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Patients with isolated lateral osteoarthritis: Unicompartmental or total knee arthroplasty?

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ABSTRACT

Background: Lateral unicompartmental knee arthroplasty (UKA) and total knee arthroplasty (TKA) are both reliable treatment options for patients with isolated lateral osteoarthritis (OA). However, studies comparing both procedures are scarce. Aims of this study were to (I) compare short-term functional outcomes following lateral UKA and TKA and (II) assess the role of patient characteristics on outcomes as measured by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC).
Methods: In this retrospective cohort study, 82 patients (48 undergoing lateral UKA and 34 undergoing TKA) were identified that presented with lateral OA and completed the WOMAC. Independent t-tests were used to compare outcomes following lateral UKA and TKA.
Results: Mean follow-up was 2.8 years (range: 2.0 – 5.0 years). Preoperatively, no differences between lateral UKA and TKA were seen (50.1 ± 13.5 and 53.3 ± 17.1, respectively, $p = 0.551$). Postoperatively, lateral UKA patients reported better overall outcomes than TKA (90.5 ± 11.7 vs. 81.8 ± 17.9, $p = 0.017$). Subgroup analysis showed better outcomes following lateral UKA than TKA in patients younger than 75 years (92.1 ± 9.9 vs. 81.3 ± 19.6, $p = 0.014$) and in females (91.6 ± 9.9 vs. 81.0 ± 18.2, $p = 0.014$).
Conclusion: These findings indicate that lateral UKA has superior short-term functional outcomes compared to TKA in patients with isolated lateral OA. Better outcomes were especially seen in younger patients and females. These findings may help orthopedic surgeons choose treatment for patients presenting with lateral OA and optimize treatment for individual patients.

1. Introduction

Unicompartmental knee arthroplasty (UKA) has gained popularity over the past decade for the treatment of isolated osteoarthritis (OA) [1–4]. Lateral UKA comprises only five to 10% of these procedures [3,5,6], while high-volume centers reportedly perform 17–23% of all UKA at the lateral side [7–9]. This discrepancy can be explained by several factors. Firstly, isolated lateral OA is less frequently encountered than medial OA and as a result, many authors consider lateral UKA to be more technically demanding [10–12]. Secondly, anatomic and kinematic differences exist between both compartments [12–17]. In particular, more laxity at the lateral compartment [13] has historically been associated with high incidence of bearing dislocation following mobile bearing lateral UKA, which further decreased the confidence in lateral UKA [18,19].

These factors suggest that lateral UKA may be an underutilized procedure in the setting of isolated lateral OA [9,20]. This represents a suboptimal situation given the benefits of UKA over total knee arthroplasty (TKA) including faster recovery [21,22], better range of motion [23], better functional outcomes [24,25], less complications [26,27], shorter hospital stay [27–29] and easier revisions [30]. On the other hand, several cohorts and registry data showed that survivorship of TKA is higher compared to that of lateral UKA [1,2,31].

A recent study stressed that lateral UKA leads to better functional outcomes and range of motion compared to TKA in the setting of isolated lateral OA [24]. However, no other studies have confirmed this finding to date. Furthermore, it remains undefined in which patients each option is preferable since distinct advantages exist for both treatment options. Therefore, the primary goal of this retrospective study was to compare short-term patient-reported outcomes following lateral UKA and TKA for the indication of isolated lateral OA. The secondary goal was to assess the role of patient characteristics on outcomes of lateral UKA and TKA in patients with lateral OA. Hypothesis of this study was that lateral UKA patients would report better outcomes than TKA patients, particularly in younger and non-obese patients.

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2. Methods

2.1. Study design

Following Institutional Review Board (IRB) approval (IRB-number 2013-056), an electronic search was performed in the database of the senior author (ADP) for patients who underwent lateral UKA or TKA surgery for the indication of lateral OA between September 2008 and April 2014. A total of 104 patients underwent lateral UKA (n = 61) or TKA (n = 43) for the indication of lateral OA. Inclusion criteria for the lateral UKA cohort were (I) primary indication of isolated lateral OA, (II) use of tibial onlay implants and (III) functional outcome scores between two-year and five-year follow-up. Inclusion criteria for the TKA cohort were (I) primary indication of isolated lateral OA, (II) functional outcome scores between two-year and five-year follow-up and (III) intact anterior cruciate ligament.

Included patients of both cohorts were radiographically checked for the primary indication of isolated lateral OA using the Kellgren–Lawrence (KL) score [32] and were excluded from either cohort if (I) there was OA presence of the medial compartment (KL score > 1) or if there was significant OA of the patellofemoral compartment (i.e. KL score > 2). This higher grade for patellofemoral OA was chosen since mild severity patellofemoral OA does not influence outcomes following UKA [33,34] and the patella was resurfaced in all TKA procedures. Finally, a radiographically matched cohort was created with patients that underwent arthroplasty treatment for the same indication of isolated lateral OA (Figure 1) and reported functional outcomes at short-term follow-up (Table 1).

Table 1
Patient demographics of patients undergoing lateral UKA and TKA.

	Lateral UKA (n = 48)		TKA (n = 34)		
	N	Mean (±SD)	N	Mean (±SD)	*p*-Value
Age (years)	48	66.2 (±12.1)	34	66.8 (±7.9)	0.771
BMI (kg/m^2)	46	26.6 (±4.7)	33	29.6 (±5.0)	0.007
Gender (M:F)	48	17:31	34	10:24	0.569
Side (R:L)	48	25:23	34	19:15	0.477
Follow-up (years; range)	48	2.7 (±1.1; 2.0–5.0)	34	2.9 (±1.3; 2.0–5.0)	0.555
OA severity MC	48	0.5 (±0.6)	34	0.7 (±0.5)	0.061
OA severity LC	46	2.8 (±0.7)	34	3.2 (±0.6)	0.004
OA severity PFC	47	0.7 (±0.7)	34	0.9 (±0.7)	0.236
Preoperative valgus	45	6.1 (±4.1)	27	7.7 (±5.3)	0.155
Postoperative valgus	46	2.8 (±2.5)	30	−0.5 (±2.6)	<0.001

UKA indicates unicompartmental knee arthroplasty; TKA, total knee arthroplasty; SD, standard deviation; BMI, body mass index; MC, medial compartment; LC, lateral compartment; PFC, patello-femoral compartment.

