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Primary Knee

Evaluating the "Patella-Friendly" Concept in Total Knee Arthroplasty: A Minimum 15-Year Follow-Up Outcome Study Comparing Constant Radius, Multiradius Cruciate-Retaining, and Nonanatomical Cruciate-Retaining Implants

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ABSTRACT

Background: Patella-friendly femoral components were developed in order to reduce anterior knee pain and patellofemoral complications in total knee arthroplasty (TKA), but their effect on long-term outcome is still unclear.

Methods: We retrospectively evaluated prospectively collected data from 3 groups consisting of 100 patients (100 knees in each). In group A, the constant radius a-MP, in group B the multiradius cruciate-retaining Genesis II, and in group C the nonanatomic, multiradius, cruciate-retaining AGC TKA was implanted. Patients of all groups were matched for age, gender, side, body mass index, and length of follow-up. Preoperative and postoperative clinical outcome data in the form of Knee Society System (KSS), Short Form-12, Western Ontario and McMaster University Osteoarthritis Index, and Oxford Knee Score were available at regular intervals for groups A and B. For patients of group C, KSS score data were available at the same time intervals. In all groups, the patellofemoral compartment was assessed using the Clinical Patella Score scale. Anterior knee pain, secondary patella resurfacing, implant failure, and radiological outcome were assessed in patients of all groups.

Results: At 10-year and 15-year follow-up, patients of group A showed statistically significant (s.s.) higher (all $P = .000$) KSS values as compared to those of groups B and C. At 15-year follow-up, patients of group B showed s.s. higher ($P = .001$) KSS values as compared to those of group C. At 10-year and 15-year follow up, patients of group A showed s.s. higher (all $P = .00$) Western Ontario and McMaster University Osteoarthritis Index and Oxford Knee Score values as compared to those of group B. At 15-year follow-up only, patients of group A showed s.s. higher ($P = .00$) Short Form-12 (physical) values as compared to those of group B. In terms of Clinical Patella Score, patients in group A had s.s. higher values ($P = .05$) when compared to those of groups B and C. Anterior knee pain was recorded in 4.4% of TKAs in group A, 7.5% in group B, and 17.2% in group C. One (1.1%) patient in group A, 3 (3.25%) in group B, and 7 (8%) in group C underwent secondary resurfacing.

Conclusion: Anatomical, patella-friendly, constant radius femoral components outperform others in reducing anterior knee pain and patella complications in TKA in which the patellae are left nonresurfaced.

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Total knee arthroplasty (TKA) is one of the most successful operations performed for end stages of knee arthritis, with 95%-98% survival rates reported at 10-year to 15-year follow-up [1–4]. However, functional outcomes are perhaps inferior when compared to total hip arthroplasty and a high incidence (up to 30%) of patients with objectively sound joints are dissatisfied with the procedure [5–7]. Clinical databases and worldwide national registries suggest that modern TKAs fail and are subsequently revised due to aseptic loosening, infection, instability, and stiffness [4,8,9]. However, there is still a high incidence of anterior knee pain, patella malalignment, and patella complications which are difficult to treat [10–13].

Optimal patella tracking and extensor mechanism efficiency in TKA are multifactorial issues [14–16]. Rotational placement of both components, replacement or not of the patella, technical errors in replacing the patella, femoral component design features, joint line restoration, and patella and tibiofemoral instability are all factors related to anterior knee symptoms and complications [14–16]. Knee implant designers developed the so-called "patella-friendly" contemporary femoral components in order to, at least partially, address the problem of symptomatic knee extensor mechanism [17]. These designs typically include deepening and lengthening of the intercondylar notch, a laterally oriented trochlear groove, and a high lateral flange [18–20]. However, the long-term effect of these designs on clinical outcome is still not clear [17,20,21].

We report 15-year to 18-year comparative clinical and radiological outcomes of 2 patella-friendly TKA designs (a-MP and Genesis II) compared to an older non–patella-friendly design (AGC).

