Original Article | Journal of Clinical Orthopaedics | 2026 January-June; 11(1):-102-109

Favorable Prognosis for Recovery of Numbness following Medial Uni-compartmental Knee Arthroplasty: A 2-Year Prospective Cohort Study with Patient-reported Outcomes

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Abstract

Introduction: Unlike in total knee arthroplasties, the rates of lateral flap numbness following medial unicompartmental knee arthroplasty (MUKA) and its impact on outcomes are not well-studied. Our study aims to investigate the prevalence and extent of numbness following MUKA and its impact on 2-year patient-reported outcomes. The study also aims to explore factors that predict recovery of lateral skin flap numbness following MUKA.

Methods: This level 3 prospective cohort study involved 20 patients (21 MUKAs) over a 2-year follow-up period. The area of pinprick and fine touch numbness around the knee were measured at 1- and 2-year post-MUKA. Pre-operative, 3 months, 1 year, and 2 years post-surgery Knee Society Scores (KSS) and 36-item short form survey scores were also obtained.

Results: The incidence of pinprick and fine touch numbness was 52% and 48% at 2 years, respectively. Between the 1st and 2nd year post-MUKA, the median area of numbness to fine touch sensation improved from 100 (interquartile range [IQR], 554) to 0 mm2 (IQR, 180), P = 0.008. Area of numbness to pinprick sensation also showed statistically significant improvement from median area 156 (IQR, 1079) to 43 mm2 (IQR, 279), P < 0.001. The recovery of numbness was not correlated with the patient's age, body mass index (BMI), incision length, thigh or calf girth (P > 0.05). There was also no statistically significant correlation between recovery of numbness and improvement in patient-reported outcome measures (PROMs) (KSS, mental component score, physical component score) (P > 0.05).

Conclusion: Our study demonstrated that following MUKA, there is a significant proportion of patients that experience lateral flap numbness. Reassuringly, this numbness improves significantly over time and PROMs continue to improve significantly. Patient's age, BMI, or incision length was not predictors for subsequent recovery of lateral skin flap numbness in patients with persistent numbness after 1-year post-MUKA.

Keywords: Medial unicompartmental knee arthroplasty, numbness, functional outcomes, outcome measures (patient-reported outcome measure).

Level of Evidence: Level III.

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Introduction

Medial unicompartmental knee arthroplasty (MUKA) has become increasingly prevalent as the treatment for symptomatic medial-compartment knee osteoarthritis. This is especially so after the indications for unicompartmental knee arthroplasty (UKA) were expanded upon by the Oxford group from the original description by Kozinn and Scott in 1989 [1, 2].

Lateral skin flap numbness after knee arthroplasty remains a commonly reported post-surgical complication, particularly

Submitted Date: 10-08-2025, Review Date: 09-09-2025, Accepted Date: 11-02-2026 & Published Date: 10-05-2026

Journal of Clinical Orthopaedics | Available on www.jcorth.com | DOI: https://doi.org/10.13107/jcorth.2026.v11.i01.854