2.2. Surgical technique

The senior author (ADP) performed all UKA and TKA surgeries. In the beginning of this study period, the preference of the senior author was to perform TKA surgery while this later changed to lateral UKA surgery with the publication of encouraging literature on (lateral) UKA outcomes [35–38]. UKA surgery was performed using a robotic-assisted technique (MAKO Surgical Corp, Ft. Lauderdale, FL, USA) [39,40]. All UKA patients received a RESTORIS® MCK Lateral Onlay implant (MAKO Surgical Corp, Ft. Lauderdale, FL, USA). The goal of surgery was a postoperative valgus alignment in order to prevent progression of OA in the medial compartment [41,42]. TKA surgery was performed using image-based computer navigation-assisted technique using the Vanguard® Total Knee (Biomet, Warsaw, IN, USA) [43]. The goal of TKA surgery was neutral alignment [44] and the patella was resurfaced in all TKA procedures. All implants were cemented. None of the cases was converted intraoperatively from lateral UKA to TKA or vice versa.

2.3. Functional outcome measurements

Western Ontario and McMaster Universities Arthritis Index (WOMAC) scores were collected preoperatively and prospectively at routine follow-up. The WOMAC score is a Likert scale-based questionnaire, validated to assess knee joint OA [45,46]. It measures overall outcomes (24 questions in total), pain (five questions), stiffness (two questions) and function (17 questions). All scores were indexed with 0 as the worst possible score and 100 as the best possible score. Outcomes were reported as mean ± standard deviation (SD).

Forty-eight patients who underwent lateral UKA reported WOMAC scores postoperatively (mean follow-up 2.7 years; range 2.0–5.0 years) of which 18 completed the WOMAC survey preoperatively. Thirty-four patients who underwent TKA completed the WOMAC survey

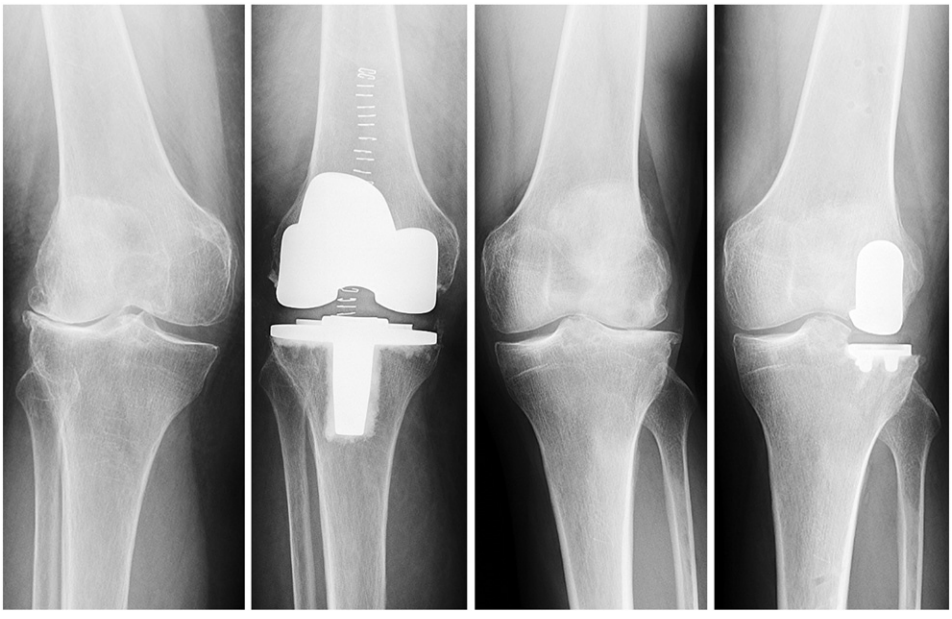

Figure 1. Pre- and postoperative radiographs are shown of two patients with isolated lateral osteoarthritis either treated with total knee arthroplasty (left) or unicompartmental knee arthroplasty (right).

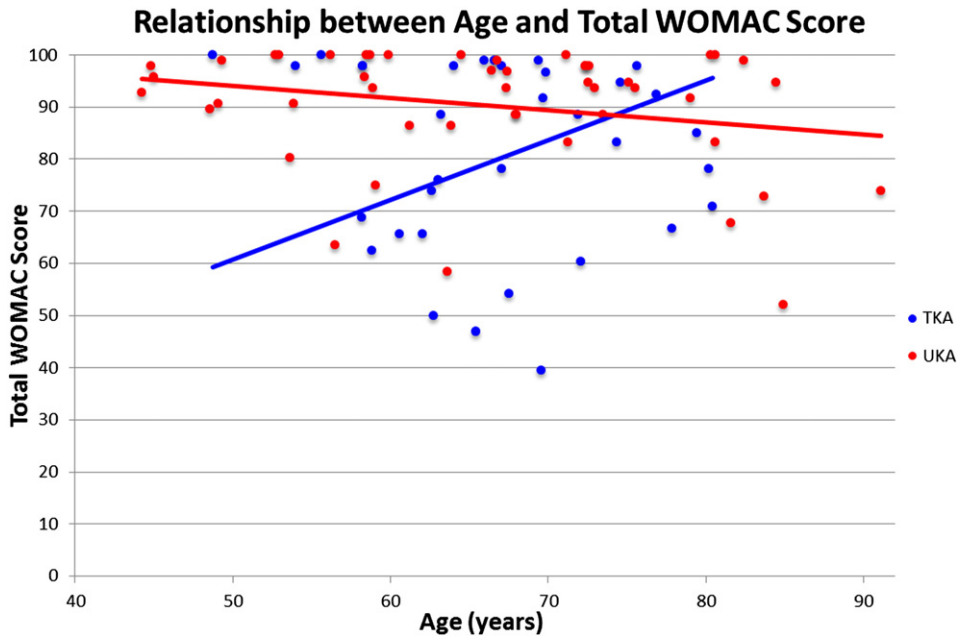

Figure 2. Correlation between WOMAC Total scores and age are shown for both lateral UKA and TKA. It was noted that younger patients undergoing TKA showed a trend of inferior outcomes when compared to younger UKA patients and older TKA patients. This is also seen in Table 3.

postoperatively (mean follow-up 2.9 years; range 2.0–5.0 years) of which 15 completed the questionnaire preoperatively.