Patients and Methods

For the needs of this study, a total of 300 patients (300 knees) were divided into 3 groups. Two hundred patients (200 knees), divided into 2 groups (group A and B), underwent a unilateral TKA between February 2002 and July 2005, and a further 100 patients (group C), who had been operated on between January 1995 and December 1998, were separated out from our departmental arthroplasty database. Inclusion criteria for patients of all groups were degenerative osteoarthritis of the knee joint, age between 50 and 70 years, good mental health, less than 20° varus or valgus deformity, fixed flexion deformity of less than 20°, flexion greater than 90°, and body mass index (BMI) less than 35. Exclusion criteria were rheumatoid arthritis or other inflammatory arthritis, previous surgery on the same joint, and arthritis of the ipsilateral hip, contralateral hip, or knee joint. All procedures were performed by one surgeon (TK) who in the time period 2002-2005 performed a total of 364, and in the period 1995-1998 a total of 187, primary TKAs on patients with various ages, diagnoses, and deformities. For groups A and B (2002-2005), 2 different implants were used on alternate months (as required by 2 concurrently running MD theses). Written informed consent forms for future studies were obtained from all patients before surgery, and the study was approved by the National and Hospital Ethical Committees.

In 100 patients (group A), the cemented a-MP TKA (MicroPort Orthopaedics Inc, Arlington, TN) was used (Fig. 1). In 100 patients (group B), the cemented Genesis II oxidised zirconium cruciate-retaining (CR) TKA (Smith & Nephew Orthopedics, Memphis, TN) was used (Fig. 1). Finally, in group C (100 patients) the cemented AGC TKA (AGC; Zimmer Biomet, Bridgend, UK) was used (Fig. 1). All operations (in all groups) were performed in a sterile orthopedic theater with a vertical laminar airflow system, using a conventional surgical approach. The patella was not replaced and instead patella aponeurosis (5-mm all round patella retinacular release with a cautery) removal of osteophytes and patellar reshaping were performed on all patients. All patients were given patient-controlled epidural anesthesia for 48 hours. Prophylactic antibiotics were used preoperatively and postoperatively for 2 days (until removal of the drain) and anticoagulants (low molecular weight heparin) for 30 days. Intensive physiotherapy was started from the first postoperative day.

For patients of groups A and B, objective and subjective clinical and radiological data were prospectively collected preoperatively and at 3 and 6 weeks, 3 and 6 months, and at 1 year postoperatively, then yearly thereafter and stored in the OrthoWave database (Aria Ltd, Lyon, France). For patients of group C, objective clinical (KSS) and radiological data were collected preoperatively and at 3 and 6 weeks, 3 and 6 months, and at 1 year postoperatively, then yearly thereafter and recorded in a conventional database. For patients of groups A and B, a final follow-up evaluation was performed from January 2020 to October 2020 (interrupted by the COVID-19 pandemic). For patients of group C, the 15-year time interval clinical and radiological recordings were analyzed without organizing a final in-person follow-up. By design, this study is a retrospective review of prospectively collected data.

The following validated scoring systems were used [22]: the Knee Society system (KSS, Knee score and Function score) [23]; the Western Ontario and McMaster University Osteoarthritis Index

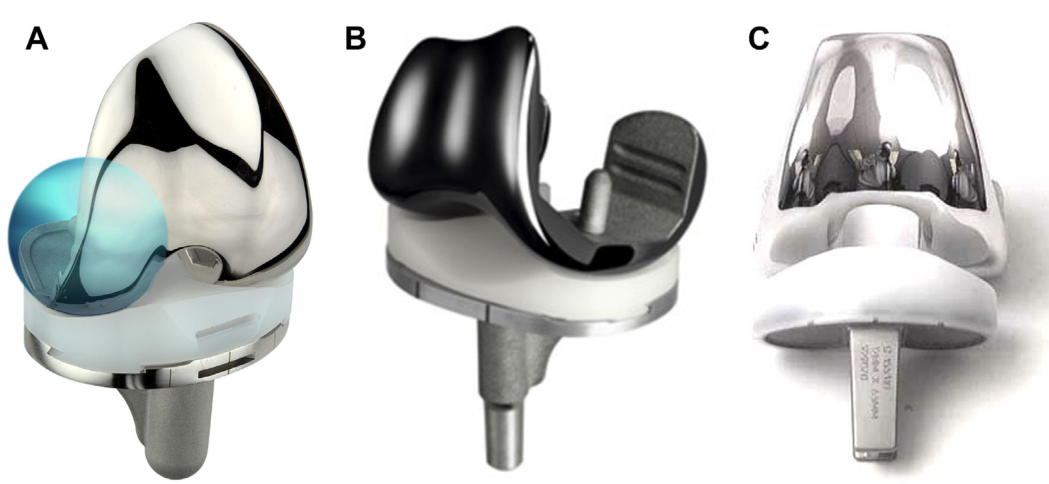

Fig. 1. Total knee arthroplasty implants evaluated in the study are shown: patella-friendly a-MP (A), patella-friendly Genesis II (B), and nonanatomical, non–patella-friendly AGC (C).