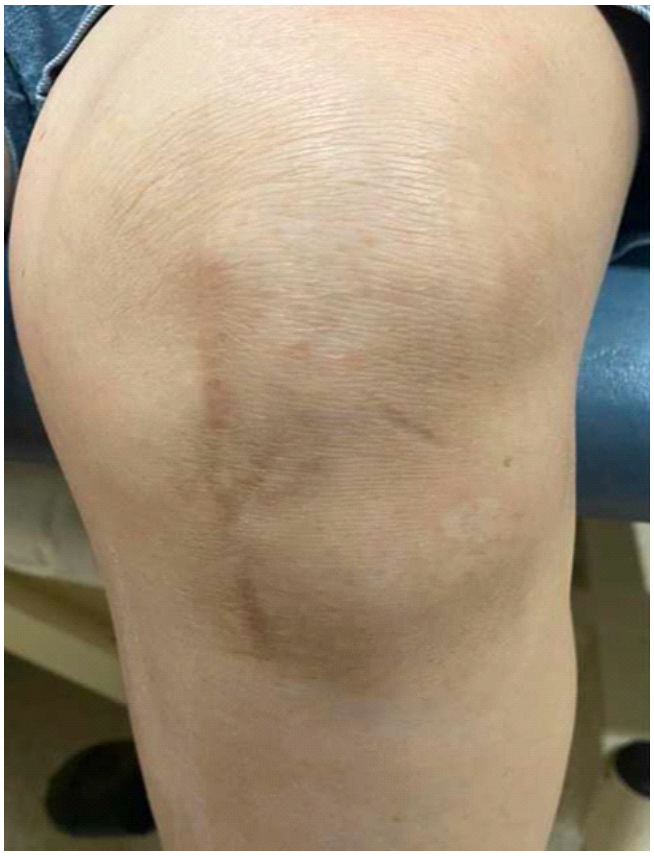

Figure 1: Example of Incision used in medial unicompartmental knee arthroplasty. Clinical photograph of a patient's left knee with a healed incision starting from the medial pole of the patella extending down to the tibial plateau, parallel to the patella tendon.

with a midline incision, because of disruption of the infrapatellar branch of the saphenous nerve (IPBSN) and the medial femoral cutaneous nerve. Studies by Kerver et al. and Tanavalee et al. showed that the course and number of branches of the IPBSN varied significantly between patients as it crossed the patella, making it difficult to avoid with a standard midline approach to the knee [3, 4]. As such, the prevalence of numbness following total knee arthroplasty (TKA) with a midline incision is reported in some studies to be as high as 86% [5]. A shorter and more laterally placed incision during TKA has been shown in some studies to lower the incidence and magnitude of post-operative (op) lateral skin flap numbness [5, 6, 7].

Other studies have also explored predictive factors for recovery of numbness following TKA. Ruangsomboon et al. in a double-blinded randomized controlled trial, found that oral mecobalamin had no effect on the recovery of numbness at the 3-month mark post-TKA [8].

Despite increasing evidence surrounding the incidence and recovery of lateral flap numbness post-TKA, there remains a lack of similar evidence for MUKA. The incision in MUKA is shorter and more medially placed compared to the TKA, and

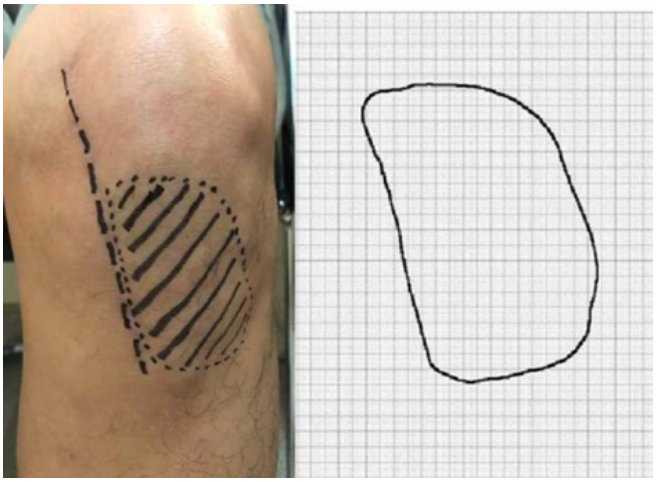

Figure 2: Method for measuring area of fine touch and pinprick numbness. Photograph (left) with shaded out area of altered sensation on patient's left knee. The shaded area was subsequently marked out on tracing paper and plotted on graph paper to allow for measurement of area in mm2 (right).

results from TKA studies may not be generalizable to the MUKA population in view of differences in incision location and length. There is also a lack of evidence in the present literature regarding the mid to long-term recovery of lateral skin flap numbness post-MUKA.

Our study aims to fill this gap by evaluating the incidence and magnitude of numbness after MUKA with a longer follow-up duration. This longitudinal study also aims to explore predictors of recovery of lateral skin flap numbness and the effect of residual numbness on patient-reported outcomes over a 2-year follow-up period.

Methods

Institutional review board approval was obtained before commencement of the study.

Study population

This was a level 3 prospective cohort study involving 20 participants with 21 knees that underwent MUKA by a single fellowship-trained consultant orthopedic surgeon over a 1-year recruitment period. Patients aged 85 and below, American Society of Anesthesiologists physical status class I or II, and had normal knee sensation before surgery were included in this study. Exclusion criteria included patients with previous knee surgery, scars over the knee, or pre-existing neurological comorbidities, such as spinal nerve root compression and peripheral neuropathy.