2.4. Statistical analysis

Statistical analysis was performed using SPSS Version 21 (SPSS Inc., Armonk, NY, USA). Independent t-tests and chi-square tests were used to compare WOMAC scores preoperatively and postoperatively, length of stay and reoperation rates between patients undergoing lateral UKA and TKA. Subgroups were analyzed by age (i.e. <75 vs. ≥75 years), body mass index (BMI) (i.e. <30 vs. ≥30 kg/m^2) and gender (i.e. female vs. male). Furthermore, all outcome scores were plotted against age and BMI in a scatter plot graph using Microsoft Excel 2011 (Microsoft Corp., Redmond, WA, USA) (Figures 2 and 3). Multilinear regression analysis was performed to assess if type of arthroplasty was a significant predictor for functional outcomes when corrected for BMI and OA severity of the lateral compartment since these factors were significantly different between both groups (Table 1). All tests were two-sided and with significance if $p < 0.05$.

In order to estimate the sample size, a standard deviation of 12.0 (preliminary data) was used with an alpha of 0.05, 80% power and an enrollment ratio of 1.3:1. It was calculated that 26 lateral UKA and 20 TKA patients were necessary in order to show a clinically relevant difference in a total WOMAC score of 10.0 points.

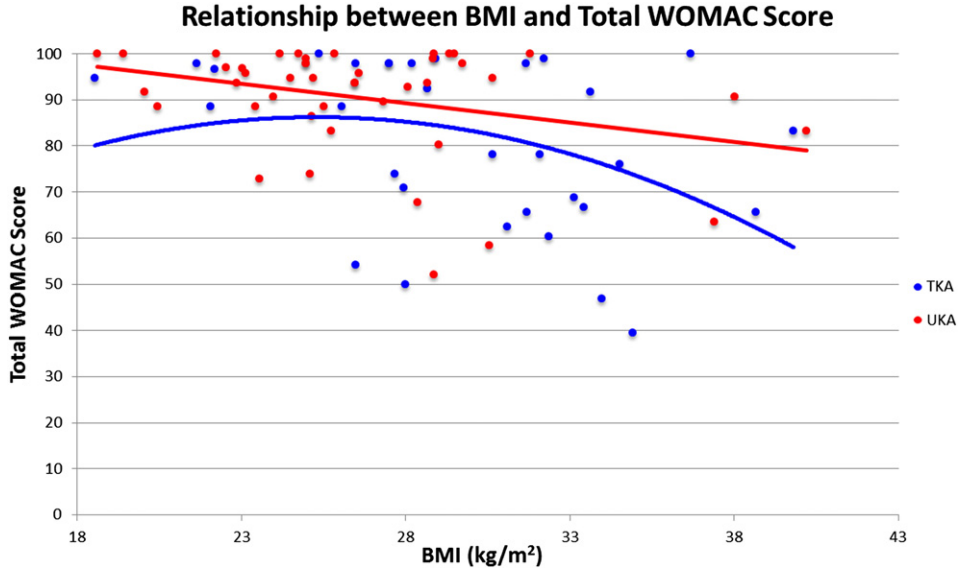

Figure 3. Correlation between WOMAC Total scores and BMI are shown for both lateral UKA and TKA. It is noted that for both procedures less optimal outcomes are seen in obese patients when compared to non-obese patients. It can also be seen that non-obese patients undergoing TKA reported better outcomes than obese patients undergoing TKA. This is also noted in Table 4.

Table 2
Preoperative and postoperative WOMAC scores following lateral UKA and TKA for the indication of lateral osteoarthritis.

	Lateral UKA (n = 48)		TKA (n = 34)		*p*-Value
	N	Mean (±SD)	N	Mean (±SD)	
Preoperative total	18	50.1 (±13.5)	15	53.3 (±17.1)	0.551
Preoperative pain	18	54.2 (±13.6)	15	54.3 (±18.1)	0.976
Preoperative stiffness	18	46.0 (±19.2)	15	45.2 (±20.8)	0.909
Preoperative function	18	50.0 (±14.1)	15	53.9 (±17.5)	0.480
Postoperative total	48	90.5 (±11.7)	34	81.8 (±17.9)	0.017
Postoperative pain	48	92.5 (±11.1)	34	86.0 (±14.9)	0.036
Postoperative stiffness	48	86.6 (±16.3)	34	76.6 (±19.4)	0.024
Postoperative function	48	90.2 (±12.6)	34	80.7 (±19.3)	0.015

UKA indicates unicompartmental knee arthroplasty; TKA, total knee arthroplasty; SD, standard deviation; WOMAC, Western Ontario and McMaster Universities Arthritis Index.

Table 4
Postoperative WOMAC scores following lateral UKA and TKA for the indication of isolated lateral osteoarthritis stratified by BMI.

		Lateral UKA		TKA		*p*-Value
BMI		N	Mean (±SD)	N	Mean (±SD)	
<30	Postoperative total	39	92.1 (±10.8)	17	89.1 (±15.6)	0.406
	Postoperative pain	39	93.3 (±10.8)	17	92.4 (±11.5)	0.757
	Postoperative stiffness	39	89.5 (±15.0)	17	81.8 (±16.6)	0.072
	Postoperative function	39	91.9 (±11.9)	17	88.1 (±17.4)	0.330
≥30	Postoperative total	7	84.3 (±17.0)	16	73.9 (±16.6)	0.204
	Postoperative pain	7	89.3 (±15.1)	16	79.1 (±15.7)	0.162
	Postoperative stiffness	7	78.7 (±21.4)	16	69.6 (±27.3)	0.445
	Postoperative function	7	83.0 (±16.9)	16	72.8 (±19.3)	0.238

UKA indicates unicompartmental knee arthroplasty; TKA, total knee arthroplasty; WOMAC, Western Ontario and McMaster Universities Arthritis Index; BMI, body mass index.

