016/j.arth.2017.10.019.

* Reprint requests: Matteo Marullo, MD, Joint Replacement Department, IRCCS Istituto Ortopedico Galeazzi, Via R. Galeazzi 4, Milano 20161, Italy.

https://doi.org/10.1016/j.arth.2017.10.019

unicompartmental knee arthroplasty (UKA) in combination with a PFA. This combined approach permits preservation of all the ligaments of the knee and minimal bone excision. Outcome and kinematic studies have demonstrated that maintaining the anterior cruciate ligament could be advantageous for joint kinematics, stair climbing ability, and patient satisfaction [13–16]. Given the affirmative short-term and mid-term results of several series of BKA, there are grounds for considering BKA a viable alternative to TKA in appropriately selected patients [13,14,16–18].

The aim of this study is to evaluate the clinical and radiographic mid-term outcomes in a consecutive series of patients receiving patellofemoral replacement with a gender-specific, third-generation PFA prosthesis either isolated or in combination with UKA. The hypothesis was that PFA would result in improved clinical and functional outcomes compared to preoperative baseline in patients treated with an isolated procedure as well as in those treated with concomitant medial UKA for concomitant medial tibiofemoral OA.

Materials and Methods

The study was approved by the Ethical Committee of our institution. Each patient signed an informed consent to be included in the study. The medical records of patients who had undergone primary isolated or combined PFA at our institution between 2007 and 2012 were reviewed. Inclusion criteria were PFA or BKA performed with a gender-specific PFA prosthesis, availability of complete preoperative and postoperative X-rays, completeness of patients' medical records, and postoperative follow-up of at least 2 years.

Of the total 145 PFAs, a third-generation PFA prosthesis with a gender-specific design (Zimmer Gender Solutions PFJ; Zimmer Inc, Warsaw, IN) was implanted in 108 consecutive cases (88 patients). Two patients died and 1 was lost before the end of the minimum 2-year follow-up period, leaving 85 patients (105 knees) available for evaluation. Of these 105 knees, 64 knees had isolated patellofemoral OA and were treated with isolated PFA (group 1), and 41 knees had bicompartmental OA and were treated with combined medial UKA and PFA (group 2).

The indications for isolated PFA were symptomatic isolated patellofemoral OA (Iwano grade 2 or greater), primary or secondary to malalignment/dysplasia or trauma, and absence of tibiofemoral arthritis (Kellgren-Lawrence 2 or lower) [19,20]. The indications for UKA + PFA were patellofemoral OA (Iwano grade 2 or greater) and either symptomatic tibiofemoral OA (Kellgren-Lawrence 3 or greater) or varus malalignment (mechanical axis <177°), with faintly symptomatic tibiofemoral OA (Fig. 1).

Contraindications to PFA or BKA were OA of both tibiofemoral compartments; a clinically instable knee in the frontal or sagittal plane; a preoperative range of motion (ROM) less than 90°; flexion contracture greater than 10°, and inflammatory disease.

Table 1 presents the characteristics of both groups. Comparison between groups pointed out that there was a substantial prevalence of women in group 1 compared to group 2 (85.4% vs 75.7%); consequently, the mean patients' weight in group 1 was lower than the one of patients in group 2. The higher prevalence of women in Group 1 was a consequence of the higher prevalence of isolated patellofemoral OA in women compared to men and it was in line with other series of PFA presented in literature [1,4–8,10]. The creation of these 2 groups wanted to point out the results of this gender-specific PFA in 2 different patterns of knee OA: isolated patellofemoral OA with a high prevalence of women and bicompartmental OA with a gender distribution more similar to the one of the population candidate to TKA.

Simultaneous bilateral procedures were performed in 31 patients: 14 bilateral PFAs, 4 bilateral BKAs, 2 PFA and BKA on the other knee, 1 PFA and UKA on the other knee, 7 BKA and UKA on the other knee, 2 BKA and total knee replacement on the other knee, and 1 PFA and ipsilateral total hip replacement.

Implants

A third-generation PFA prosthesis with a gender-specific design was implanted in all 105 knees. This PFA prosthesis has an asymmetric left-right onlay design with a wide trochlear groove angle to accommodate the documented anatomical difference between male and female knees in trochlear obliquity according to the femoral axis [21,22]. Moreover, the anterior flange has a thinner profile to reduce overhang or overstuffing and it extends proximally to improve patellofemoral contact also in cases of patella alta. Five different implant sizes are available for each side, with increments of 4-5 mm in mediolateral width. Female design characteristics are applied to smaller sizes (1-4), while the larger size implant is designed to match male knees.

When a concomitant UKA was performed (41 knees), an Allegretto unicompartmental prosthesis (Zimmer) was used in 28 knees and a Zimmer unicompartmental High Flex Knee System prosthesis (Zimmer Inc) in 13. All UKA implants had a metal-backed tibial baseplate.

Surgical Technique and Rehabilitation

A single orthopedic surgeon performed all surgeries using a medial parapatellar skin incision and a mini-midvastus approach without applying a tourniquet. In isolated PFA, care must be taken not to extend the arthrotomy too distally to avoid injury to the medial meniscus. After exposure of the knee, the indication for PFA or BKA has to be confirmed, otherwise a TKA is performed.

