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Gender does not influence outcomes and complications in medial unicompartmental knee arthroplasty

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Abstract

Purpose: The impact of gender on the outcomes of unicompartmental knee arthroplasty (UKA) remains a topic of active discussion with limited exploration thus far. The study aims to elucidate the gender effect on clinical outcomes, complications, pre- and postoperative radiological outcomes following the implantation of a medial UKA at mid-term follow-up in a large section of patients.

Methods: This was a single-centre, retrospective cohort study encompassing patients undergoing medial UKA between 2011 and 2019. The International Knee Society (IKS) Knee and Function score, patient satisfaction, complications, revisions, pre- and postoperative radiological outcomes (coronal plane alignment, femoral and tibial component positioning, posterior tibial slope) were evaluated. Survival rate at the time of the last follow-up was also recorded.

Results: Of the 366 knees that met the inclusion criteria, 10 were lost to follow-up, accounting for a 2.7% loss. Mean follow-up was 5.2 ± 2 years [2.1–11.3]. Out of the total population, 205 patients were females (57.6%, 205/356) and 151 were males (42.4%, 151/356). Men exhibited superior pre- and postoperative IKS function scores ($p = 0.017$). However, no significant differences were observed between women and men regarding improvements of IKS Knee and Function scores, radiographic outcomes and implant survivorship.

Conclusion: At a mean follow-up of 5 years, this study revealed no significant impact of gender on clinical outcomes and complications in patients undergoing medial UKA. Furthermore, no significant differences were evident in radiographic outcomes, implant positioning and knee phenotype.

Level of Evidence: Level III.

KEYWORDS

complications, coronal alignment, female, gender, male, patient reported outcome measures, survivorship, unicompartmental knee arthroplasty

Abbreviations: ACL, Anterior cruciate ligament; BMI, body mass index; DAIR, debridement–antibiotics–implant retention; FMA, femoral mechanical angle; HKA, hip–knee–ankle; IKS, International Knee Society; mLDFA, mechanical lateral distal femoral angle; mMPTA, mechanical medial proximal tibial angle; NEU, neutral; OA, osteoarthritis; OKS, Oxford knee score; PROM, patient-reported outcome measures; PTS, posterior tibial slope; TKA, total knee arthroplasty; TMA, tibial mechanical angle; UKA, unicompartmental knee arthroplasty; VAL, valgus; VAR, varus.

INTRODUCTION

Unicompartmental knee arthroplasty (UKA) is a highly effective strategy for selected patients with unicompartmental knee osteoarthritis (OA). This surgical approach offers improved functional outcomes, shorter operative time [45], enhanced restoration of native joint mechanics and faster recovery in comparison to total knee arthroplasty (TKA) [15, 39], despite an increased revision risk [1, 8] frequently attributed to surgical technique, inappropriate patient selection [14] or precision of component positioning [7, 29]. Previous studies have implicated knee alignment outliers, significant flexion deformity and alterations in joint line height as potential risk factors associated with suboptimal outcomes, but impact of gender on the outcomes of UKA remains a topic of active discussion. Some studies assert no significant gender influence on UKA outcomes [19, 26, 34] while others underscore marked discrepancies in clinical scores, survivorship or radiological outcomes [23, 32, 33, 44, 48, 49]. Moreover, most of them were constrained by a limited patient sample [6, 19, 23], short follow-up periods of 2 years or less [26] and the inclusion of both medial and lateral UKA [34, 44, 48], only few were designed to primarily compare outcomes based on gender. Examination of registries might yield ambiguous conclusions, due to the absence of key information such as type of implant used, precision of implant positioning and surgeon expertise [20, 24].

No previous study has been designed to evaluate effect of gender on mid-term outcomes after medial UKA in a large section of patients.

The aim of this article was to determine the influence of gender on clinical and radiographic outcomes, complication rates and survivorship after implantation of a medial UKA, assessed at mid-term follow-up (over 2 years) in a large section of patients. The hypothesis of this study was that there is no gender influence on those parameters.

MATERIALS AND METHODS

Study design

This retrospective study was conducted in a single unit between January 2011 and December 2019. During this period, 396 medial UKA were performed in our unit. All patients with a follow-up of less than 2 years were excluded.