3. Results

3.1. Preoperative data

Demographic data revealed no differences in age, follow-up length, gender, side or OA severity of the medial compartment or patellofemoral compartment. Higher BMI and more severe lateral compartment OA were present in patients undergoing TKA (Table 1). Preoperatively, no significant and, more importantly, no clinically relevant differences were observed between patients undergoing lateral UKA or TKA in overall outcomes (50.1 ± 12.8 and 53.3 ± 17.1, respectively, $p = 0.551$) and all subdomains (Table 2).

3.2. Lateral UKA vs. TKA

At follow-up, patients undergoing lateral UKA had significantly better overall outcomes (90.5 ± 11.7 vs. 81.8 ± 17.9, $p = 0.017$), less pain (92.5 ± 11.1 vs. 86.0 ± 14.9, $p = 0.036$), less stiffness (86.6 ± 16.3 vs. 76.6 ± 19.4, $p = 0.024$) and better function (90.2 ± 12.6 vs. 80.7 ± 19.3, $p = 0.015$) than patients undergoing TKA (Table 2). Regression analysis showed that lateral UKA outcomes were better than TKA outcomes ($p = 0.036$) when corrected for BMI and OA severity of lateral compartment.

No perioperative complications or revisions were reported in both groups at short-term follow-up. Three re-operations of manipulation under anesthesia were performed in the TKA group and one re-operation of partial medial meniscectomy with synovectomy was performed in the lateral UKA group for recurrent hemarthrosis. This was not statistically different ($p = 0.163$).

Median and mean postoperative lengths of stay were two and 2.6 ± 1.0 days (range: one to five), respectively, in the lateral UKA group. This was significantly shorter ($p < 0.001$) when compared to length of stay following TKA surgery (mean 3.9 ± 1.1 days, range: three to seven, median four).

3.3. Lateral UKA vs. TKA in subgroups

In patients younger than 75 years, lateral UKA patients reported better overall outcomes (92.1 ± 9.9 vs. 81.3 ± 19.6, $p = 0.014$), less pain and better function (Table 3). In patients older than 75 years, neither significant nor clinically relevant differences were observed between lateral UKA and TKA (Table 3, Figure 2).

In patients with BMI below 30, no differences were noted between patients undergoing lateral UKA and TKA in overall outcome (92.1 ± 10.8 vs. 89.1 ± 15.6, $p = 0.406$) and stiffness, pain or function (Table 4). Similarly, in patients with high BMI, no significant differences were seen, although the number of patients in the lateral UKA group was low (Table 4, Figure 3).

In females, it was noted that patients undergoing lateral UKA reported better overall outcomes (91.6 ± 9.9 vs. 81.0 ± 18.2, $p = 0.014$), less pain (93.4 ± 10.0 vs. 84.8 ± 16.3, $p = 0.029$), less stiffness (88.4 ± 14.4 vs. 73.0 ± 24.6, $p = 0.010$) and better function (91.3 ± 10.9 vs. 80.7 ± 19.2, $p = 0.021$) when compared to TKA (Table 5). In males neither statistically significant nor clinically relevant differences were noted between lateral UKA patients and TKA patients in pain (90.3 ± 13.0 vs. 89.0 ± 11.0, respectively, $p = 0.705$), stiffness (83.2 ± 19.2 vs. 85.1 ± 16.5, respectively, $p = 0.800$) and function (88.1 ± 15.3 vs. 80.6 ± 20.8, respectively, $p = 0.291$) and thus overall outcomes (Table 5).

4. Discussion

The main finding of this study was that in the setting of isolated lateral OA, patients undergoing lateral UKA reported better functional outcomes than those undergoing TKA at short-term follow-up and

Table 3
Postoperative WOMAC scores following lateral UKA and TKA for the indication of isolated lateral osteoarthritis stratified by age.

		Lateral UKA		TKA		*p*-Value
Age		N	Mean (±SD)	N	Mean (±SD)	
<75	Postoperative total	36	92.1 (±9.9)	26	81.3 (±19.6)	0.014
	Postoperative pain	36	93.8 (±9.4)	26	84.4 (±16.3)	0.013
	Postoperative stiffness	36	85.2 (±16.3)	26	76.1 (±25.2)	0.088
	Postoperative function	36	92.3 (±10.4)	26	80.2 (±20.8)	0.010
≥75	Postoperative total	12	85.4 (±15.4)	8	83.6 (±11.2)	0.781
	Postoperative pain	12	88.8 (±15.1)	8	91.3 (±7.4)	0.671
	Postoperative stiffness	12	90.7 (±16.1)	8	78.3 (±14.4)	0.095
	Postoperative function	12	83.8 (±16.6)	8	82.3 (±14.6)	0.829

UKA indicates unicompartmental knee arthroplasty; TKA, total knee arthroplasty; WOMAC, Western Ontario and McMaster Universities Arthritis Index.

Table 5
Postoperative WOMAC scores following lateral UKA and TKA for the indication of isolated lateral osteoarthritis stratified by gender.

		Lateral UKA		TKA		*p*-value
Gender		N	Mean (±SD)	N	Mean (±SD)	
Males	Postoperative total	17	88.3 (±14.5)	10	83.9 (±18.0)	0.494
	Postoperative pain	17	90.9 (±13.0)	10	89.0 (±11.0)	0.705
	Postoperative stiffness	17	83.2 (±19.2)	10	85.1 (±16.5)	0.800
	Postoperative function	17	88.1 (±15.3)	10	80.6 (±20.8)	0.291
Females	Postoperative total	31	91.6 (±9.9)	24	81.0 (±18.2)	0.014
	Postoperative pain	31	93.4 (±10.0)	24	84.8 (±16.3)	0.029
	Postoperative stiffness	31	88.4 (±14.4)	24	73.0 (±24.6)	0.010
	Postoperative function	31	91.3 (±10.9)	24	80.7 (±19.2)	0.021

UKA indicates unicompartmental knee arthroplasty; TKA, total knee arthroplasty; WOMAC, Western Ontario and McMaster Universities Arthritis Index.

these patients had significantly shorter postoperative length of stay. Lateral UKA was the preferred treatment in (1) patients younger than 75 years and (2) females. Furthermore, no clinically relevant differences in outcomes were found between both treatments in the groups of patients above 75 years, males and non-obese patients.