Table 1
Patient Demographics.

	Group A	Group B	Group C
Number of patients	100	100	100
Mean age at surgery (y) (range)	63.2 (52-70)	63.8 (55-70)	64 (56-70)
Gender (female/male)	69/31	71/29	66/34
Left/right knee	57/43	54/46	52/48
Mean BMI value (range)	32 (24-35)	31.5 (25-35	) 33 (26-35)
Diagnosis			
Osteoarthritis	100	100	100

(WOMAC) questionnaire [24]; the Short Form-12 (SF-12) questionnaire [25]; and the original (60 to 12) Oxford Knee Score (OKS) [26]. In order to separately evaluate the patellofemoral compartment, a simple 0-10 point Clinical Patella Score (CPS) (both objective and subjective) was used consisting of 5 elements: anterior knee pain, pain on stairs, patella tenderness, crepitus/catching, and clinical maltracking (each of these were scored severe = 0, moderate = 1, and none = 2) [27]. The active range of movement when sitting was recorded using a goniometer.

Standardized standing short anteroposterior and lateral radiographs were recorded and analyzed in all 3 groups by 2 experienced knee surgeons. The patellofemoral compartment was assessed using tangential radiological knee projections. The Knee Society system was used for radiological evaluation [28]. The performance of intraoperative lateral retinacular release was recorded in all patients. Failures were recorded in terms of considerable anterior knee pain, secondary patella resurfacing, revision either performed

Table 2
Pre and Postoperative Values (Mean, Range) of Objective and Subjective Knee Evaluation Scales Used in the Study.

	Group A	Group B	Group C	*P*- values
Objective Knee Score				
Preop	35.6 (16-67)	32.8 (14-70)	33.2 (15-72)	A vs B: 0.019 A vs C: 0.093 B vs C: 0.999
5 y	98.1 (94-100)	95.8 (85-100)	96.2 (84-100)	A vs B: 0.130 A vs C: 0.392 B vs C: 0.999
10 y	91.2 (74-100)	87.4 (78-100)	86.2 (76-96)	A vs B: 0.000 A vs C: 0.000 B vs C: 0.933
15 y	88.4 (70-95)	74.5 (65-95)	72.8 (64-92)	A vs B: 0.000 A vs C: 0.000 B vs C: 0.576
Objective Function Score				
Preop	46.4 (10-60)	46.5 (20-50)	46.7 (20-49)	A vs B: 1.000 A vs C: 1.000 B vs C: 1.000
5 y	97 (90-100)	95.1 (85-100)	94.8 (84-98)	A vs B: 0.402 A vs C: 0.186 B vs C: 1.000
10 y	84.3 (70-98)	76.7 (65-90)	76.4 (64-88)	A vs B: 0.000 A vs C: 0.000 B vs C: 1.000
15 y	79.6 (40-98)	68.4 (55-90)	67.9 (58-88)	A vs B: 0.000 A vs C: 0.000 B vs C: 0.999
Objective Total Score				
Preop	84.1 (45-115)	85.9 (57-110)	84.7 (56-112)	A vs B: 0.933 A vs C: 0.999 B vs C: 0.997
5 y	194.3 (180-200)	190.2 (160-200)	188.5 (165-196)	A vs B: 0.026 A vs C: 0.000 B vs C: 0.955
10 y	174.8 (145-190)	161.9 (143-190)	158.2 (140-190)	A vs B: 0.000 A vs C: 0.000 B vs C: 0.074
15 y	167.7 (115-180)	145.4 (120-175)	140.3 (115-170)	A vs B: 0.000 A vs C: 0.000 B vs C: 0.001
Subjective SF-12 (physical component)				
Preop	26.6 (20-40)	27.2 (20-40)		A vs B: 0.929
5 y	48.5 (34-56.2)	49.1 (31-56.4)		A vs B: 0.928
10 y	46.2 (35-56.3)	44.8 (30-50.1)		A vs B: 0.088
15 y	41.6 (29-50.3)	37.9 (27-48.4)		A vs B: 0.000
Subjective WOMAC				
Preop	31.8 (14-54)	32.4 (16-50)		A vs B: 0.998
5 y	71.3 (42-85)	70.2 (35-82)		A vs B: 0.951
10 y	69.2 (37-83)	64.6 (31-78)		A vs B: 0.000
15 y	62.7 (30-76)	55.1 (28-72)		A vs B: 0.000
Subjective Oxford Knee Score				
Preop	44.3 (38-50)	43.8 (39-51)		A vs B: 0.871
5 y	20.5 (14-24)	23.3 (18-28)		A vs B: 0.000
10 y	23.1 (17-34)	25.2 (19-36)		A vs B: 0.000
15 y	26.9 (20-36)	31.4 (24-38)		A vs B: 0.000

SF-12, Short Form-12; WOMAC, Western Ontario and McMaster University Osteoarthritis Index.