Inclusion criteria comprised patients undergoing medial UKA for isolated medial femorotibial primary or secondary (postmeniscectomy or posttraumatology) osteoarthritis (OA) or osteonecrosis of medial femoral condyle. No limitations regarding age, body mass index (BMI) or activity level were imposed for inclusion in the study. Contraindications of UKA were lower limb coronal plane deformity greater than 20° of varus (VAR), flexion less than 90° and flexion contracture more than 10°, nonreducible deformity or noncompetent anterior cruciate ligament (ACL) at clinical assessment. Exclusion criteria were associated surgical procedures (ACL reconstruction, bicompartmental-UKA, osteotomy) ($n = 10$) (Figure 1).

Patient population

A total of 366 knees met the inclusion criteria (329 patients) for the study. Of these, 10 were lost to follow-up (2.7%, 10/366) and excluded from the analysis. Mean follow-up time was 5.2 years ± 2 [2.1–11.3]. The study population included 205 females (57.6%, 205/356) and 151 males (42.4%, 151/356).

There was no significant difference in age between males and females [43], BMI, OA aetiology, International Knee Society (IKS) knee score and preoperative knee constitutional alignment (Tables 1 and 2). However, significant differences were observed in weight, height with males having higher values compared to females. Activity level and preoperative IKS function scores were significantly lower among females (Tables 1 and 2).

Data collection

Preoperatively the following parameters were collected: age, gender, BMI, side of surgery, OA aetiology and the IKS score [10, 25]. Postoperative data, including patient satisfaction (categorised as

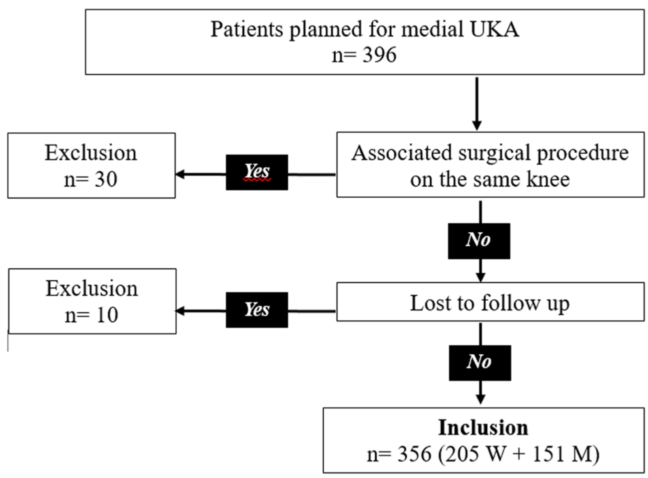

FIGURE 1 Patient flowchart. M, men; UKA, unicompartmental knee arthroplasty; W, women.

TABLE 1 Baseline characteristics and preoperative scores.

	Total (*N* = 356)	Male (*N* = 151)	Female (*N* = 205)	*p* Value
Age (years)	67.4 ± 9.63 [41.8–91]	67.9 ± 9.06 [48.7–91]	67.1 ± 10 [41.8–89.3]	n.s
Weight (kg)	75.1 ± 14.2 [40–131]	81.9 ± 11.5 [58–120]	70.1 ± 13.9 [40–131]	0.001
Height (cm)	166 ± 9.66 [147–196]	173.9 ± 7.5 [150–196]	160 ± 6.3 [147–179]	0.001
BMI (kg/cm^2)	27.2 ± 4.39 [16.2–48.7]	27.1 ± 3.4 [18.5–37.6]	27.3 ± 5 [16.2–48.7]	n.s
Diagnosis				n.s
Primary osteoarthritis	235 (66%)	94 (62.3%)	141 (68.8%)	
Postmeniscectomy	78 (21.9%)	36 (23.8%)	42 (20.5%)	
Avascular osteonecrosis	39 (11%)	18 (11.9%)	21 (10.2%)	
Posttraumatology	4 (1.1%)	3 (2%)	1 (0.5%)	
Preoperative maximum activity level				0.03
Strenuous labour/contact sports	88 (24.7%)	48 (31.8%)	40 (19.5%)	
Light labour/noncontact sports	110 (30.9%)	48 (31.8%)	62 (30.2%)	
Leisure activities/gardening	105 (29.5%)	36 (23.8%)	69 (33.7%)	
Semisedentary/household chores	53 (14.9%)	19 (12.6%)	34 (16.6%)	
Sedentary/dependent	0 (0%)	0 (0%)	0 (0%)	
IKS knee score (/100)	66 ± 11 [32–93]	66 ± 12 [41–93]	66 ± 11 [32–91]	n.s
IKS function score (/100)	70 ± 14 [5–95]	72 ± 14 [40–95]	68 ± 14 [5–95]	0.02
Procedure				
Conventional	159 (44.7%)	62 (41.1%)	97 (47.3%)	n.s
Robotic	197 (55.3%)	89 (58.9%)	108 (52.7%)	

Abbreviations: BMI, body mass index; IKS, International Knee Society.

disappointed, moderately satisfied, satisfied, very satisfied), IKS score, complications and revisions were collected at 2, 6 months, 1 year and at the time of the last follow-up. If preoperative scores were not comparable between groups, the emphasis was placed on the improvement between pre- and postoperative scores in interpreting the results. This methodology allowed for a balanced and consistent assessment of the surgical outcomes.