Methodology

All participants underwent MUKA by a single fellowship-trained consultant orthopedic surgeon at a single tertiary institution. All MUKAs were performed through a medial

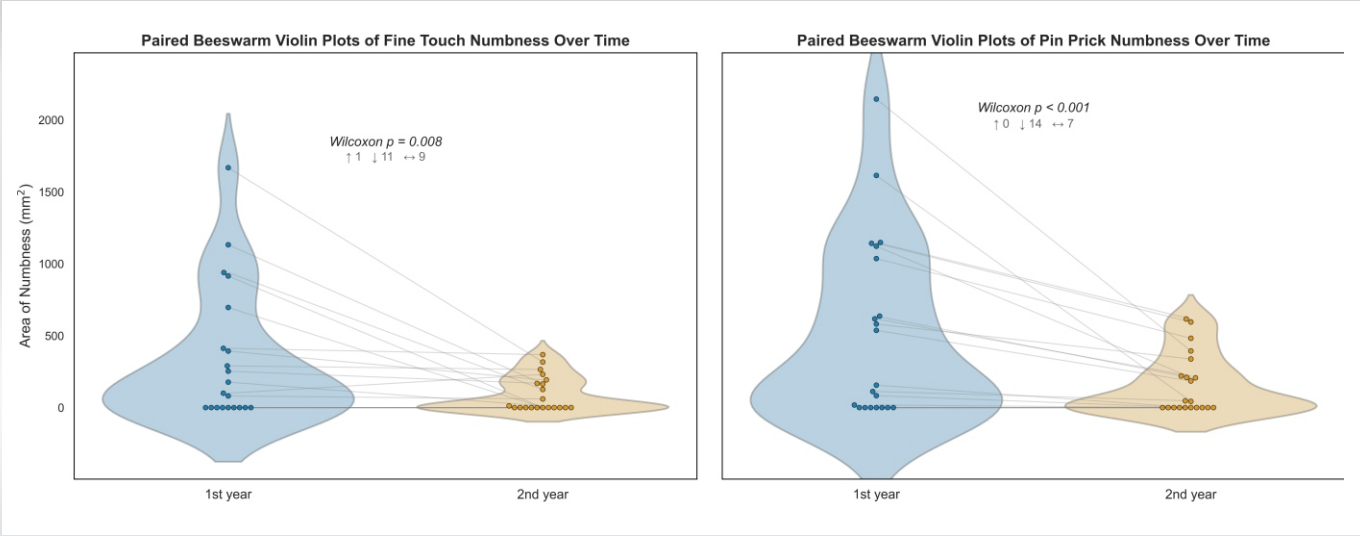

Figure 3: Paired bee-swarm violin plots of area of fine touch numbness and pinprick numbness over time. Paired bee-swarm violin plots with kernel density estimators were used to display individual cases of area of numbness at 1- and 2-year post-operative (op). Cases of fine touch numbness were plotted on the left (a) and cases of pinprick numbness were plotted on the right (b). Each case is connected through a line to demonstrate recovery trajectory. Wilcoxon-signed rank test with P-value was applied to determine significant change between 1- and 2-year post-op. Number of cases with area of numbness that increased, decreased and remained the same are summarized as well.

incision beginning at the medial pole of the patella extending down to the tibial plateau, parallel to the patella tendon (Fig. 1). Patient baseline demographics were recorded, including age, gender, laterality, body mass index (BMI), thigh and calf circumference, and length of incision (with knee flexed at 90°). Participants were reviewed at 3 months, 1 year, and 2 years post-operatively. The patient reported sections of the 2011 Knee Society Score (KSS) were recorded pre-operatively, at 3 months, 1-year, and 2-year post-surgery, where a higher score indicated a better outcome [9]. The 36-item short form survey (SF-36) score was documented at the 1- and 2-year mark and was subsequently transformed into a physical component score (PCS) and mental component score (MCS) as described by Ware [10]. Area of lateral flap skin numbness was also recorded at 1 year and 2 years post-surgery.