Several limitations exist in this study, which can mostly be contributed to the relatively low incidence of isolated lateral OA. The first limitation was that this study was non-randomized, which includes a potential selection bias. The findings of this study suggest that the underutilization of lateral UKA in the setting of lateral OA may be suboptimal in treating these patients and a randomized prospective study for these patients is necessary. Furthermore, due to the low incidence of lateral OA, we had to be selective in the matching process and patients could not be further matched for BMI. However, multilinear regression analysis showed that type of arthroplasty treatment was still a significant factor when corrected for BMI and preoperative lateral compartment OA. Furthermore, no differences preoperative in outcome scores were noted while patients in both treatment groups were not different in age, gender, side, follow-up length and preoperative OA severity, which suggest that both groups were similar preoperatively.

Secondly, due to the limited number of patients, analysis in the high BMI group, males and older patients were underpowered. In the male group and older patients the differences were not clinically relevant but the differences may have been clinically relevant in the high BMI group. Future studies should aim to confirm our findings and assess the role of BMI in the setting of isolated lateral OA. Thirdly, preoperative data was lacking in some patients and therefore no analysis of outcome improvement could be performed. Because preoperative outcome scores and patient characteristics between both groups were neither significant nor clinically relevant, we feel that enough patients had preoperative data to show that the preoperative situation was similar for both groups. Moreover, because TKA patients even had slightly better preoperative scores, measuring a change in outcome scores would probably show a stronger preference for lateral UKA in the setting of isolated lateral OA. Finally, a change in the preference of the senior author existed during the time period and it is possible that hospital regulations or general precautions in the operating room may have caused a difference in treatment. However, both procedures were performed throughout the entire study period and no difference in follow-up length was noted between both groups. Despite these limitations, this study is, to our knowledge, the largest study comparing short-term patient-reported outcomes following lateral UKA and TKA in the setting of isolated lateral OA. Furthermore, this is the first study comparing both treatment options in several subgroups.

After radiographically matching patients, it was observed that patients undergoing lateral UKA reported better overall outcomes, less stiffness and better function than patients undergoing TKA (Table 2) and differences were considered to be large enough to be clinically relevant [47]. It was noted that higher BMI and more severe lateral OA were present in the TKA group. Although it is suggested that these factors may be important confounders in outcomes of UKA and TKA [48–50], regression analysis showed that type of arthroplasty was a significant predictor of functional outcomes when correcting for these factors. Comparing our outcomes with other studies in the literature, several studies have similarly reported better functional outcomes following UKA versus TKA. Liddle et al. performed a comparison between UKA of either compartment and TKA in a national registry [51]. Matching patients by age, BMI, preoperative outcome scores and comorbidities, they showed that UKA patients had higher Oxford Knee Score (OKS) compared to TKA at a six-month follow-up.

Similarly, Newman et al. found in a randomized controlled trial that more patients reported excellent outcomes following UKA versus TKA at a 15-year follow-up [35]. One study specifically compared lateral UKA to TKA [24]. Walker et al. reported OKS scores following 22 patients undergoing lateral UKA versus 22 patients undergoing TKA using a similar method as this current study. They recommended lateral UKA for patients with higher functional demands although cautioning that slightly more revisions may occur following UKA [24]. Furthermore, the finding of shorter length of hospital stay following UKA has also been commonly found in the literature [27–29], although this is the first study showing this difference for lateral UKA treatment. This finding was not only significant but also clinically relevant with a median stay of two days following lateral UKA and four days following TKA. The findings of this study and findings in the literature suggest that lateral UKA is the preferred treatment for isolated lateral OA with regard to functional outcomes.

Several studies, however, have also shown that good results can be achieved with TKA in the setting of isolated lateral OA [52,53] and that TKA survivorship is generally higher than UKA survivorship [1,2,54]. It is therefore important to assess what the outcomes of UKA or TKA are in different patient populations for patients with lateral OA. This study is, to our opinion, unique in the fact that direct comparison of lateral UKA and TKA is performed in several patient subgroups with the same radiographic indication. The results of this study show that in patients younger than 75 years of age lateral UKA is the preferred treatment for isolated lateral OA with regard to functional outcomes. In patients older than 75 years no significant difference was noted between both treatments, which may be explained by the small groups. However and more importantly, no clinically relevant differences were noted between UKA and TKA in this group with a 1.8-WOMAC score difference. When reviewing the trend lines in Figure 2, it can similarly be noted that young patients undergoing TKA reported inferior outcomes when compared to young UKA patients and older TKA patients. These findings could be explained by fact that younger patients have higher demands in combination with the fact that several advantages of UKA exist over TKA with regard to faster recovery [21,22,24] and better range of motion [23,24].

Several studies have assessed the role of age on functional outcomes in patients undergoing UKA [55,56]. Von Keudell et al. compared functional outcomes following UKA and TKA in different age groups [56]. They found that in younger patients, UKA treatment was also associated with better outcomes in pain, motion and kneeling ability than TKA. In older patients, however, TKA was associated with better outcomes for these parameters. Similar results were found in this current study indicating that lateral UKA may indeed be the preferred treatment in younger patients with regard to function. In older patients, the results of this current study indicate that both procedures tend to do well with no clinically relevant difference, which might be explained by the fact that in these patients the limitations of TKA, such as less range of motion [23,24] and more return to sports [57], may be less relevant. In this subgroup, other factors such as patient expectations and level of daily activity should be considered for choosing the optimal treatment.

Interestingly, it was noted that in females significantly better outcomes were reported with regard to pain, stiffness and function following lateral UKA than following TKA for isolated lateral OA. In males, however, no significant differences were noted between both treatment options for overall outcomes, pain, stiffness and function. Although the analysis in males is underpowered, the differences, with the highest WOMAC difference of 4.4 points, are likely not large enough to be clinically relevant [47]. Differences in outcomes between genders have not been reported before in the literature for UKA [58–61]. Lustig et al. assessed the role of gender in UKA and reported no differences in functional outcomes between males and females [58]. Other studies also showed that no significant differences exist between genders with regard to UKA survivorship [59–61].