Imaging

Standardised weight-bearing antero-posterior and lateral (20° of flexion) knee radiographs, patellar axial views and full-length standing radiographs were performed before surgery and at each follow-up period. Preoperative radiographic measurements included hip–knee–ankle (HKA) angle, mechanical lateral distal femoral angle (mLDFA), mechanical medial proximal tibial angle (mMPTA) and posterior tibial slope (PTS) of the medial compartment. All measurements were performed by an independent experienced surgeon with the utilisation of the software Centricity Universal Viewer Zero Footprint (version 6.0 SP77.0.2—GE Healthcare) with an accuracy of one decimal. HKA angle measured on full-length standing radiographs is formed by two lines, which correspond to the mechanical axes of the femur and the tibia, and represents the overall lower limb alignment. First line connects the centre of the femoral head to the centre of the femoral intercondylar notch. Second line connects the tibial interspinous point to the centre of the talus. mLDFA formed between the femoral mechanical axis and a tangent to the distal femoral condyles represents the orientation of the femoral joint line. mMPTA formed between the tibial mechanical axis and a tangent to the proximal tibial joint surface represents the orientation of the tibial joint line. The PTS measured on true profile was defined as the angle subtended by the articular surface of the medial tibial plateau and a line perpendicular to the axis of the tibial diaphysis. Postoperative radiographic measurements included HKA angle, PTS, alignment of the tibial implant according to the tibial mechanical axis (+: implant in VAR, −: implant in valgus [VAL]), alignment of the tibial implant according to the

TABLE 2 Pre- and postoperative alignment and radiographic outcomes.

	Total (*N* = 356)	Male (*N* = 151)	Female (*N* = 205)	*p* Value
HKA angle (°)				
Preoperative	174.3 ± 3.2 [164–185.6]	174.1 ± 3.1 [164–183.4]	174.6 ± 3.2 [164.4–185.6]	n.s
Postoperative	177 ± 3.2 [165.3–189]	176.6 ± 3.5 [168.4–185]	176.6 ± 3.5 [165.3–189]	n.s
Difference	2.2 ± 2.6 [−8.1 to 9.3]	2.5 ± 2.4 [−4 to 9]	2 ± 2.8 [−8.1 to 9.3]	n.s
mLDFA (°)				
Preoperative	88.6 ± 2 [82.7–94]	88.8 ± 2 [82.7–94]	88.6 ± 2.6 [84–93]	n.s
Postoperative	87 ± 2.6 [79–95.8]	87.1 ± 2.1 [82–92]	86.9 ± 2.9 [79–95.8]	n.s
mMPTA (°)				
Preoperative	86.1 ± 2.1 [78.9–93.7]	85.7 ± 2.3 [78.9–93.7]	86.4 ± 2 [80.2–92.7]	n.s
Postoperative	86.2 ± 1.9 [80–90]	86.1 ± 1.8 [81–90]	86.3 ± 2 [80–90]	n.s
Slope (°)				
Preoperative	7.2 ± 2.1 [0.4–11]	7.2 ± 2.4 [0.4–10.8]	7.3 ± 2 [1.5–11]	n.s
Postoperative	5.2 ± 2.1 [0–10]	5 ± 2.1 [0–9.1]	5.4 ± 2.1 [0–10]	n.s
Cartier angle (°)	2.8 ± 3 [−8 to 12]	3.2 ± 3.1 [−8 to 12]	2.5 ± 2.9 [−5.4 to 11]	n.s
Varus in tibial implant (°)	4 ± 2.6 [−4.2 to 14.3]	4 ± 2.6 [−4.2 to 14.3]	4 ± 2.6 [−3.7 to 11.9]	n.s
Δ Cartier (°)	1.3 ± 3.6 [−8.6 to 12.6]	0.8 ± 3.6 [−8.6 to 12.6]	1.6 ± 3.6 [−8.6 to 10.7]	n.s
Joint line restitution (mm)	1.6 ± 1.8 [−5.1 to 7.7]	1.4 1.7 [−5.1 to 6.4]	1.7 ± 1.9 [−3.9 to 7.7]	n.s

Abbreviations: HKA, hip–knee–ankle; mLDFA, mechanical lateral distal femoral angle; mMPTA, mechanical medial proximal tibial angle.