When a BKA was performed, UKA should be implanted first in order to correct any coronal misalignment and rebalance the forces on the patellofemoral joint. UKA should be performed with the same technique as the isolated procedure, aiming for kinematic alignment in the coronal plane and a slight undercorrection of the coronal deformity. Once the UKA trial implant is in place, patellofemoral replacement can start.

The surgical technique for PFA is the same as that described above whether it is performed isolated or in combination with UKA. As it has an onlay design, the first bone cut is to the trochlear bone. The anterior femoral cut is made perpendicular to the sagittal axis of the joint. When the trochlear sulcus is present, drawing Whiteside's line is helpful to identify the sagittal axis. In patients with primary arthritis, the thickness of the femoral implant should replace the amount of bone and cartilage removed plus any cartilaginous wear. In patients with concomitant trochlear dysplasia, the lateral facet height must be recreated by the prosthesis, undercutting the lateral facet. This can be done only by using an onlay PFA design. An anterior cut in slight external rotation is desirable in high-grade trochlear dysplasia to accommodate for the abnormally tight lateral retinaculum and abnormally lax medial retinaculum. In any case, internal rotation should be avoided. After the anterior cut is made, a dedicated milling guide of the appropriate size is placed such that its distal aspect is flush with the articular cartilage both medially and laterally and its mediolateral width covers the entire trochlea. The implant should not overhang mediolaterally so as to prevent soft tissue impingement that could cause pain. A high-velocity cutter removes a minimal amount of bone and creates the bed for the prosthesis. Accurate preparation of the width and depth of this area is of paramount importance to avoid any step in the cartilage-prosthesis transition zone, which could create patellar impingement and clunks. The final step is realized with an appropriate guide hole for the implant stems. The patella is then everted

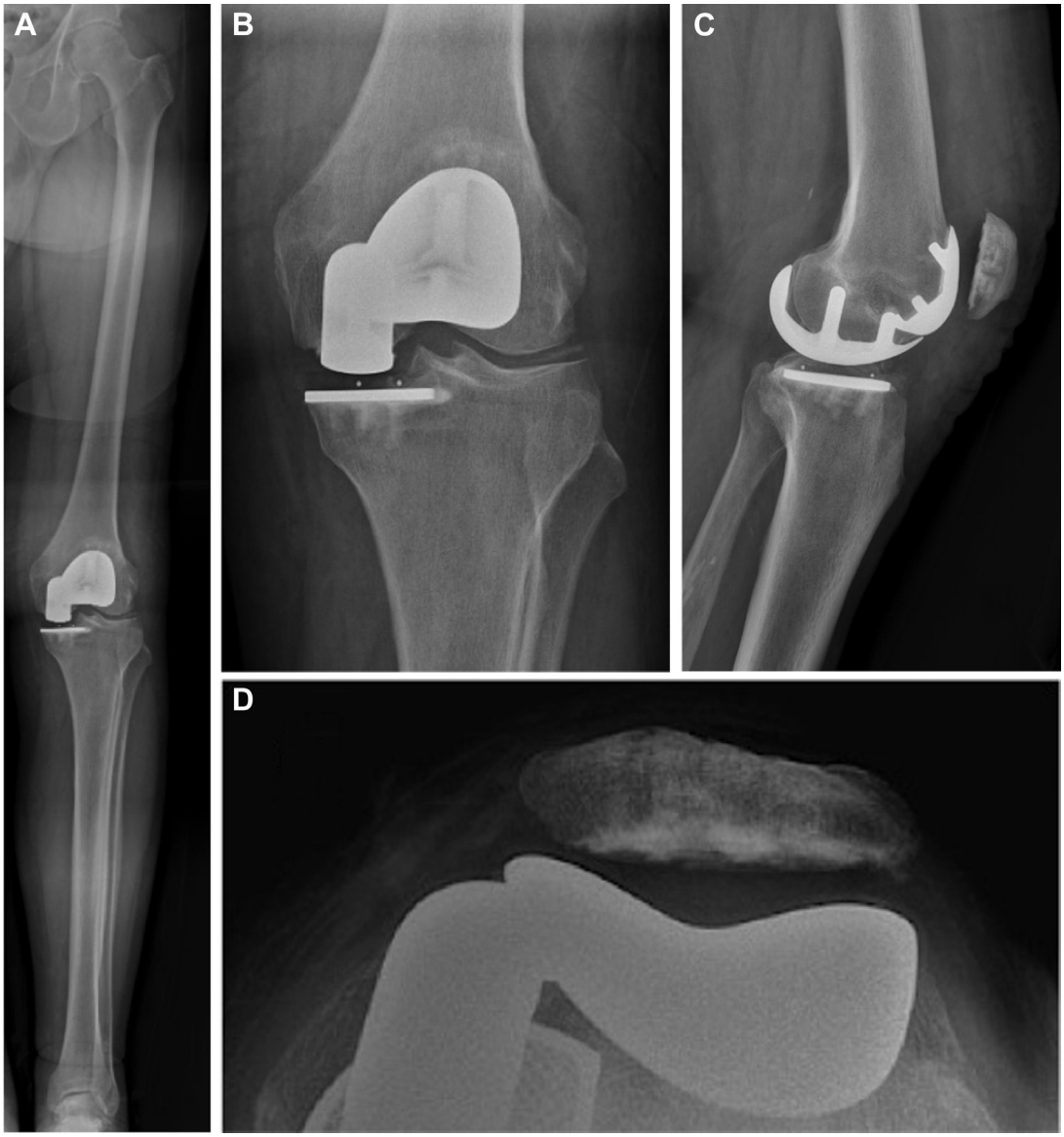

Fig. 1. Bicompartmental replacement. Long-standing whole-leg (A), anteroposterior (B), lateral (C), and sunrise radiographs (D) of a 66-year-old man 1 year after medial unicompartmental and patellofemoral replacement.

and resurfaced. The patella was always resurfaced in order to recreate the native patellar thickness. Intraoperative assessment of patellar tracking was done during trialing and again after cementation. The patella should be centered into the trochlea during the whole ROM, without any tilting, clunking, or subluxation. Cementation starts from the UKA implant and then the PFA.