However, in the literature of TKA, some authors have reported that females have significantly inferior outcomes when compared to males [62–65]. This is commonly attributed to the fact that females have smaller femoral condyles and different ratios of anatomic landmarks, while implants are used that are designed according to male anatomy and it is thought that this discrepancy

may lead to pain and inferior outcomes [63,65]. Several authors over the recent years have therefore suggested the usage of gender-specific implant designs [62,64]. We could not clearly identify if differences in outcomes between genders could be explained by UKA, TKA or both and we feel more research in this field of interest is necessary. Results of this study suggest that gender may play a role in the treatment algorithm of patients with lateral OA and that lateral UKA may be the preferred treatment in females with lateral OA. This information might help the orthopedic surgeon in managing patient expectations.

With regard to BMI, however, no preference for one arthroplasty treatment could be detected in the high or low BMI group. In the literature the role of BMI has been widely discussed. Some authors reported that a higher BMI negatively influences the outcomes of UKA [49,55,66] and TKA [48,67] while others reported that BMI does not influence outcomes of these procedures [9,68–72]. When evaluating our results, larger differences in outcomes of TKA patients were noted between non-obese and obese patients when compared to UKA patients. Looking at Figure 3, trend lines show a similar pattern with a strong decrease in functional outcomes following TKA in higher BMI patients when compared to low BMI patients while a similar, but less strong pattern, is seen for UKA. Several authors have reported worse outcome scores with increasing BMI in patients undergoing UKA [49,55,66] and TKA [48,67]. However, to our opinion, none of the studies have directly compared the influence of BMI on the outcomes of these arthroplasty treatments. Our results may suggest that, in the setting of lateral OA, BMI may have a stronger influence on patients undergoing TKA when compared to lateral UKA. However, larger comparative studies are clearly needed to confirm these findings.

5. Conclusion

Results of this retrospective study showed that patients reported superior functional outcomes following lateral UKA when compared to TKA in the setting of isolated lateral OA. Furthermore, lateral UKA appears to be the preferred treatment in patients younger than 75 years and in females. These findings might help the orthopedic surgeon in individualizing arthroplasty treatment for patients who present with isolated lateral OA and managing patient expectations.

Conflict of interest

The authors declare that they have no conflict of interest.