Cartier's angle (Δ Cartier) (+: implant in VAR, −: implant in VAL) [16, 17, 41], mLDFA and mMPTA. Functional pre- and postoperative knee phenotypes [22] were defined by the following nomenclature: the first part (neutral [NEU], VAR, VAL) defines the direction of alignment, the second (HKA, femoral mechanical angle [FMA], tibial mechanical angle [TMA]) states the measured angle and the last part (0°, 3°, 6°) shows the mean deviation of the phenotype from the mean value.

Surgical technique

Surgical procedures were performed using a mini midvastus approach [47]. Comprehensive examination of all three articular compartments and the cruciate ligaments was performed to confirm suitability for UKA. The tourniquet was inflated only during cementation of the implants [38]. The implantation involved either a cemented all-polyethylene tibial component (HLS Uni Evolution, Tornier®) or a cemented metal-backed tibial component (Journey Uni, Smith & Nephew®). Both implants were suitable of being implanted using robotic assistance. The utilisation of an image-free robotic system or the conventional technique was based on patient choice, surgeon's expertise and confidence with the surgical technique [3]. The image-free robotic-assisted (BlueBelt Navio robotic surgical system—Smith & Nephew®) and conventional techniques have been elaborately described in a preceding study of our group [21]. Of the cases, 159 (44.7%, 159/356) were performed using the conventional technique and 197 (55.3%, 197/356) with the robotic technique, displaying an equitable distribution among men and women (Table 1).

Statistical analysis

Continuous variables following a normal distribution are presented as mean value, standard deviation and minimum and maximum values. Normality in continuous variables was assessed by observing the boxplot, skewness and kyrtosis and performing the Shapiro–Wilk test. The following statistical tests were used for continuous variables to perform comparisons among groups: Student's *t* test or paired Student's *t* test when normal distribution was evident and the independent samples Mann–Whitney *U* test or the Wilcoxon signed rank test when there was a violation of normality. Categorical variables are presented as percentages. A χ^2 test or Fisher's exact test was used to ascertain any differences. The survival curves were calculated using the Kaplan–Meier method with a 95% confidence interval based on the following endpoints: implant removal and/or a lateral UKA performed for OA progression in the contralateral compartment. The Log-rank test was used to compare the survival curves obtained. The significance threshold was set at 5%. The R software (4.3.1 version—R Development Core Team [40]) was used for all statistical analyses. Sample size was taken into account using a Wald test to measure the significance of the regression coefficients. Using the 356 observations available, coefficients were estimated using standard regression models (GLM for scores and Cox for durations), maximising likelihood (partial for Cox). For each coefficient, the *p* value of a significance test was determined using a Wald test. Numerical calculations were performed using the GLM (scores) and coxph (Cox) functions of the R software.

RESULTS

Functional improvement and satisfaction

In the male group, there was a significant improvement in the mean knee score ($p < 0.001$), accompanied by a significant rise in the function score ($p < 0.001$). Similarly, in the female group, the mean knee score markedly improved ($p < 0.001$) and the IKS function score increased ($p < 0.001$). A comparative analysis between both groups revealed no significant difference in the improvement of these scores (Table 3).

At the time of the last follow-up, a significant majority of patients reported satisfaction. Specifically, 79.5% (120/151) of the male cohort and 78.1% (160/205) of the female cohort described their status as 'satisfied' or 'very satisfied'. This comparison did not yield a significant difference (Table 3).

Complication rates

Examining the overall complication rates, comparable results were observed in both groups with 15.1% (31/205) females experiencing a complication versus 12.6% (19/151) males (n.s) (Table 4). Tibial loosening emerged as the predominant complication, recorded at 6.8% participants (14/205) in the female group and 3.3% (5/151) in the male group (n.s). A detailed age analysis presented a comparable age average for women, 67.7 years ± 7.8 with tibial loosening, and 67.1 years ± 8.4 without (n.s). Upon assessing the overall survivorship, the study found a rate of 92.1%. Detailed examination showed a trend towards improved survivorship of 95.4% in the male group and 89.8% in the female group, however, this did not reach statistical significance (n.s) (Figure 2).