Patients began progressive weight bearing the day after surgery. Passive and active ROM is initiated within 24 h of surgery. Patients

Table 1
Demographic Characteristics of the Entire Patient Population and the 2 Groups.

Variables	Overall	PFA (Group 1)	UKA + PFA (Group 2)	*P* Value
Age (y)	67.7 ± 10.6 (39-88)	66.8 ± 12.0 (39-86)	68.8 ± 8.5 (53-88)	.11
Weight (kg)	74.5 ± 13 (48-100)	71.5 ± 12 (48-100)	78.7 ± 13 (56-100)	.03
Height (cm)	164 ± 7 (148-188)	164 ± 8 (150-185)	164 ± 7 (148-188)	.71
BMI (kg/m^2)	27.5 ± 4.4 (18.7-41.1)	26.4 ± 3.9 (18.7-36.0)	28.9 ± 4.6 (21.3-41.1)	.05
Gender distribution (%)				
Female	69 (81.1%)	41 (85.4%)	28 (75.7%)	.004
Male	16 (18.9%)	7 (14.6%)	9 (24.3%)	
Side number (%)				
Right	63 (60%)	36 (56.2%)	27 (65.8%)	
Left	42 (40%)	28 (43.8%)	14 (34.2%)	.005

Age, weight, height, and BMI are given as mean ± SD (range). Gender distribution and side number are expressed in absolute values and percentages.
BMI, body mass index; SD, standard deviation.

are typically discharged from the Orthopedic Department on postoperative day 2, after demonstrating the ability to ambulate alone with the aid of crutches and flex the knee at least 90°.

Clinical and Radiographic Evaluation

Patients' records were examined for the following variables: gender, age at surgery, body mass index (weight in kilograms divided by the square of the height in meters), preoperative and postoperative knee ROM, and pain measured using a visual analogue scale (VAS). Preoperative and postoperative clinical and functional evaluation was done with the Knee Society clinical and functional rating system [23]. Knee Society scores were calculated from routine examinations performed preoperatively, 6 and 12 months postoperatively, and yearly thereafter. To evaluate the sports-related outcome, the University of California Los Angeles Activity score and the Tegner Activity Levels were obtained retrospectively from patient records [24,25]. Patient satisfaction with the procedure was assessed at the last follow-up and classified as very satisfied, satisfied, the same, dissatisfied, and very dissatisfied.

Revision of the prosthesis or replacement of any other compartment was considered as failure of the implant.

All radiological data were evaluated and calculated digitally (Picture Archiving Communication Systems, Philips Medical Systems; Sectra-Imtec AB, Linköping, Sweden) by a single author who was not a participating surgeon. Preoperative and postoperative radiographic evaluation included a full-leg standing radiograph, a standing posterior-anterior radiograph of both knees at 45° of knee flexion (Rosenberg view), a true lateral view, and a 30° patellar axial view. The shape of the patella was assessed using the Wiberg classification [26]. Preoperative and postoperative patellar height was assessed using the Caton-Deschamps Index [27]. The Dejour classification method was used to determine whether trochlear dysplasia was present and its grade [28]. The grade of patellofemoral OA was assessed using the Iwano classification system [19]. The tibiofemoral joint was evaluated preoperatively using the Kellgren-Lawrence classification system [20]. Preoperative radiographic data are presented in Table 2.

The whole-leg mechanical axis was calculated on a digital long-standing hip-knee-ankle radiograph by drawing an angle formed by a line from the center of the femoral head to the center of the knee and a second line from the center of the knee to the center of the talus. Lower limbs with a mechanical axis less than 180° were categorized as having varus alignment, and those with a mechanical axis greater than 180° were categorized as having valgus alignment. Implant-related radiographic results were based on comparison of the first through to last follow-up radiographs, assessing periprosthetic radiolucency, implant subsidence, or loosening.

Statistical Analysis

Data were analyzed using SPSS software version 22.0 (IBM-SPSS, Armonk, NY). Mean values ± standard deviation and range are reported for quantitative normally distributed measurements. For non-normally distributed data, the median with interquartile range (from 25th to 75th percentile) is reported. Student's paired t-test or the non-parametric Wilcoxon test, in case of not normally distributed values, was used to compare the preoperative and postoperative values within each group. Student's t-test or the non-parametric Mann-Whitney *U* test for independent samples was used to compare patient characteristics, follow-up, clinical scores, and radiographic data between the 2 groups. All statistical tests were performed 2-sided. Statistical significance was set at $P < .05$. An a priori power analysis was performed to guarantee statistical power not lower than 80%.

Table 2
Preoperative Radiographic Evaluation of the Overall Population and the 2 Groups.