Testing area of numbness

Area of numbness to fine touch and pinprick was measured at 1- and 2-year post-surgery with a quantifiable grid-based system first described by Yap et al. [11]. This was done using a cotton ball and a blunt tip 18-gauge needle, respectively. With the knee flexed at 90°, the area of numbness was tested in a circumferential manner. Testing would commence from the area of normal sensation in the periphery and progress clockwise toward the area around the scar with abnormal sensation. The area of numbness was subsequently marked out on tracing paper, and the same area was plotted on graph paper to allow for measurement of area in mm2 (Fig. 2). Patients were blinded while performing sensory testing to prevent any bias from their sense of vision.

Data analyses

Descriptive statistics for baseline characteristics were calculated. Categorical data were presented with frequencies and percentages, while continuous data were presented as either mean or median, depending on normality. The Shapiro–Wilk test was used to determine normality. Spearman's rho analysis was performed to evaluate for correlation between the change in area of lateral flap numbness over time and age, BMI, length of incision, thigh, and calf girth. Spearman rho analysis was also performed to determine if the improvement in patient-reported

Table 1: Baseline demographics and characteristics

Gender (*n*, %)	
Male	5 (25)
Female	15 (75)
Laterality (*n*, %)	
Right	8 (38)
Left	13 (62)
Age (years, SD)	59.25 (7.7)
Height (m, SD)	1.58 (0.08)
Weight (kg, IQR)	66 (20.9)
BMI (kg/m^2, IQR)	27.02 (7.33)
Incision length (cm, SD)	10.49 (1.38)
Thigh girth (cm, SD)	45.97 (7.79)
Calf girth (cm, SD)	38.14 (4.48)

IQR: Interquartile range, SD: Standard deviation, BMI: Body mass index

Table 2: Area of numbness over time

	Area of numbness 1-year post-op (mm^2)		Area of numbness 2-year post-op (mm^2)		Wilcoxon signed rank (Z)	*P*-value
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)		
Pinprick	521.29 (628.85)	156 (1079)	158.9 (209.60)	43 (279)	−3.296	**<0.001**
Fine touch	336 (469.91)	100 (554)	90.67 (122.24)	0 (180)	−2.667	**0.008**

IQR: Interquartile range, op: Operative, SD: Standard deviation

outcome measures (PROMs) between 1- and 2-year post-surgery was a result of the improvement in the area of numbness over the same period. Friedman's test was utilized to compare KSS over time. Statistical significance was defined as a two-tailed P < 0.05.

Paired bee-swarm violin plots showing kernel density estimates were plotted to illustrate the area of numbness over time and the overall distribution of numbness at each time point.

The IBM Statistical Package for the Social Sciences v28.0 was used to perform data analysis for this study. Plots were generated in Python using the Seaborn and Matplotlib libraries.

Results

A total of 21 knees from 20 patients were included in this study, with all participants completing the 2-year follow-up. The study population was predominantly women (75%). One patient underwent MUKA on both knees on separate dates 8 months apart. The mean age was 59.2 years (standard deviation [SD], 7.7) and the median BMI was 27.02 kg/m2 (interquartile range [IQR], 7.33). The mean incision length was 10.49 cm (SD, 1.38). Mean thigh and calf girth were 45.97 cm (SD, 7.79) and 38.14 cm (SD, 4.48), respectively (Table 1).

The incidence of numbness to fine touch sensation was 57% at 1 year post-surgery and improved to 48% at the 2-year mark. The incidence of numbness to pinprick sensation also improved from 67% at the 1-year mark to 52% at the 2-year mark. At 1-year post-surgery, 9 knees had no numbness to fine touch sensation, while 7 knees had no numbness to pinprick sensation. For the remaining 12 knees with residual fine touch numbness at 1 year, 11 knees improved in area of numbness by the 2nd year, and 2 knees had complete recovery (Fig. 3a). Similarly,` for the 14 remaining knees with residual pinprick numbness at 1 year, all 14 knees improved in area of numbness by the 2nd year with 3 knees making a complete recovery (Fig. 3b).

The area of numbness for both fine touch and pinprick sensations also showed marked recovery across the 2 years (Fig. 3a and b).

The median area of numbness to fine touch sensation improved from 100 mm2 (IQR, 554) at the 1-year mark to a median area of 0 mm2 (IQR, 180) at the 2-year mark, P = 0.008. Area of numbness in pinprick sensation also showed statistically significant improvement from median area 156 mm2 (IQR, 1079) to 43 mm2 (IQR, 279), P < 0.001 (Fig. 3a and b, Table 2).