Radiological outcomes and coronal alignment

No pre- or postoperative differences were observed between the two groups regarding radiological outcomes and component alignment (Table 2). Overcorrection, quantified as a postoperative HKA exceeding 180°, was reported in 8.3% (17/205) of the female cohort compared to 6% (9/151) in the male cohort, a difference that was not statistically significant (n.s). Concerning knee phenotypes, 53 different preoperative and 60 different postoperative phenotypes were found out of 125 possible combinations. The most common preoperative functional knee phenotype in males (14.6%) and females (13.2%) was $VAR_{HKA}6° + VAR_{FMA}3° + NEU_{TMA}0°$ (Figure 3). The most common postoperative functional knee phenotype in males (19.9%) and females (14.6%) was $VAR_{HKA}3° + NEU_{FMA}0° + NEU_{TMA}0°$ (Figure 4).

TABLE 3 Postoperative clinical outcomes at the last follow-up.

	Total (*N* = 366)	Male (*N* = 151)	Female (*N* = 205)	*p* Value
IKS—Knee (/100)	88.8 ± 13.2	90 ± 13	88 ± 13	n.s
Improvement	22.8 ± 15.6	24.1 ± 14.7	21.9 ± 16.2	n.s
IKS—Function (/100)	89.3 ± 15	92 ± 12	87 ± 17	0.01
Improvement	19.4 ± 17.1	20 ± 15.6	18.9 ± 18.2	n.s
Satisfaction				
disappointed	46 (12.9%)	32 (15.6%)	16 (10.6%)	
moderately satisfied	30 (8.4%)	13 (6.3%)	15 (9.9%)	n.s
satisfied	126 (35.4%)	77 (37.6%)	49 (32.5%)	
very satisfied	154 (43.3%)	83 (40.5%)	71 (47%)	

Abbreviation: IKS, International Knee Society.

TABLE 4 Complications and need for further surgery.

	Total	Men (*N* = 151)	Women (*N* = 205)	*p* Value	Surgical treatment
Total	50 (14%)	19 (12.6%)	31 (15.1%)	n.s	-
Tibial aseptic loosening	19 (5.3%)	5 (3.3%)	14 (6.8%)	n.s	16 conversions to TKA 3 tibial implant revision
Stiffness (flexion)	11 (3.1%)	5 (3.3%)	6 (2.9%)	n.s	Artholysis (arthroscopy) + MUA
Unexplained pain	5 (1.4%)	3 (0.2%)	2 (1%)	n.s	2 conversions to TKA 3 arthroscopy (lateral OA)
OA (controlateral/femoroptatellar)	3 (0.8%)	1 (0.7%)	2 (1%)	n.s	3 conversions to TKA
Infection	3 (0.8%)	1 (0.7%)	2 (1%)	n.s	DAIR
Lateral meniscal tear	2 (0.6%)	2 (1.3%)	0 (0%)	n.s	Arthroscopy: lateral meniscectomy
Medial tibial overhang	1 (0.3%)	0 (0%)	1 (0.5%)	n.s	Tibial implant revision
Medial tibial plateau fracture	1 (0.3%)	0 (0%)	1 (0.5%)	n.s	Conversion to TKA
Vastus medialis desinsertion	1 (0.3%)	1 (0.7%)	0 (0%)	n.s	Open reinsertion
Valgus malalignment	1 (0.3%)	0 (0%)	1 (0.5%)	n.s	Conversion to TKA
Tibial implant undersized	1 (0.3%)	0 (0%)	1 (0.5%)	n.s	Tibial implant revision
Articular foreign body	1 (0.3%)	0 (0%)	1 (0.5%)	n.s	Arthroscopy (removal)
Baker cyst	1 (0.3%)	1 (0.7%)	0 (0%)	n.s	Open surgical resection

Abbreviations: DAIR, debridement–antibiotics–implant retention; MUA: mobilisation under anesthesia; OA, osteoarthritis; TKA, total knee arthroplasty.