Variables	Overall	PFA (Group 1)	UKA + PFA (Group 2)
Patellar OA, Iwano grade			
Grade 1	4 (3.8%)	2 (3.1%)	2 (4.9%)
Grade 2	21 (20.0%)	10 (15.6%)	11 (26.8%)
Grade 3	22 (20.9%)	12 (18.7%)	10 (24.4%)
Grade 4	58 (55.3%)	40 (62.5%)	18 (43.9%)
Patellar shape, Wiberg classification			
Type 1	32 (30.5%)	16 (25%)	16 (39.0%)
Type 2	54 (51.4%)	34 (53.1%)	20 (48.8%)
Type 3	19 (18.1%)	14 (21.9%)	5 (12.2%)
Trochlear dysplasia, Dejour classification			
None	45 (42.8%)	26 (40.6%)	19 (46.4%)
Type A	32 (30.4%)	22 (34.4%)	10 (24.4%)
Type B	16 (15.2%)	7 (10.9%)	9 (21.9%)
Type C	8 (7.6%)	5 (7.8%)	3 (7.3%)
Type D	4 (3.8%)	4 (6.3%)	0 (0%)
KL lateral			
Grade 1	73 (69.5%)	38 (59.4%)	35 (85.4%)
Grade 2	29 (27.6%)	24 (37.5%)	5 (12.2%)
Grade 3	3 (2.9%)	2 (3.1%)	1 (2.4%)
Grade 4	0 (0%)	0 (0%)	0
KL medial			
Grade 1	43 (40.9%)	41 (64.1%)	2 (4.9%)
Grade 2	31 (29.5%)	21 (32.8%)	10 (24.4%)
Grade 3	22 (21.0%)	2 (3.1%)	20 (48.8%)
Grade 4	9 (8.6%)	0 (0%)	9 (21.9%)

Iwano grade, Wiberg classification, KL grade of the medial and lateral tibiofemoral compartment, and trochlear dysplasia according to Dejour's classification are expressed as absolute values and percentages.
KL, Kellgren-Lawrence grading system.

Results

The mean follow-up was 5.5 ± 1.6 years (range 3-8). The clinical and radiographic results are shown in Table 3. Overall, statistically significant improvements ($P < .01$) were observed for knee joint ROM (112.3° vs 124.6°), clinical Knee Society Score (KSS) (62.7 vs 92.0), functional KSS (59.1 vs 85.2), VAS pain score (from a median of 8 to 1), and University of California Los Angeles Activity score (from a median of 4 to 5). For the same parameters, statistically significant improvements ($P < .01$) were observed even in both groups. A statistically significant improvement ($P = .001$) for the Tegner Score was noted only in group 1. No statistically significant differences in clinical variables between the 2 groups were observed at the final follow-up. There was a statistically significant decrease in patellar height in both groups ($P < .001$). The hip-knee-ankle angle changed only in group 2 after correction of the coronal deformity due to UKA implantation ($P < .001$). No loosening or subsidence of the implants or signs of osteolysis were recorded.

At a mean follow-up of 5.5 ± 1.6 years, 5 prostheses failed, yielding an overall survival rate of 95.2%. Three (4.6%) isolated PFA failed: 1 due to wrong indication (rheumatoid arthritis), revised with TKA 2.4 years after the index operation; because 1 isolated PFA (Fig. 2) showed progression of arthritis in the medial compartment, a medial UKA was performed 4.3 years after the index operation. One isolated PFA was revised with TKA 3.0 years after the index operation at another hospital due to anteroposterior instability consequent to a fall. Two BKA (4.8%) were revised with TKA at other hospitals; one 7.5 years after the index operation due to aseptic loosening of the UKA tibial component, and the other 3.3 years after due to unexpected pain.

Of the 85 patients (105 knees) asked about their satisfaction with outcome at the final follow-up, 70 (82.4%) stated they were very satisfied, 8 (9.4%) were satisfied, 4 (4.7%) were undecided, and 3 (3.5%) were dissatisfied. There were no differences in satisfaction rates between the 2 groups. All 3 patients who expressed dissatisfaction underwent complete revision for implant failure.

Table 3
Postoperative Clinical, Functional, and Radiographic Data of the 2 Groups and the Entire Patient Population.

	Overall		*P* Value	Group 1 (PFA)		*P* Value	Group 2 (UKA + PFA)		*P* Value
	Preop	Postop		Preop	Postop		Preop	Postop	
ROM	112.3 ± 15.6	124.6 ± 10.6	<.001	112.6 ± 17.6	125.4 ± 10.4	<.001	112.3 ± 11.2	123.3 ± 10.7	<.001
KSS Clinical	62.7 ± 11.1	92.0 ± 11.5	<.001	64.0 ± 12.2	92.9 ± 11.1	<.001	60.6 ± 8.5	90.4 ± 12.1	<.001
KSS Functional	59.1 ± 15.9	85.2 ± 15.0	<.001	59.9 ± 16.9	87.6 ± 13.7	<.001	57.7 ± 14.1	81.3 ± 16.4	<.001
VAS mean	7.5 ± 1.5	2.2 ± 1.7	<.001	7.4 ± 1.7	2.1 ± 1.6	<.001	7.7 ± 1.1	2.5 ± 2.0	<.001
VAS median	8 (2-10)	1 (1-7)	<.001	8 (2-10)	1 (1-7)	<.001	8 (5-9)	2 (1-7)	<.001
UCLA median	4 (2-7)	5 (2-9)	<.001	4 (2-7)	5 (3-9)	<.001	3 (2-6)	5 (2-9)	.004
Tegner median	2 (1-5)	3 (1-5)	<.001	2 (1-5)	3 (1-5)	.001	2 (1-4)	3 (1-5)	.166
Caton-Deschamps	1.01 ± 0.13	0.97 ± 0.12	<.001	1.02 ± 0.12	0.98 ± 0.10	.002	0.99 ± 0.14	0.94 ± 0.13	.006
HKA	179.4 ± 4.0	180.3 ± 3.2	.003	181.2 ± 2.8	181.1 ± 3.3	.091	176.5 ± 3.8	179.0 ± 2.5	<.001