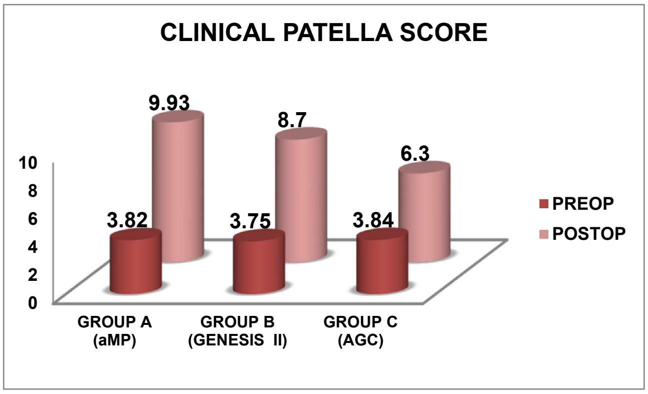

Fig. 2. Preoperative and postoperative mean values of Patella Clinical Scores.

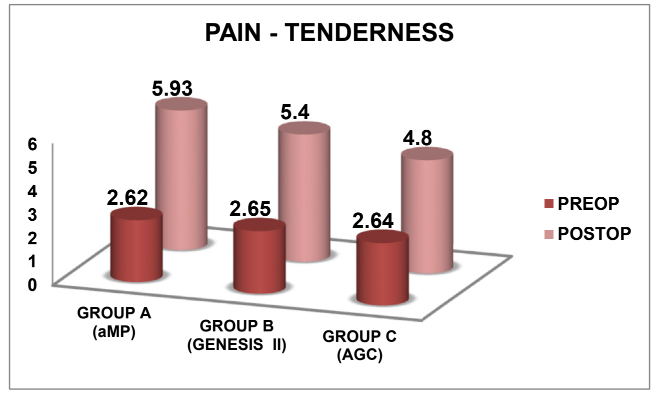

Fig. 3. Preoperative and postoperative mean values of the pain and tenderness elements of Patella Clinical Scores.

or planned because of aseptic loosening, infection, or dislocation or ligament instability.

Statistical Analysis

Data were analyzed for normal distribution using Kolmogorov-Smirnov analysis. Clinical scores (KSS, WOMAC, SF-12, OKS, and CPS) were normally distributed. In order to evaluate possible statistical differences of values within and between groups, a mixed model approach was used, with the time and prosthesis group as independent variables. Main effects as well as interactions were examined, and the results were adjusted for the effect of preoperative BMI values. Tukey's criterion was used to adjust for multiple comparisons. The power for detecting the observed postoperative mean differences in Knee Score, Function Score, Total Score, SF-16, WOMAC, Oxford Score, and CPS given that 60 patients were allocated to each group, was 99% [29]. Kaplan-Meier analysis with calculation of 95% confidence intervals (CIs) was performed to calculate survivorship [30,31]. The log-rank test was used to compare time-survival curves. All statistical analyses were performed using SPSS version 23.0 (SPSS; IBM) at the biostatistics department of our university. A P-value of $\leq$.05 was considered significant.

Results

A total of 300 patients were included in this study. Patient demographics are shown in Table 1. Patients of all groups were matched for gender, age, operated side, BMI, and diagnosis. At a minimum final follow-up of 15 (range 15-18) years, 91 patients from group A and 92 patients from group B were available, while there were records available for 87 patients of group C at the 15-year time interval. Four patients in group A, 3 in group B, and 8 in group C had died for reasons unrelated to surgery. There was 82% compliance (all groups) in the time interval follow-up evaluations.

In group A, survival analysis at 15 years showed a cumulative success rate of 97.3% (95% CI 96.7-98.2) for revision for any reason, 96.4% (95% CI 95.2-97.6) for all operations, and 98.8% (95% CI 98.2-99.5) for aseptic loosening as an end point. One TKA (1.1%) was revised due to aseptic loosening, 2 (2.2%) due to infection, and 1 (1.1%) due to instability. One (1.1%) patient underwent secondary patella resurfacing in the third postoperative year.