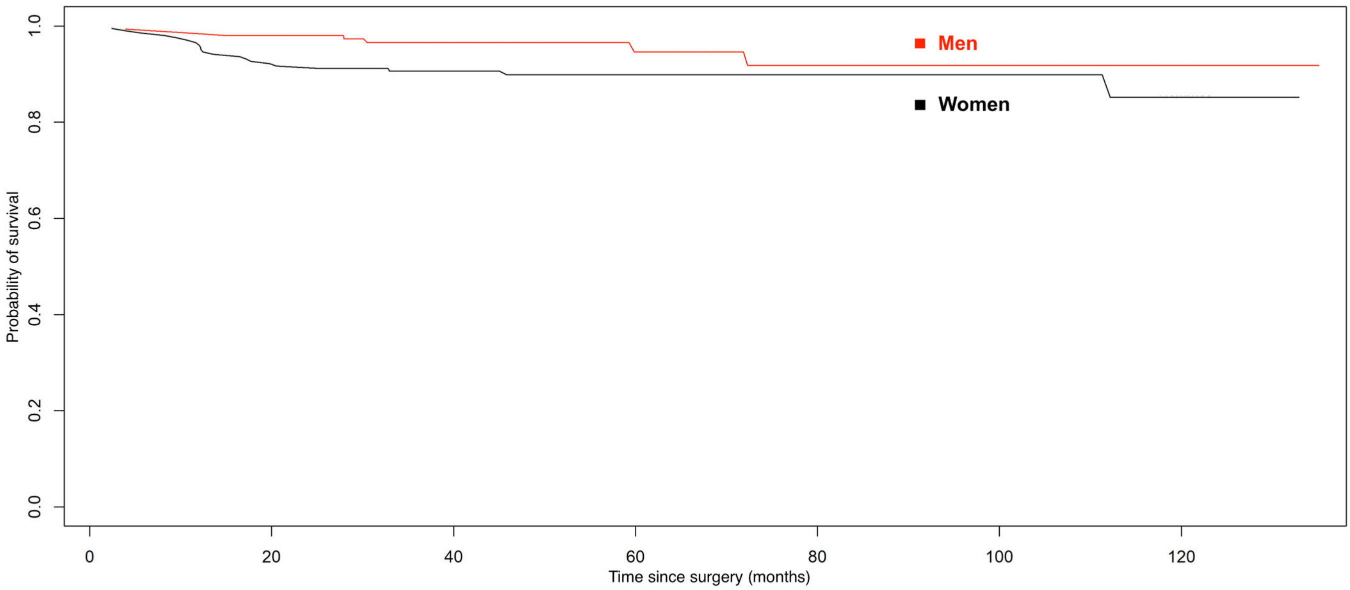

FIGURE 2 Survival analysis for revision of female and male group.

DISCUSSION

The main finding in our study was the nonsignificant impact of gender on clinical outcomes and overall complications postoperatively. Other findings extend to the lack of gender influence on the knee phenotype and postoperative radiographic implant positioning.

A considerable body of research has evaluated gender influence on clinical outcomes and complications after primary TKA signifying superior improvements in patient-reported outcome measures (PROMs) for males and a reduction in complication rates for females [28, 35–37, 46]. Concerning UKA, in a prospective observational single-centre study of 150 medial UKA with a