ROM and HKA are given as degrees, mean ± SD. VAS is expressed as both mean ± SD and median ± IQR; UCLA activity and Tegner scores are expressed as median ± IQR. The Caton-Deschamps index is given as mean ± SD.
HKA, hip-knee-ankle angle; IQR, interquartile range; SD, standard deviation.

Discussion

The main finding of this study is that a gender-specific PFA prosthesis improves functional outcome and knee joint pain at a mean follow-up of 5.5 years both when used in an isolated procedure and when combined with medial UKA for concomitant medial tibiofemoral OA. No significant differences in any of the clinical or radiographic variables were found between the 2 groups. Both groups showed a postoperative decrease in the Caton-Deschamps Index, with no clinical consequences, and improvement in knee joint ROM, clinical and functional KSS, and VAS pain. Survivorship analysis showed an overall 95.2% implant survival rate at a mean follow-up of 5.5 years, which is in line with previous reports of isolated PFA [29–33].

Although PFA was introduced more than 30 years ago, it remained somewhat controversial until recently because of the high failure rates seen with early trochlear prosthesis designs. In general, early failures of all PFA implants were related to patellar maltracking or instability, whereas long-term failures were associated with progression of tibiofemoral OA [29,30,32,33]. Early failures were also due to errors in surgical technique or to problems stemming from the design of the trochlear component [30,31,33].

First-generation PFA implants were characterized by an inlay trochlear design. The trochlear component replaced the worn cartilage with highly conservative bone preparation and was positioned flush with the surrounding cartilage. In this way, the trochlear component had the same rotational alignment as the native one and a limited mediolateral and proximal coverage [30,31]. These implants were associated with poor clinical results and high failure rates [2,3,30,31].

The limitations of the early implants were overcome by the majority of second-generation PFA implants that have an onlay trochlear design based on the femoral anterior flange of total knee replacement, replacing the entire anterior trochlear surface [33,34]. Also, the trochlear components are wider and extend more proximal than the components of inlay PFA. This permits correction of some of the factors that largely contribute to patellofemoral instability (and consequent joint wear) without the need for any further surgery: trochlear dysplasia, lateral facet aplasia, and excessive distal femur extrarotation. Moreover, this approach increases reproducibility in placement, reducing technique-related surgical errors. These changes have reduced the incidence of many of the early complications like patellar maltracking, instability, or catching and snapping of the patellar component during knee flexion. In general, second-generation PFA implants have lower revision rates and higher functional scores compared to first-generation inlay-style prostheses [4,8,32,35].

The PFA prosthesis here reported had an onlay trochlear component that is wider and more proximally extended than the native trochlear edge. Moreover, the anterior flange has a thinner profile that reduces overhang or overstuffing and prevents catching or snapping of the patellar component during knee flexion. The proximally extended trochlear component improves patellar tracking also in patella alta, reducing or even eliminating the need for combined procedures like tibial tuberosity distalization.

The trochlear groove angle is wide, greater than 145° from 0° to 45° of knee flexion. This feature, associated with the 7° laterally oriented trochlear groove in the coronal plane, permits free transverse movement of the patella in knee extension and accommodates the anatomical differences between the male and the female knee in trochlear obliquity according to the femoral axis. This allows the replacement of trochlear grooves differing in size, trochlear obliquity, and trochlear angle with only 5 implant sizes. The first 4 sizes have female design features, while the larger size is designed to match male knees.

To our knowledge, this is the first study to compare a series of isolated PFA with a series of combined UKA + PFA using the same gender-specific PFA implant. Moreover, the BKA-treated group (41 knees) is one of the largest series reported so far.

TKA is the treatment of choice for bicompartmental OA. While TKA offers high survival rates and high functional scores, it sacrifices bone stock, the unaffected lateral compartment, and the anterior cruciate ligament, if not both cruciate ligaments. Because this alters the biomechanics of the replaced knee [17,36], TKA may be unacceptable for young patients who have higher functional demands and are at higher risk for potential revision. In contrast, preservation of both cruciate ligaments in BKA enhances stability, maintains proprioception, and a more physiological tibiofemoral kinematics [37]. Clinical consequences are greater comfort during everyday activities and better functional outcomes for BKA performed with the more recent PFA and UKA implants compared to TKA [16]. On the contrary, long-term follow-up showed high revision rate for BKA, even if long-term results are available only for BKA performed with first-generation PFA and UKA implants [18]. With these assumptions, BKA could bridge the gap between UKA and TKA, especially in younger, more active “high-demand” patients who may be eligible for this type of resurfacing surgery.