None of the patients in our study population had hyperalgesia surrounding the wound, chronic regional pain syndrome, or neuroma formation. There were also no other post-op

Table 3: Spearman correlation between different factors and recovery of numbness

	Age		BMI1		Incision length		Thigh girth		Calf girth	
	Spearman Rho	*P*-value	Spearman Rho	*P*-value	Spearman Rho	*P*-value	Spearman Rho	*P*-value	Spearman Rho	*P*-value
Area of pinprick numbness										
1 year (*n*=21)	−0.072	0.755	−0.078	0.737	−0.208	0.365	−0.081	0.726	−0.066	0.776
2 years (*n*=21)	0.167	0.469	−0.13	0.576	−0.151	0.514	−0.196	0.395	−0.084	0.716
Δ Numbness (*n*=14)*	−0.434	0.121	−0.158	0.589	−0.31	0.281	−0.205	0.483	−0.081	0.782
Area of fine touch numbness										
1 year (*n*=21)	−0.037	0.875	0.011	0.963	−0.155	0.502	0.116	0.618	0.09	0.698
2 years (*n*=21)	0.142	0.539	−0.307	0.175	−0.275	0.228	−0.225	0.326	−0.279	0.22
Δ Numbness (*n*=12)*	−0.049	0.879	−0.42	0.175	−0.102	0.752	−0.427	0.167	−0.406	0.19

***Those with full recovery of numbness at 1-year were excluded.[1]BMI: Body mass index**

Table 4: Knee Society scores over time

	Pre-surgery		3-months post-op		1-year post-op		2-year post-op		Friedman test	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Friedman Chi-square	*P*-value
Knee Society Score										
Symptoms	7.14 (0.87)	6 (8)	19.43 (0.94)	19 (6)	21.95 (0.76)	23 (6)	23.81 (2.02)	25 (2)	51.19	<0.001
Satisfaction	14.67 (1.56)	14 (10)	32.19 (1.18)	32 (9)	36.95 (0.82)	38 (6)	39.81 (0.87)	40 (0)	56.766	<0.001
Expectation	11.9 (0.63)	12 (6)	10.29 (0.55)	10 (3)	10.76 (2.47)	9 (4)	13.43 (0.57)	15 (6)	14.187	0.003
Functional	47.05 (3.34)	44 (24)	68.48 (4.23)	75 (22)	83.9 (2.98)	87 (19)	85.71 (2.03)	89 (10)	48.797	<0.001

IQR: Interquartile range, op: Operative, SD: Standard deviation

complications during the follow-up period.

In the subgroup of patients who still exhibited lateral skin flap numbness 1-year post-MUKA, their age, BMI, length of incision, or thigh/calf girth were not predictive factors of subsequent recovery (Table 3). There was also no statistically significant correlation between any of the above factors and the area of numbness at 1- or 2-years post-MUKA (Table 3).

Regarding PROMs, all patient-reported subcomponents of the KSS continued to improve throughout the 2-year follow-up period post-MUKA ($P < 0.003$) (Table 4). The PCS of SF-36 showed a statistically significant improvement from median 50.79 (IQR, 7.22) to 53.07 (IQR, 4.88) between the 1st and 2nd year post-op ($Z = -2.576$, $P = 0.01$), whilst the MCS did not ($P = 0.502$) (Table 5). When determining if these improvements in PROMs are attributable to changes in lateral skin flap numbness, we found no correlation between the recovery of numbness and improvements in each subgroup of KSS, PCS, or MCS (Table 6).

Discussion

Lateral skin flap numbness remains a commonly overlooked complication following knee arthroplasty, especially when compared to other, more devastating complications, such as infection and thromboembolism. However, the presence of numbness post-TKA still negatively affects patient satisfaction rates post-surgery [12].

In our study, we found that there was statistically significant improvement in incidence and magnitude of numbness between the 1st and 2nd year post-MUKA. Over the same period, there was also a statistically significant improvement in PCS and all KSS subgroups. In patients who still had persistent lateral flap numbness at the 1-year mark, the improvement in numbness between 1 year and 2 years post-op did not correlate with an improvement in PROMs (KSS, PCS, and MCS). In addition, in the same subgroup of patients who still experienced numbness at 1-year post-op, their age, BMI, incision length, and thigh/calf girth were not correlated with subsequent recovery by 2 years.