In group B, survival analysis at 15 years showed a cumulative success rate of 95.6% (95% CI 92.7-97.4) with revision for any reason, 92.3% (95% CI 90.2-94.4) for all operations, and 98.2% (95% CI 94.3-99.4) for aseptic loosening as an end point. Two TKAs (2.2%) were revised due to aseptic loosening, 2 (2.2%) due to infection, and 3 (3.25%) due to instability. Three patients (3.25%) underwent secondary patella resurfacing (in the second, third, and fourth postoperative years respectively).

In group C, survival analysis at 15 years showed a cumulative success rate of 94.8% (95% CI 92.6-96.9) with revision for any reason, 91.4% (95% CI 90.1-96) for all operations, and 95.7% (95% CI 92.4-98.5) for aseptic loosening as an end point. Four TKAs (4.6%) were revised due to aseptic loosening, 1 (1.15%) due to infection, and 3 (3.45%) due to instability. Seven (8%) patients underwent secondary patella resurfacing (between the second and fifth postoperative years).

Comparing 15 years of cumulative success rates between groups, group A showed statistically significant (s.s.) higher survival rates compared to group B (long-rank test, $P = .5$) and group C (long-rank test, $P = .4$) for all operations as an end point. Additionally, group A showed s.s. higher survival rates when compared to group C (long-rank test, $P = .5$) with revision for aseptic loosening as an end point.

Preoperative and postoperative values (mean value, range) at the 5th, 10th, and 15th year time intervals, and statistical differences between groups of the objective Knee Score, Function Score, Total Score, and the subjective SF-12, WOMAC, and OKS are shown in Table 2. In groups A and B, all patients showed an s.s. improvement on KSS ($P < .001$), WOMAC ($P < .001$), SF-12 ($P < .001$), and OKS ($P < .001$) scores at different time intervals as compared to preoperative values (Table 2). In group C, patients also showed an s.s. improvement on KSS ($P < .001$) at different time intervals as compared to preoperative values (Table 2). At the 10th and 15th year time intervals, patients in group A showed s.s. higher Knee Score, Function Score, and Total Score values as compared to patients of groups B and C (all $P = .000$). At the 10th year time interval, patients of group B did not show any differences in Knee Score, Function Score, and Total Score values as compared to those of group C. At the 15th year time interval, patients of group B showed s.s. higher Total Score values ($P = .01$) only as compared to those of group C (Table 2). At the 15th year time interval, patients of group A showed s.s. higher ($P = .00$) SF-12 (physical component) values as compared to those of group B (Table 2). At the 10th and 15th year time intervals, patients of group A also showed s.s. higher ($P = .00$) WOMAC values as compared to those of group B (Table 2). Finally, at the 5th, 10th, and 15th year time intervals, patients of group A also showed s.s. higher ($P = .00$) OKS values as compared to those of group B (Table 2). A multivariate analysis was also performed adding baseline BMI as a variable but no effect was recorded. Concerning the CPS, there were no differences for patients of all groups when baseline preoperative values were compared (Fig. 2). At final

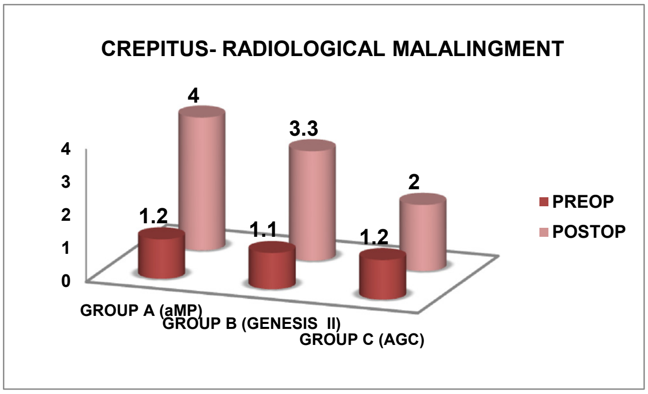

Fig. 4. Preoperative and postoperative mean values of the crepitus and patella malalignment elements of Patella Clinical Scores.