Importantly, BKA should be performed using unlinked and very versatile implants. Coronal alignment of the femur and morphology and orientation of the trochlear groove vary considerably from person to person in relation to gender, race, and morphotype [38]. Using only 2 unlinked UKA and PFA implants, it is possible to independently size and orientate the prosthetic components in each compartment and reproduce or correct the native anatomy of the femoral condyle and the trochlea. This is not possible when BKA

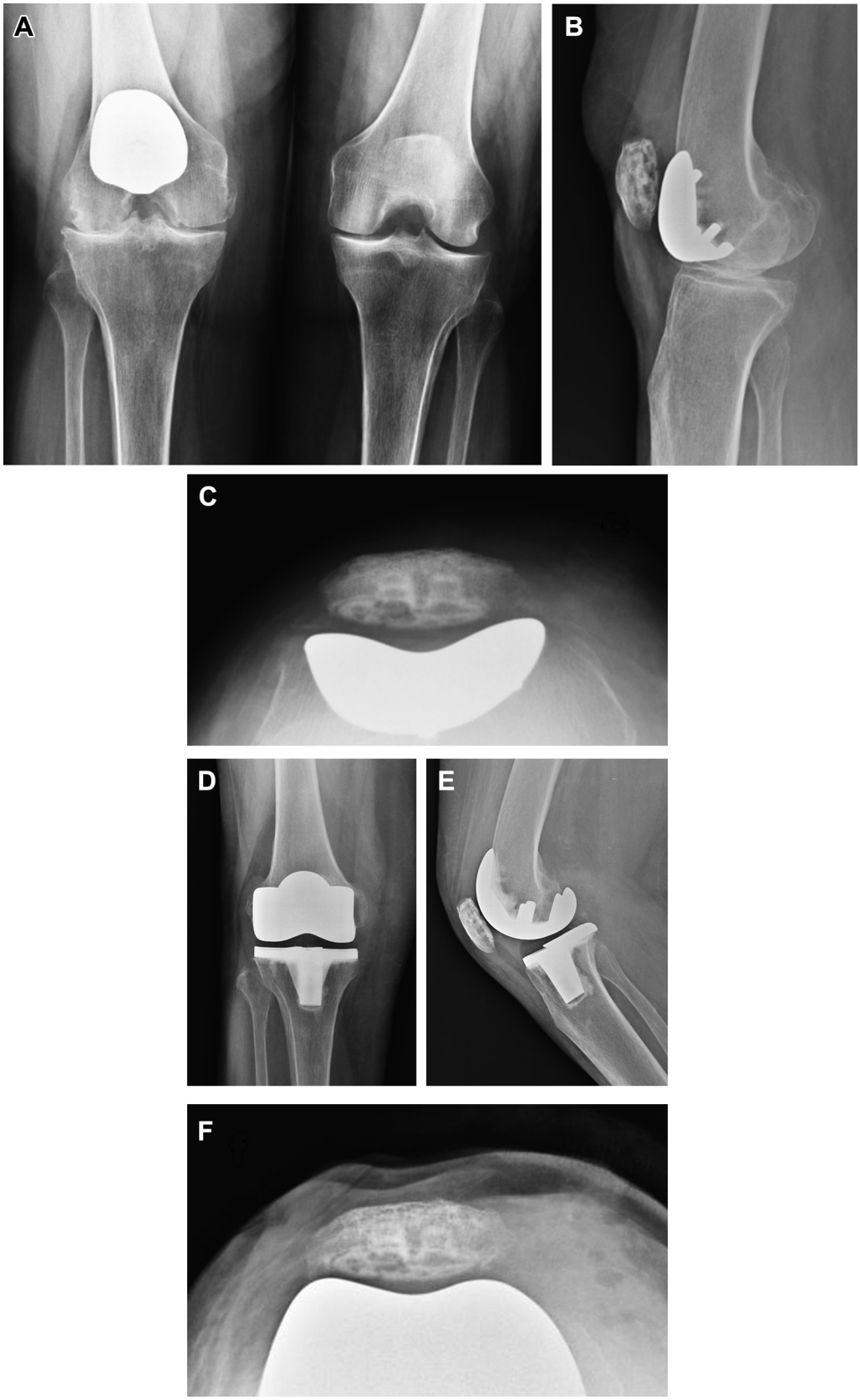

Fig. 2. Revision of an isolated PFA. Rosenberg's view (A), lateral (B), and axial views (C) of a right knee performed 2.4 years after patellofemoral replacement showed progression of tibiofemoral wear with stable and well-positioned PFA. The patient had diagnosis of rheumatoid arthritis. The PFA was removed, and a cruciate-retaining total knee arthroplasty was implanted. Anteroposterior (D), lateral (E), and axial views (F) of the right knee 1 year after revision showed the TKA stable and well positioned. PFA, patellofemoral arthroplasty; TKA, total knee arthroplasty.

is performed using a monolithic femoral implant because the varus-valgus alignment of the component is affected by apposition of the lateral transitional edge of the trochlear component with the lateral femoral condyle, and vice versa. This may compromise sizing and alignment of the condylar and/or trochlear portions of the prosthesis relative to the femoral mechanical axis. Consequent malalignment may affect the clinical results and survivorship of monolithic BKAs. Studies on this kind of prostheses have reported a high incidence of complications and revision for knee joint stiffness, patellar subluxation, and persistent anterior knee pain [14,39].