Comparison with other studies

In our cohort, the prevalence of numbness was 57% and 67% for fine touch and pinprick, respectively, at 1-year post-surgery. This decreased to 48% and 52% for fine touch and pinprick sensations, respectively, at the 2-year mark. This result is higher than previously reported in the literature, likely due to deliberate preservation of the IBPSN in other comparator studies. In a cohort of 100 UKAs, Song et al. reported the incidence of lateral skin flap numbness to be 38% over a mean

Table 5: SF-36 scores over time

	1-year post-op		2-year post-op		Wilcoxon signed rank (Z)	*P*-value
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)		
SF-36						
PCS[1]	49.69 (6.57)	50.79 (7.22)	52.85 (3.14)	53.07(4.88)	−2.576	**0.01**
MCS[2]	58.11 (6.00)	60.21 (5.34)	59.58 (1.76)	58.96 (2.56)	−0.672	0.502

[1]PCS: Physical component score, [2]MCS: Mental component score, SF-36: 36-item short form survey, IQR: Interquartile range, SD: Standard deviation, op: Operative

Table 6: Spearman correlation between change in lateral flap numbness and PROMs

	Δ Area of pinprick numbness (n=14)*		Δ Area of fine touch numbness (n=12)*	
	Spearman Rho	*P*-value	Spearman Rho	*P*-value
SF-36				
Δ PCS[1]	−0.462	0.112	−0.077	0.812
Δ MCS[2]	0.159	0.603	−0.077	0.812
Knee Society Score				
Δ Symptoms	−0.078	0.791	0.105	0.747
Δ Satisfaction	0.005	0.988	0.316	0.317
Δ Expectation	0.429	0.126	−0.238	0.457
Δ Functional	−0.121	0.68	−0.091	0.779

***Those with full recovery of numbness at 1-year were excluded.[1]PCS: Physical component score,[2]MCS: Mental component score, PROMs: Patient-reported outcome measures, SF-36: 36-item short form survey**

follow-up duration of 2 years and 8 months [13]. However, in their study, the IPBSN was successfully preserved in 68% of this cohort - naturally leading to a lower incidence of lateral skin flap numbness. The mean duration of follow-up was also longer compared to our study, allowing for a longer recovery period. The area of numbness in the same study, however, was reported to be 2130 mm2, a much higher result than the findings in our study. This is likely again due to the preservation of the IPBSN - in cases where the nerve was not able to be preserved; there was more profound numbness due to complete transaction.

Our results are comparable to other studies that did not intentionally preserve the IPBSN. In a study of 58 TKAs by Tanavalee et al., the authors found with a minimally invasive approach for TKA of mean incision length 9.1 cm (which is comparable to 10.49 cm in this study) the mean area of skin numbness at 1-year post-surgery was 210 mm2, similar to the 1 year reported median area of 156 and 100 mm2 for pinprick and fine touch, respectively [4].

Recovery of numbness

In our study, we found that time post-surgery was a statistically significant predictor in the recovery of lateral skin flap numbness. This is in keeping with existing TKA literature that also found the area of lateral skin flap numbness to decrease over time [5]. This was despite there being no further targeted interventions for numbness (i.e., topical or oral medications, physiotherapy, surgery) instituted between 1- and 2-year post-surgery. This is likely due to reinnervation of the affected area, especially for numbness arising from either partial injury of the nerve or traction injury [14]. However, in cases where the nerve branches are severed entirely, reinnervation is generally poorer, and the patients hence tend to complain of residual numbness even after prolonged periods.

Our study also found that incision length was not a predictive factor for subsequent recovery of lateral skin flap numbness in the subgroup of patients that still experienced numbness 1-year post-surgery. In contrast, Hassaballa et al.'s study of a mixed cohort of TKA and UKA knees found that incision length positively correlated with a greater area of sensory alteration post-op [15]. This difference is likely due to the heterogeneous incision types included in their study, where the location of their incision also varied, along with the length of incision (standard midline incision vs. a shorter medial incision). Existing studies by Kerver et al. described "low risk" zones over the knee that would have a greater chance of preserving the IPBSN and hence lower risk of post-surgery numbness [3]. These studies suggest that the location of incision plays an equally important role in minimizing post-arthroplasty numbness, a factor outside the scope of this study that utilized the same medial incision for all MUKAs.