follow-up, patients of group A showed s.s. higher values ($P = .05$) when compared to those of group B (Fig. 2). At the same time interval, patients of group C showed s.s. inferior values when compared to those of the other 2 groups ($P = .01$). At final follow-up, when the subjective (pain-tenderness) (Fig. 3) and the objective elements of CPS score (crepitus-radiological misalignment) (Fig. 4) were separated, patients of group C showed s.s. inferior values when compared to those of the other 2 groups ($P = .05$). Assessing the CPS element of patellofemoral pain, in group A 1 patient reported severe pain and 3 patients moderate (a total of 4.4%), in group B 3 patients reported severe pain and 4 recorded moderate (a total of 7.5%), and in group C 7 patients reported severe pain and 8 patients moderate (a total of 17.2%). The range of movement rose from a preoperative mean of 95° (range 70°-125°) to a final mean of 116° (range 85°-135°) in group A, from a preoperative mean of 82° (range 75°-120°) to a final mean of 110.2° (range 85°-135°) in group B, and from a preoperative mean of 95° (range 75°-110°) to a final mean of 105.2° (range 85°-130°) in group C. According to the intraoperative notes, lateral retinacular release was needed in 4 (4.4%) patients of group A, 7 (7.6%) patients of group B, and 12 (13.8%) patients of group C.

Radiological Evaluation

Postoperative and final follow-up mean values of implant alignment parameters of femoral valgus angle (α), tibial angle (β), femoral flexion (γ), tibial slope (σ), and knee alignment in all groups are shown in Table 3. No s.s. changes were observed among groups when preoperative and final postoperative values were compared. No gross deviations (more than 3°) from anatomical alignment were recorded at final follow-up. Evaluating tangential knee radiographs, in 7 (7.7%) knees in group A, 12 (13%) knees in group B, and 12 (13.8%) knees of group C, the patellae were found to be tilted. Moreover, patella subluxation and/or dislocation were found in 4 (4.6%) knees of group C only.

Discussion

Despite satisfactory long-term cemented TKA clinical outcomes, knee arthroplasties still fail due to aseptic loosening, instability, infection, stiffness, malalignment, and patellofemoral complications including pain [1–4,8,9]. Various issues related to patient selection, surgical approach, abnormal artificial joint kinematics, optimal biomaterials, and posterior cruciate ligament resection or preservation remain controversial. In the past, anterior knee pain following TKA attracted the attention of orthopedic surgeons [10,11,15,32] and the controversial issue of resurfacing the patella or not was well studied [13,20,33–39]. Anterior knee pain definitely affects patient outcome and satisfaction. The reported incidence of anterior knee pain following contemporary primary TKA is 8%, being slightly higher when the patella is not resurfaced [10]. Several studies have attempted to determine its causes with varying results. Anterior knee pain and patellofemoral complications are due to patient-related factors, surgical techniques, and implant design features. Patellar tracking is also influenced by various factors such as preoperative severe valgus deformity, pre-existing patellofemoral dysplasia, the design of the component, surgical approach, Q angle, limb mechanical alignment, tightness of the lateral retinaculum, and size and placement of the components [10,11]. Patellofemoral complications can occur in both resurfaced and nonresurfaced patellae [15]. Recent understanding of knee anatomy and biomechanics has indicated that effective patella tracking in TKA depends on pre-existing patella tracking, the 3-dimensional but mainly rotational placement of both femoral and tibial components and patella shape [10,14–17]. The above observations have had an important impact on surgical technique and the industry has responded with implant designs and instrumentation which facilitate the correct rotational placement of the components. Moreover, detailed patella kinematics and contact stresses depend on patella shape and femoral component design features [14–17]. The industry has also responded with the introduction of improved patella implants and the so-called patella-friendly femoral component designs which typically include an anatomical component, deepening and elongation of the intercondylar notch, a lateral oriented trochlear groove, and a high lateral flange [17,18,21]. Recently, tibiofemoral stability, especially in the sagittal plane with no abnormal anterior rollback, is considered an important factor in maintaining a constant and effective lever arm for optimal extensor mechanism performance [17,18,40,41].

Table 3
Preoperative and Postoperative Values (Mean, Range) of Total Knee Arthroplasty Alignment Parameters.