In our study, the BKA group also showed excellent clinical and functional results, with a clear reduction in knee joint pain and a high percentage of satisfied patients. Moreover, only 2 BKAs failed during the study period, yielding a 95.1% survival implant rate at a mean 5.5 years of follow-up, comparable to that of the isolated PFA group (95.4%). Previous studies have reported similar optimal clinical results with modular BKA at an even longer follow-up [16–18].

The limitations of this study are its retrospective design and the lack of long-term data for these patient cohorts. Its strengths are the examination of a consecutive series of patients operated on by a single surgeon using a single PFA implant and standardized technique, with radiographic review and near-complete follow-up. Furthermore, because the PFA implanted in our patients was released in 2007, we presented the longest follow-up on the topic with the largest sample of patients enrolled. The clinical and radiographic evaluation of this new PFA in combination with medial UKA in treating medial tibiofemoral and patellofemoral OA is another peculiarity of this study.

Conclusions

Patellofemoral replacement with a modern, gender-specific implant led to improvement in clinical and functional scores, an evident decrease in knee joint pain, and a high percentage of patient satisfaction. These excellent results were also achieved in patients with medial tibiofemoral and patellofemoral OA, who received PFA in combination with medial UKA. Survivorship analysis showed a 95.2% implant survival rate at a mean follow-up of 5.5 years, comparable with the most recent PFA implant design. If these mid-term results will be confirmed at longer term follow-up, BKA with small implants may become an alternative to TKA in younger, high demand patients.