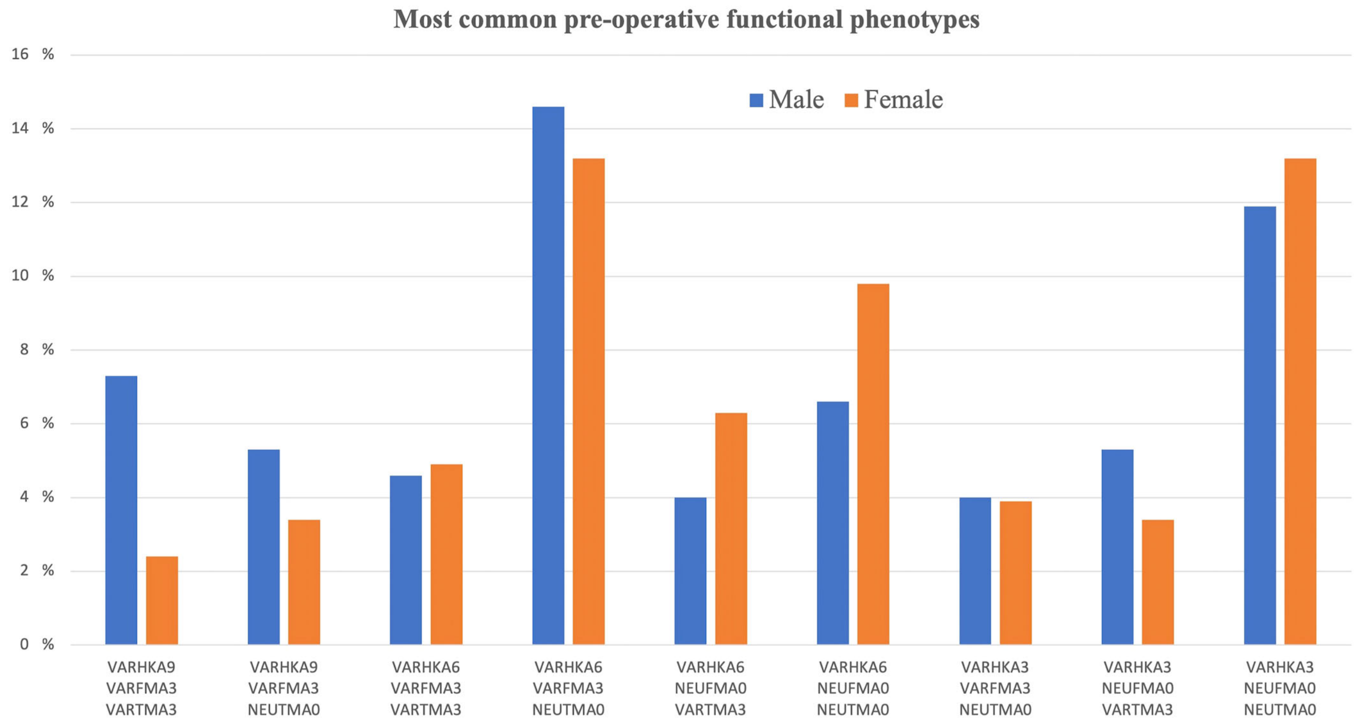

FIGURE 3 Most frequent preoperative functional knee phenotypes separated by gender (the height of the bars equals the percentages a functional knee phenotype represents within the female/male population).

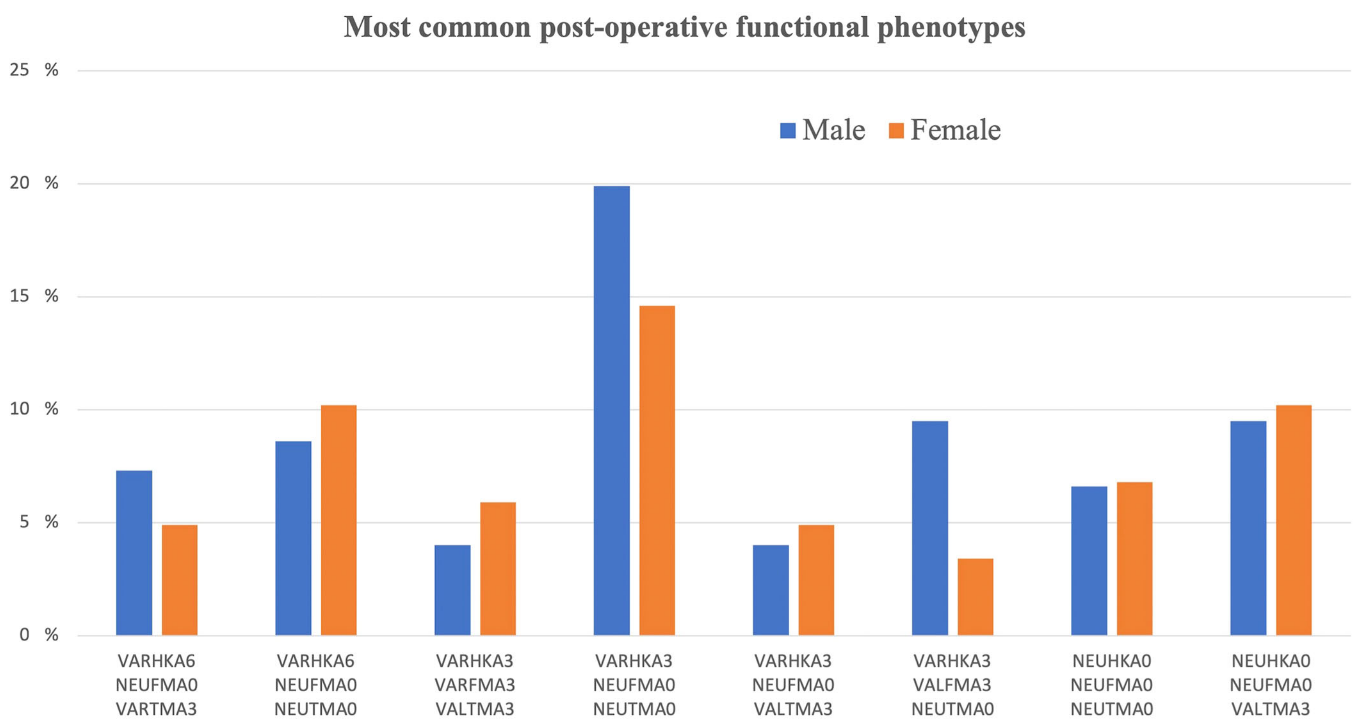

FIGURE 4 Most frequent postoperative functional knee phenotypes separated by gender (the height of the bars equals the percentages a functional knee phenotype represents within the female/male population).