Radiological Evaluation	Group A		Group B		Group C	
	Preop	Postop	Preop	Postop	Preop	Postop
Mean femoral valgus angle (α)	96 (93-101)	97 (92-102)	96 (94-103)	97 (93-101)	96 (93-101)	97 (94-103)
Mean tibial angle (β)	89 (82-93)	88.5 (81-93)	89 (81-94)	89 (83-93)	88 (82-94)	89 (81-92)
Mean femoral flexion (γ)	1 (−3 to 4)	1 (−3 to 4)	1 (−3 to 4)	1 (−3 to 4)	1 (−3 to 3)	1 (−2 to 3)
Mean tibial slope (σ)	87 (82-91)	85 (83-92)	86 (83-91)	85 (81-92)	86 (83-91)	86 (84-91)
Mean knee alignment	5 valgus (8 valgus to 4 varus)	4.7 valgus (7 valgus to 4 varus)	5.2 valgus (8 valgus to 5 varus)	4.8 valgus (7 valgus to 3 varus)	5.1 valgus (8 valgus to 3 varus)	4.9 valgus (7 valgus to 4 varus)

Following a literature search 3 important observations can be made. First, existing long-term data, based on quality level I and II studies and related to the question of whether or not to resurface the patella, also include older nonanatomical femoral components used during a period when surgical techniques were not well advanced in terms of the 3-dimensional placement of the components [20,25,34,39]. Second, excluding patient-related factors affecting patella complications, the remaining factors (implant design and surgical technique related) are modifiable. Finally, there is recent evidence which suggests that existing TKA clinical evaluation scales are not sensitive enough to assess differences in pain changes related to the patellofemoral compartment of the knee [42,43] and that future related studies should rely on the evaluation of patient satisfaction and patient-reported outcome measures [36,38]. Overall, the main clinical question is this: Do the complications related to patella resurfacing, including those of future revision, outweigh the increased incidence of anterior knee pain in those knees in which the patella was left nonresurfaced? The current literature does not give clear answers to this question [32–39].

In this study, we compared 3 different design implants. The a-MP Advance TKA has an anatomical constant radius femoral component with a deep and long linear trochlear groove which is oriented 3.6° between the anatomical and mechanical axis, lateral to the middle sagittal plane (patella friendly). A special jig for correct rotational placement of the femoral component was available for this implant. Satisfactory long-term outcomes have been published using this implant [2]. Moreover, it shows good in vivo sagittal plane stability [2,44]. The Genesis II posterior CR TKA has a multiradius femoral component with a deep, shorter (as compared to the a-MP implant), and S-shaped nonlinear trochlear groove which is oriented lateral to the middle sagittal plane (patella friendly). External rotation of 3° has been incorporated in the posterior flanges of the femoral component. We, along with other authors, have also published satisfactory long-term outcomes with this implant [3]. The third implant used was the AGC TKA. This was the nonanatomical variant of a multiple radius femoral component with a deep and wide but vertical trochlear groove (non-patella friendly). AGC instrumentation did not allow for precise control of femoral component rotation. Satisfactory long-term results have also been shown with the use of this implant [45,46]. Additionally, in this study, apart from contemporary knee evaluation scales, a separate, simple objective and subjective evaluation scale was used for the patellofemoral compartment (CPS) of the TKA. We started using this scale in Bristol as part of a patella resurfacing or not randomized controlled trial (RCT) study in the early 90s and we reported results in 2000 [27]. Surprisingly, Baldini et al [43] used and reported results from a similar scale for the same purposes in 2006. In the present study, it was found that there was an s.s. improvement from baseline values on all evaluation scales studied, across all groups, up to the 10th postoperative year. When the average values of KSS scores were compared among the 3 groups, patients of group A showed s.s. higher scores when compared to those of groups A and B at the 10th and 15th year time intervals. At the 15th year time interval, patients of group B also showed s.s. higher average values when compared to patients of groups C. The above findings are possibly explained by the fact that the KSS score (and its elements) is not sensitive enough to patellofemoral compartment problems and that the constant radius a-MP femoral component protects against late sagittal stability loss (posterior cruciate ligament insufficiency). Evaluating groups A and B using the subjective SF-12 score, s.s. improvements from baseline values were observed in patients of both groups. When average values of the above scores were compared between groups A and B, s.s. differences were found only at the 15th year time interval. These observations are also explained by the SF-12 lack of sensitivity concerning patellofemoral problems. Similar observations were made when evaluating groups A and B using the subjective WOMAC and OKS scores up to the 10th postoperative year. At the 10th and 15th year time intervals, patients of group A showed s.s. higher average values when compared to patients of group B. A possible explanation for the differences, in favor of the a-MP implant, at the level of 15 years is its superior sagittal stability (constant radius femoral component, as compared to the multiradius Genesis II femoral implant) and improved extensor mechanism performance in patients of advanced age. All scores both subjective and objective showed a non-s.s. decline after the 10th postoperative year, perhaps due to senility-related reduction in activities, a finding that we have previously reported [2,3]. Looking at CPS scores (both objective and subjective) which separate and evaluate the patellofemoral compartment of the TKA, patients of group A showed s.s. higher values and patients of group C showed s.s. lower values of the total score at final follow-up. Similar findings were observed when the subjective (pain, tenderness) and the objective (radiological malalignment and crepitus) elements of the score were evaluated. The above observations indicate that a patella-friendly femoral component has a positive effect on patellofemoral symptoms after TKA. In all groups, the patellae were left nonresurfaced and anterior knee pain in the patella-friendly implants (4.4% and 7.5% respectively) was found at lower levels compared to historical controls [10,12,15–17]. Secondary patella resurfacing and lateral retinacular release were performed at lower numbers in the patella-friendly constant radius implant (a-MP). Moreover, on radiological examination of postoperative radiographs, significant patella alignment deviations were found in the nonanatomical, non–patella-friendly TKA group only. All the above observations are indicative of the positive effect of the patella-friendly femoral component TKA concept (especially of those with constant radius) on patellofemoral symptoms and tracking.