References

[1] Mihalko WM, Boachie-Adjei Y, Spang JT, Fulkerson JP, Arendt EA, Saleh KJ. Controversies and techniques in the surgical management of patellofemoral arthritis. J Bone Joint Surg Am 2007;89:788–802.
[2] Tauro B, Ackroyd C, Newman J, Shah NA. The Lubinus patellofemoral arthroplasty: a five- to ten-year prospective study. J Bone Joint Surg Br 2001;83:696–701.
[3] van Wagenberg JMF, Speigner B, Gosens T, de Waal Malefijt J. Midterm clinical results of the Autocentric II patellofemoral prosthesis. Int Orthop 2009;33:1603–8. https://doi.org/10.1007/s00264-009-0719-z.
[4] Ackroyd CE, Newman JH, Evans R, Eldridge JDJ, Joslin CC. The Avon patellofemoral arthroplasty: five year survivorship and functional results. J Bone Joint Surg Br 2007;89:310–5.
[5] Leadbetter WB, Kolisek FR, Levitt RL, Brooker AF, Zietz P, Marker DR, et al. Patellofemoral arthroplasty: a multi-centre study with minimum 2-year follow-up. Int Orthop 2009;33:1597–601. https://doi.org/10.1007/s00264-008-0692-y.
[6] Mont MA, Johnson AJ, Naziri Q, Kolisek FR, Leadbetter WB. Patellofemoral arthroplasty: 7-year mean follow-up. J Arthroplasty 2012;27:358–61. https://doi.org/10.1016/j.arth.2011.07.010.
[7] Morris MJ, Lombardi Jr AV, Berend KR, Hurst JM, Adams JB. Clinical results of patellofemoral arthroplasty. J Arthroplasty 2013;28:199–201. https://doi.org/10.1016/j.arth.2013.05.012.
[8] Odumenya M, Costa ML, Parsons N, Achten J, Dhillon M, Krikler SJ. The Avon patellofemoral joint replacement: five-year results from an independent centre. J Bone Joint Surg Br 2010;92:56–60. https://doi.org/10.1302/0301-620X.92B1.23135.
[9] Sisto DJ, Sarin VK. Custom patellofemoral arthroplasty of the knee. J Bone Joint Surg Am 2006;88:1475–80.
[10] Starks I, Roberts S, White SH. The Avon patellofemoral replacement—independent assessments of early functional outcomes. J Bone Joint Surg Br 2009;91:1579–82. https://doi.org/10.1302/0301-620X.91B12.23018.
[11] Noble PC, Conditt MA, Cook KF, Mathis KB. The John Insall Award: patient expectations affect satisfaction with total knee arthroplasty: who is satisfied and who is not? Clin Orthop Relat Res 2006;452:35–43.
[12] Komistek RD, Allain J, Anderson DT, Dennis DA, Goutallier D. In vivo kinematics for subjects with and without an anterior cruciate ligament. Clin Orthop Relat Res 2002;404:315–25.
[13] Confalonieri N, Manzotti A, Cerveri P, De Momi E. Bi-unicompartmental versus total knee arthroplasty: a matched paired study with early clinical results. Arch Orthop Trauma Surg 2009;129:1157–63. https://doi.org/10.1007/s00402-008-0713-8.
[14] Rolston L, Bresch J, Engh G, Franz A, Kreuzer S, Nadaud M, et al. Bicompartmental knee arthroplasty: a bone-sparing, ligament-sparing, and minimally invasive alternative for active patients. Orthopedics 2007;30:70–3.
[15] Stiehl JB, Komistek RD, Cloutier JM, Dennis DA. The cruciate ligaments in total knee arthroplasty: a kinematic analysis of 2 total knee arthroplasties. J Arthroplasty 2000;15:545–50.
[16] Parratte S, Ollivier M, Opsomer G, Lunebourg A, Argenson JN, Thienpont E. Is knee function better with contemporary modular bicompartmental arthroplasty compared to total knee arthroplasty? Short-term outcomes of a prospective matched study including 68 cases. Orthop Traumatol Surg Res 2015;101:547–52. https://doi.org/10.1016/j.otsr.2015.03.019.
[17] Heyse TJ, Khefacha A, Cartier P. UKA in combination with PFR at average 12-year follow-up. Arch Orthop Trauma Surg 2010;130:1227–30. https://doi.org/10.1007/s00402-009-0997-3.
[18] Paratte S, Pauly V, Aubaniac JM, Argenson JN. Survival of bicompartmental knee arthroplasty at 5–23 years. Clin Orthop 2010;468:64–72. https://doi.org/10.1007/s11999-009-1018-0.
[19] Iwano T, Kurosawa H, Tokuyama H, Hoshikawa Y. Roentgenographic and clinical findings of patellofemoral osteoarthrosis: with special reference to its relationship to femorotibial osteoarthrosis and etiologic factors. Clin Orthop 1990;252:190–7.
[20] Kellgren JH, Lawrence JS. Radiological assessment of osteoarthrosis. Ann Rheum Dis 1957;16:494–502.
[21] Tillman MD, Smith KR, Bauer JA, Cauraugh JH, Falsetti AB, Pattishall JL. Differences in three intercondylar notch geometry indices between males and females: a cadaveric study. Knee 2002;9:41–6.
[22] Varadarajan KM, Gill TJ, Freiberg AA, Rubash HE, Li G. Gender differences in trochlear groove orientation and rotational kinematics of human knees. J Orthop Res 2009;27:871–8. https://doi.org/10.1002/jor.20844.
[23] Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the knee society clinical rating system. Clin Orthop Relat Res 1989;248:13–4.
[24] Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. Clin Orthop Relat Res 1995;198:43–9.
[25] Zahiri CA, Schmalzried TP, Szuszczewicz ES, Amstutz HC. Assessing activity in joint replacement patients. J Arthroplasty 1998;13:890–5.
[26] Wiberg G. Roentgenographic and anatomic studies on the patellofemoral joint with special reference to chondromalacia patellae. Acta Orthop Scand 1941;12:319–410.
[27] Caton J, Deschamps G, Chambat P, Lerat JL, Dejour H. Patella infera. Apropos of 128 cases. Rev Chir Orthop Reparatrice Appar Mot 1982;68:317–25.
[28] Dejour D, Reynaud P, Lecoultre B. Douleurs et instabilité rotulienne, essai de classification. Méd Hyg 1998;56:1466–71.
[29] Dahm DL, Kalisvaart MM, Stuart MJ, Slettedahl SW. Patellofemoral arthroplasty: outcomes and factors associated with early progression of tibiofemoral arthritis. Knee Surg Sports Traumatol Arthrosc 2014;22:2554–9. https://doi.org/10.1007/s00167-014-3202-3.
[30] Leadbetter WB, Ragland PS, Mont MA. The appropriate use of patellofemoral arthroplasty: an analysis of reported indications, contraindications, and failures. Clin Orthop Relat Res 2005;436:91–9.
[31] Lonner JH. Patellofemoral arthroplasty: the impact of design on outcomes. Orthop Clin North Am 2008;39:347–54. https://doi.org/10.1016/j.ocl.2008.02.002.
[32] Lonner JH, Bloomfield MR. The clinical outcome of patellofemoral arthroplasty. Orthop Clin North Am 2013;44:271–80. https://doi.org/10.1016/j.ocl.2013.03.002.
[33] Lustig S, Magnussen RA, Dahm DL, Parker D. Patellofemoral arthroplasty, where are we today? Knee Surg Sports Traumatol Arthrosc 2012;20:1216–26. https://doi.org/10.1007/s00167-012-1948-z.
[34] Walker T, Perkinson B, Mihalko WM. Patellofemoral arthroplasty: the other unicompartmental knee replacement. J Bone Joint Surg Am 2012;94:1712–20.

[35] Beitzel K, Schottle PB, Cotic M, Dharmesh V, Imhoff AB. Prospective clinical and radiological two-year results after patellofemoral arthroplasty using an implant with an asymmetric trochlea design. Knee Surg Sports Traumatol Arthrosc 2013;21:332–9. https://doi.org/10.1007/s00167-012-2022-6.

[36] Pritchett JW. Patient preferences in knee prostheses. J Bone Joint Surg Br 2004;86:979–82.

[37] Wunschel M, Lo J, Dilger T, Wulker N, Muller O. Influence of bi-and tri-compartmental knee arthroplasty on the kinematics of the knee joint. BMC Musculoskelet Disord 2011;12:29. https://doi.org/10.1186/1471-2474-12-29.

[38] Li P, Tsai TY, Li JS, Zhang Y, Kwon YM, Rubash HE, et al. Morphological measurement of the knee: race and sex effects. Acta Orthop Belg 2014;80:260–8.

[39] Palumbo BT, Henderson ER, Edwards PK, Burris RB, Gutiérrez S, Raterman SJ. Initial experience of the Journey-Deuce bicompartmental knee prosthesis. A review of 36 cases. J Arthroplasty 2011;26:40–5. https://doi.org/10.1016/j.arth.2011.03.026.