Recovery of numbness and impact on PROMs

Previous studies looking at numbness following TKA have reported that in a small percentage of patients (4–10%), the residual numbness interferes significantly with patient's activities of daily living [5, 16, 17]. We did not find that in our study of UKA patients. The presence of and magnitude of numbness to fine touch and pinprick had no correlation with the overall KSS and SF-36 scores at 1- and 2-years post-surgery. This could be related to the fact that the area of numbness found in our study was smaller than the reported area of numbness in these other studies conducted in the TKA population [18, 19, 20].

Furthermore, we have found that despite both the area of numbness and PROMs improving significantly over the 2 years follow-up period, there was no statistically significant correlation between recovery in lateral flap numbness and improvement in PROMs. One possibility for this difference is that the KSS and SF-36 are not specifically designed to capture sensory deficits, which may explain the lack of correlation between recovery of numbness and improvement in PROMs. The authors find this null result reassuring; despite having a relatively high incidence of lateral flap numbness post-MUKA, the overall disease burden and effect on patient quality of life is low. Our findings allow for improved pre-op risk counseling for MUKA, especially in terms of lateral flap numbness.

Limitations

The authors acknowledge that there are certain potential limitations to this study. The area of numbness in our study was assessed using pinprick and cotton ball testing, which is inherently subjective and dependent on patient perception and examiner technique. Instead, the use of an objective clinical instrument, such as Semmes–Weinstein monofilaments or other methods for quantitative sensory testing may reduce measurement bias and improve the reproducibility of our

results. In addition, we only utilized one measurement at each follow-up, which impeded our assessment of intra-observer reliability and increased our study's susceptibility to random measurement error. Multiple measurements averaged over a greater number of visits may have yielded a closer reflection of the true area of numbness.

Furthermore, the study was a single-center single-surgeon study that had a relatively short follow-up of 2 years, which may limit external validity and generalizability. Although longer than many studies, sensory nerve recovery may continue beyond this period, and late persistence or recurrence of numbness outside the follow-up period of this study cannot be excluded. Our study also only included a small sample size of 20 patients (21 knees), which limits statistical power and increases the risk of type II error, particularly when evaluating predictors of numbness recovery.

Other important variables, such as the use of tourniquet, tourniquet time, relevant microvascular comorbidities (such as smoking and diabetes mellitus), and length of surgery, were not analyzed in this study – variables which may also be confounding factors in the recovery of numbness following MUKA.

Lastly, the inclusion of a comparator group (i.e., alternative incision lengths or approaches) was outside the scope of this study, limiting our study's ability to establish causal relationships. Future studies comparing different incision locations and approaches are warranted to better characterize their relationship with lateral flap numbness following knee arthroplasty.

Conclusion

Post-surgery numbness affects a significant number of patients undergoing MUKA. Reassuringly, the area of numbness decreases significantly over time without intervention. Moreover, the presence and extent of numbness does not impact a patient's functional outcomes. In patients with residual numbness at 1-year post-surgery, their age, BMI, incision length, and thigh/calf girth were not correlated with subsequent recovery. This information is useful for surgeons in their pre-op counseling of patients to prevent patient dissatisfaction and subsequent management of this often-encountered post-surgery complaint.

Clinical Relevance

What are the new findings?

- Good prognosis for recovery of lateral flap numbness following medical uni-compartmental knee arthroplasty over a 2 year period
- Patient-reported outcomes improve significantly and are independent of lateral flap numbness
- Incision length, age, and body mass index were not statistically significant predictors for recovery of lateral flap numbness, whereas duration post-surgery was a statistically significant predictor.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

Conflict of Interest: NIL; **Source of Support:** NIL

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Conflict of Interest: NIL
Source of Support: NIL

How to Cite this Article

Quah ESH, Chua MJ, Yap WMQ, Kau CY, Thwin L. Favorable Prognosis for Recovery of Numbness following Medial Uni-compartmental Knee Arthroplasty: A 2-Year Prospective Cohort Study with Patient-reported Outcomes. Journal of Clinical Orthopaedics. January-June 2026;10(1):102-109.