References

[1] Annual report 2013 Swedish Knee Arthroplasty Register; 2013.
[2] Annual report 2014 Australian Hip and Knee Arthroplasty Register; 2014.
[3] Baker PN, Jameson SS, Deehan DJ, Gregg PJ, Porter M, Tucker K. Mid-term equivalent survival of medial and lateral unicondylar knee replacement: an analysis of data from a National Joint Registry. J Bone Joint Surg (Br) 2012;94:1641–8.
[4] Riddle DL, Jiranek WA, McGlynn FJ. Yearly incidence of unicompartmental knee arthroplasty in the United States. J Arthroplasty 2008;23:408–12.
[5] Lewold S, Robertsson O, Knutson K, Lidgren L. Revision of unicompartmental knee arthroplasty: outcome in 1,135 cases from the Swedish Knee Arthroplasty study. Acta Orthop Scand 1998;69:469–74.
[6] Pennington DW, Swienckowski JJ, Lutes WB, Drake GN. Lateral unicompartmental knee arthroplasty: survivorship and technical considerations at an average follow-up of 12.4 years. J Arthroplasty 2006;21:13–7.
[7] Heyse TJ, Khefacha A, Peersman G, Cartier P. Survivorship of UKA in the middle-aged. Knee 2012;19:585–91.
[8] Liebs TR, Herzberg W. Better quality of life after medial versus lateral unicondylar knee arthroplasty knee. Clin Orthop Relat Res 2013;471:2629–40.
[9] Xing Z, Katz J, Jiranek W. Unicompartmental knee arthroplasty: factors influencing the outcome. J Knee Surg 2012;25:369–73.
[10] Demange MK, Von Keudell A, Probst C, Yoshioka H, Gomoll AH. Patient-specific implants for lateral unicompartmental knee arthroplasty. Int Orthop 2015;39:1519–26.
[11] Ollivier M, Abdel MP, Parratte S, Argenson JN. Lateral unicondylar knee arthroplasty (UKA): contemporary indications, surgical technique, and results. Int Orthop 2014;38:449–55.
[12] Scott RD. Lateral unicompartmental replacement: a road less traveled. Orthopedics 2005;28:983–4.
[13] Bare JV, Gill HS, Beard DJ, Murray DW. A convex lateral tibial plateau for knee replacement. Knee 2006;13:122–6.
[14] Hill PF, Vedi V, Williams A, Iwaki H, Pinskerova V, Freeman MA. Tibiofemoral movement 2: the loaded and unloaded living knee studied by MRI. J Bone Joint Surg (Br) 2000;82:1196–8.
[15] Iwaki H, Pinskerova V, Freeman MA. Tibiofemoral movement 1: the shapes and relative movements of the femur and tibia in the unloaded cadaver knee. J Bone Joint Surg (Br) 2000;82:1189–95.
[16] Nakagawa S, Kadoya Y, Todo S, Kobayashi A, Sakamoto H, Freeman MA, et al. Tibiofemoral movement 3: full flexion in the living knee studied by MRI. J Bone Joint Surg (Br) 2000;82:1199–200.
[17] Weidow J, Mars I, Karrholm J. Medial and lateral osteoarthritis of the knee is related to variations of hip and pelvic anatomy. Osteoarthritis Cartilage 2005;13:471–7.
[18] Gunther TV, Murray DW, Miller R, Wallace DA, Carr AJ, O'Connor JJ, et al. Lateral unicompartmental arthroplasty with the Oxford meniscal knee. Knee 1996;3:33–9.
[19] Pandit H, Jenkins C, Beard DJ, Price AJ, Gill HS, Dodd CA, et al. Mobile bearing dislocation in lateral unicompartmental knee replacement. Knee 2010;17:392–7.
[20] Schindler OS, Scott WN, Scuderi GR. The practice of unicompartmental knee arthroplasty in the United Kingdom. J Orthop Surg (Hong Kong) 2010;18:312–9.
[21] Lombardi Jr AV, Berend KR, Walter CA, Aziz-Jacobo J, Cheney NA. Is recovery faster for mobile-bearing unicompartmental than total knee arthroplasty? Clin Orthop Relat Res 2009;467:1450–7.
[22] Smith TO, Chester R, Glasgow MM, Donell ST. Accelerated rehabilitation following Oxford unicompartmental knee arthroplasty: five-year results from an independent centre. Eur J Orthop Surg Traumatol 2012;22:151–8.
[23] Laurencin CT, Zelicof SB, Scott RD, Ewald FC. Unicompartmental versus total knee arthroplasty in the same patient. A comparative study. Clin Orthop Relat Res 1991;151-6.
[24] Walker T, Gotterbarm T, Bruckner T, Merle C, Streit MR. Total versus unicompartmental knee replacement for isolated lateral osteoarthritis: a matched-pairs study. Int Orthop 2014;38:2259–64.
[25] Zuiderbaan HA, van der List JP, Khamaisy S, Nawabi DH, Thein R, Ishmael C, et al. Unicompartmental knee arthroplasty versus total knee arthroplasty: which type of artificial joint do patients forget? Knee Surg Sports Traumatol Arthrosc 2015.
[26] Arirachakaran A, Choowit P, Putananon C, Muangsiri S, Kongtharvonskul J. Is unicompartmental knee arthroplasty (UKA) superior to total knee arthroplasty (TKA)? A systematic review and meta-analysis of randomized controlled trial. Eur J Orthop Surg Traumatol 2015;25:799–806.
[27] Robertsson O, Borgquist L, Knutson K, Lewold S, Lidgren L. Use of unicompartmental instead of tricompartmental prostheses for unicompartmental arthrosis in the knee is a cost-effective alternative. 15,437 primary tricompartmental prostheses were compared with 10,624 primary medial or lateral unicompartmental prostheses. Acta Orthop Scand 1999;70:170–5.
[28] Drager J, Hart A, Khalil JA, Zukor DJ, Bergeron SG, Antoniou J. Shorter hospital stay and lower 30-day readmission after unicondylar knee arthroplasty compared to total knee arthroplasty. J Arthroplasty 2016;31:356–61.
[29] Yang KY, Wang MC, Yeo SJ, Lo NN. Minimally invasive unicondylar versus total condylar knee arthroplasty—early results of a matched-pair comparison. Singapore Med J 2003;44:559–62.
[30] Siddiqui NA, Ahmad ZM. Revision of unicondylar to total knee arthroplasty: a systematic review. Open Orthop J 2012;6:268–75.
[31] van der List JP, McDonald LS, Pearle AD. Systematic review of medial versus lateral survivorship in unicompartmental knee arthroplasty. Knee 2015.
[32] Kellgren JH, Lawrence JS. Radiological assessment of osteo-arthrosis. Ann Rheum Dis 1957;16:494–502.
[33] Thein R, Zuiderbaan HA, Khamaisy S, Nawabi DH, Poultsides LA, Pearle AD. Medial unicondylar knee arthroplasty improves patellofemoral congruence: a possible mechanistic explanation for poor association between patellofemoral degeneration and clinical outcome. J Arthroplasty 2015;30:1917–22.
[34] van der List JP, Chawla H, Zuiderbaan HA, Pearle AD. Patient selection criteria for unicompartmental knee arthroplasty: a meta-analysis critique. J Arthroplasty 2016.
[35] Newman J, Pydisetty RV, Ackroyd C. Unicompartmental or total knee replacement: the 15-year results of a prospective randomised controlled trial. J Bone Joint Surg (Br) 2009;91:52–7.
[36] Noticewala MS, Geller JA, Lee JH, Macaulay W. Unicompartmental knee arthroplasty relieves pain and improves function more than total knee arthroplasty. J Arthroplasty 2012;27:99–105.
[37] Lygre SH, Espehaug B, Havelin LI, Furnes O, Vollset SE. Pain and function in patients after primary unicompartmental and total knee arthroplasty. J Bone Joint Surg Am 2010;92:2890–7.
[38] Lustig S, Elguindy A, Servien E, Fary C, Munini E, Demey G, et al. 5- to 16-year follow-up of 54 consecutive lateral unicondylar knee arthroplasties with a fixed-all polyethylene bearing. J Arthroplasty 2011;26:1318–25.
[39] Pearle AD, O'Loughlin PF, Kendoff DO. Robot-assisted unicompartmental knee arthroplasty. J Arthroplasty 2010;25:230–7.
[40] Werner SD, Stonestreet M, Jacofsky DJ. Makoplasty and the accuracy and efficacy of robotic-assisted arthroplasty. Surg Technol Int 2014;24:302–6.
[41] Ohdera T, Tokunaga J, Kobayashi A. Unicompartmental knee arthroplasty for lateral gonarthrosis: midterm results. J Arthroplasty 2001;16:196–200.
[42] van der List JP, Chawla H, Villa JC, Zuiderbaan HA, Pearle AD. Early functional outcome after lateral UKA is sensitive to postoperative lower limb alignment. Knee Surg Sports Traumatol Arthrosc 2015.
[43] Lombardi Jr AV, Berend KR, Adams JB. Patient-specific approach in total knee arthroplasty. Orthopedics 2008;31:927–30.