minimum follow up of 5 years, Hooper [23] showed a small, yet statistically significant difference between male and female patients. Despite scoring lower on both preoperative and 5-year postoperative High-Activity Arthroplasty Score and Oxford knee score (OKS), women manifested a superior improvement in mean OKS, suggesting an enhanced benefit from the procedure. Additionally, Sébilo et al. [44], in a large-scale retrospective multicentre study encompassing 944 UKAs with a mean follow-up of 5.2 years, reported the only significant gender-related difference was superior preoperative IKS function score in male patients. This observation is concordant with our findings underscoring superior function and activity level in the male population translating to superior postoperative function but no statistically significant difference with respect to scores improvement.

Kristensen et al. [30] in a series of 695 medial UKAs reported an overall 10-year survival rate of 85.3% with no discernible gender difference in survival rates. At the last follow-up, the predominant causes for revision were OA progression followed by aseptic loosening and pain, as described in more recent studies [4, 13, 31]. However, within the initial 2 years, the leading cause for revision mirrored our findings (tibial aseptic loosening). It could be postulated that older females may demonstrate a higher rate of aseptic loosening owing to poorer bone quality [9]. Notwithstanding this, consistent with the findings of Barret et al. in a meta-analysis of 96,294 knees [2], no gender differences were found with the age of females experiencing tibial loosening comparable to that of the control group. In the same vein, a recent retrospective cohort study by Foissey et al. [17] evaluated the distinct risk factors associated with this complication. The study unveiled that the majority of revisions attributable to tibial loosening occurred within the first 5 years postoperatively and that the combination of joint line lowering ≥2 mm and postoperative HKA ≤ 175° was associated with a 10-fold increase in the risk of tibial implant failure without any significant age or gender related impact.

With respect to the preoperative knee phenotype, it could be hypothesised that females would exhibit less VAR alignment compared to males [5, 18, 37, 42]. However, our study did not corroborate this and uncovered no significant differences. A limitation that should be considered when interpreting our findings is the UKA indications that could have introduced selection bias. This point is well highlighted by the difference between the functional knee phenotypes of our population with medial OA and a non-OA population where there is a different frequency of VAR and VAL knee OA according to gender [27, 50]. Moreover, one might have anticipated an increased risk of VAL overcorrection in women due to the reported tendency of having laxer collateral ligaments [11, 12]. However, no gender difference occurs in this regard.

Several limitations must be acknowledged for this study. Its retrospective design and the use of two different techniques (conventional and robotic assistance) and two different implants makes it prone to confounding and selection bias. In addition, procedures were carried out by several surgeons. However, surgical indications were standardised, all operating surgeons were past the learning curve, and the study reflects pragmatic practice. The limited number of patients (356 knees) is a source of lack of power, but to our knowledge it is one of the biggest numbers concerning medial UKA with a mid-term follow-up. Also, lack of blinding of radiological outcome assessors could have potentially introduced performance bias. Finally, our study utilised only one PROM and employing different scores might have revealed discordant results.

CONCLUSION

At a mean follow-up of 5 years, our study revealed no gender difference in clinical outcomes, complications, radiographic outcomes, implant positioning and knee phenotype in patients undergoing medial UKA.

AUTHOR CONTRIBUTIONS

Thibault Royon: Intellectual development; study design; data collection; x-rays measurements; literature review and manuscript writing. **Constant Foissey**: Intellectual development; study design; data collection, x-rays measurements; statistical analysis and manuscript editing. **Andreas Fontalis**: Manuscript editing. **Frederic Planchet**: Statistical analyses. **Elvire Servien**: Study design and manuscript editing. **Cécile Batailler**: Study design and manuscript editing. **Sébastien Lustig**: Intellectual development; study design; supervision; literature review and manuscript editing.

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CONFLICT OF INTEREST STATEMENT

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DATA AVAILABILITY STATEMENT

The data were collected on a nonanonymised excel file, the sharing of which complies with medical privacy requirements.

ETHICS STATEMENT

All procedures were performed in accordance with the ethical standards of the institutional and/or national research committee, the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The Advisory Committee on Research Information Processing in the Field of Health (CCTIRS) approved this study in Paris on 17 February 2016 (number 16–140). As per institutional standards, this type of study did not necessitate formal patient consent. The study was approved by our hospital's (Hospices Civils de Lyon) Institutional Review Board (study ID Number: 69HCL17_0512). As per institutional standards, formal patient consent was not required for this type of study.

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