A limitation of this study is that the occurrence of anterior knee symptoms and patellofemoral complications is a multifactorial issue and it is difficult to control each of them in a single study. However, the comparison of 3 TKA designs with distinct femoral design features eliminates the above problem. Another limitation is that this study is not a randomized one and for the third group 3 of the subjective evaluation scales were not available since collection of the data started before the period of time when it became obvious that such data would be needed. On the other hand, adequate matching of the groups, the small numbers of drop outs and deaths, the availability of a patellofemoral assessment scale (though nonvalidated), the long-term follow-up, and the performance of the operations by one dedicated orthopedic surgeon in a specialized center are the strengths of the study.

In a study from the National Joint Registry (UK) comparing various implant designs with 8103 resurfaced and 15.290 nonresurfaced patella, no differences were found concerning the magnitude of improvement in overall knee function and anterior knee specific function as assessed by the subjective OKS at 5-year follow-up [38]. In a study from the New Zealand Joint Registry (20.495 TKAs, 96% of them with patella nonresurfaced), the question of which is the most patella-friendly TKA design was asked. Comparing various types of implants, secondary resurfacing of the patella was significantly higher in fixed-bearing posterior stabilised (PS) implants as compared to fixed-bearing CR or mobile-bearing implants at 11-year follow-up [47]. Kaseb et al compared patellar resurfacing and nonresurfacing using a patella-friendly multiradius implant. No differences were found in postoperative patient satisfaction or patella crepitus, at 1 year, as evaluated by KSS and KOOS scores [36]. Atzori et al compared the classical and the patella-friendly version of a multiradius PS TKA design with all patellae resurfaced. No differences were observed in the incidence of anterior knee pain, Burnett patellofemoral questionnaire, KSS scores, or patella complications at 2-year to 3-year follow-up [48]. Patella tilt, patella height, patella thickness, and delta angle were predictors of secondary patella resurfacing when different variants (CR, PS, condylar constrained) of a multiradius patella-friendly TKA design were compared [49]. In an RCT, a single radius was compared to a multiradius design and no differences were found when OKS and KSS scores were used [50]. In a prospective bilateral randomized trial using a single-radius PS, TKA patients were unaware of any differences due to patellar resurfacing as assessed by postoperative anterior knee pain, Forgotten Joint Score, and an objective Feller patellofemoral score at 11-year follow-up [21]. In a staged bilateral TKA trial comparing a medial pivot knee to a PS design, no differences were found using satisfaction and both objective and subjective evaluation scales (but not a separate patellofemoral score) at 1-year follow-up [51]. In an RCT comparing a medial pivot to PS design, superior patient satisfaction was observed in the medial pivot group using KSS (satisfaction and expectations elements) and OKS at 4-year follow-up. Superior sagittal stability was also found in the medial pivot group [52]. The current literature related to contemporary TKA designs indicates that nonresurfacing of the patella produces satisfactory outcomes and that multiradius and PS patella-friendly implants do not show beneficial effects on patellofemoral symptoms and tracking.

Conclusion

For the clinical assessment of patella-friendly femoral components, a separate patella evaluation score should be used. Anatomical patella-friendly constant radius femoral components outperform other types of implants in reducing anterior knee pain and patellofemoral joint complications in TKA in which the patellae are left unresurfaced.

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