[44] Kim YH, Park JW, Kim JS, Park SD. The relationship between the survival of total knee arthroplasty and postoperative coronal, sagittal and rotational alignment of knee prosthesis. Int Orthop 2014;38:379–85.
[45] Bellamy N, Campbell J, Hill J, Band P. A comparative study of telephone versus onsite completion of the WOMAC 3.0 osteoarthritis index. J Rheumatol 2002;29:783–6.
[46] Bellamy N, Campbell J, Stevens J, Pilch L, Stewart C, Mahmood Z. Validation study of a computerized version of the Western Ontario and McMaster Universities VA3.0 Osteoarthritis Index. J Rheumatol 1997;24:2413–5.
[47] Escobar A, Quintana JM, Bilbao A, Arostegui I, Lafuente I, Vidaurreta I. Responsiveness and clinically important differences for the WOMAC and SF-36 after total knee replacement. Osteoarthritis Cartilage 2007;15:273–80.
[48] Si HB, Zeng Y, Shen B, Yang J, Zhou ZK, Kang PD, et al. The influence of body mass index on the outcomes of primary total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 2015;23:1824–32.
[49] Murray DW, Pandit H, Weston-Simons JS, Jenkins C, Gill HS, Lombardi AV, et al. Does body mass index affect the outcome of unicompartmental knee replacement? Knee 2013;20:461–5.
[50] Peck CN, Childs J, McLauchlan GJ. Inferior outcomes of total knee replacement in early radiological stages of osteoarthritis. Knee 2014;21:1229–32.
[51] Liddle AD, Pandit H, Judge A, Murray DW. Patient-reported outcomes after total and unicompartmental knee arthroplasty: a study of 14,076 matched patients from the National Joint Registry for England and Wales. Bone Joint J 2015;97-B:793–801.
[52] Rajgopal A, Dahiya V, Vasdev A, Kochhar H, Tyagi V. Long-term results of total knee arthroplasty for valgus knees: soft-tissue release technique and implant selection. J Orthop Surg (Hong Kong) 2011;19:60–3.
[53] Rossi R, Rosso F, Cottino U, Dettoni F, Bonasia DE, Bruzzone M. Total knee arthroplasty in the valgus knee. Int Orthop 2014;38:273–83.
[54] Lyons MC, MacDonald SJ, Somerville LE, Naudie DD, McCalden RW. Unicompartmental versus total knee arthroplasty database analysis: is there a winner? Clin Orthop Relat Res 2012;470:84–90.
[55] Thompson SA, Liabaud B, Nellans KW, Geller JA. Factors associated with poor outcomes following unicompartmental knee arthroplasty: redefining the "classic" indications for surgery. J Arthroplasty 2013;28:1561–4.
[56] Von Keudell A, Sodha S, Collins J, Minas T, Fitz W, Gomoll AH. Patient satisfaction after primary total and unicompartmental knee arthroplasty: an age-dependent analysis. Knee 2014;21:180–4.
[57] Witjes S, Gouttebarge V, Kuijer PP, van Geenen RC, Poolman RW, Kerkhoffs GM. Return to sports and physical activity after total and unicondylar knee arthroplasty: a systematic review and meta-analysis. Sports Med (Auckland, NZ) 2016;46:269–92.
[58] Lustig S, Barba N, Magnussen RA, Servien E, Demey G, Neyret P. The effect of gender on outcome of unicompartmental knee arthroplasty. Knee 2012;19:176–9.
[59] Bruni D, Gagliardi M, Akkawi I, Raspugli GF, Bignozzi S, Marko T, et al. Good survivorship of all-polyethylene tibial component UKA at long-term follow-up. Knee Surg Sports Traumatol Arthrosc 2014.
[60] Kuipers BM, Kollen BJ, Bots PC, Burger BJ, van Raay JJ, Tulp NJ, et al. Factors associated with reduced early survival in the Oxford phase III medial unicompartment knee replacement. Knee 2010;17:48–52.
[61] Matharu G, Robb C, Baloch K, Pynsent P. The Oxford medial unicompartmental knee replacement: survival and the affect of age and gender. Knee 2012;19:913–7.
[62] Cherian JJ, O'Connor MI, Robinson K, Jauregui JJ, Adleberg J, Mont MA. A prospective, longitudinal study of outcomes following total knee arthroplasty stratified by gender. J Arthroplasty 2015;30:1372–7.
[63] Johnson AJ, Costa CR, Mont MA. Do we need gender-specific total joint arthroplasty? Clin Orthop Relat Res 2011;469:1852–8.
[64] Keeney JA, Nunley RM, Wright RW, Barrack RL, Clohisy JC. Are younger patients undergoing TKAs appropriately characterized as active? Clin Orthop Relat Res 2014;472:1210–6.
[65] Xie X, Lin L, Zhu B, Lu Y, Lin Z, Li Q. Will gender-specific total knee arthroplasty be a better choice for women? A systematic review and meta-analysis. Eur J Orthop Surg Traumatol 2014;24:1341–9.
[66] Bonutti PM, Goddard MS, Zywiel MG, Khanuja HS, Johnson AJ, Mont MA. Outcomes of unicompartmental knee arthroplasty stratified by body mass index. J Arthroplasty 2011;26:1149–53.
[67] McElroy MJ, Pivec R, Issa K, Harwin SF, Mont MA. The effects of obesity and morbid obesity on outcomes in TKA. J Knee Surg 2013;26:83–8.
[68] Baker P, Muthumayandi K, Gerrand C, Kleim B, Bettinson K, Deehan D. Influence of body mass index (BMI) on functional improvements at 3 years following total knee replacement: a retrospective cohort study. PLoS One 2013;8, e59079.
[69] Cavaignac E, Lafontan V, Reina N, Pailhe R, Wargny M, Laffosse JM, et al. Obesity has no adverse effect on the outcome of unicompartmental knee replacement at a minimum follow-up of seven years. Bone Joint J 2013;95-B:1064–8.
[70] Lash H, Hooper G, Hooper N, Frampton C. Should a patients BMI status be used to restrict access to total hip and knee arthroplasty? Functional outcomes of arthroplasty relative to BMI—single centre retrospective review. Open Orthop J 2013;7:594–9.
[71] Liao CD, Huang YC, Lin LF, Huang SW, Liou TH. Body mass index and functional mobility outcome following early rehabilitation after a total knee replacement: a retrospective study in Taiwan. Arthritis Care Res 2015;67:799–808.
[72] Plate JF, Augart MA, Seyler TM, Bracey DN, Hoggard A, Akbar M, et al. Obesity has no effect on outcomes following unicompartmental knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 2015.