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Lateral numbness in the lower leg: An underestimated complication following medial open-wedge high tibial osteotomy

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ABSTRACT

Background: This study aimed to investigate the incidence, degree, and natural course of lateral numbness following medial open-wedge high tibial osteotomy (MOWHTO). It also evaluated which predisposing factors would affect lateral numbness following MOWHTO.

Methods: One-hundred and sixty-nine knees that underwent MOWHTO for treatment of varus osteoarthritis with a minimum follow-up of three years were enrolled. Lateral numbness in the lower leg was assessed with the light-touch method using a cotton wool ball and compared with the contralateral leg. Patients were classified into groups based on a scale according to grading of sensation to light touch. To assess the improvement of lateral numbness, lower leg sensation was investigated using a sensory score compared with the contralateral leg. The predisposing factors that would affect lateral numbness were assessed.

Results: Lateral numbness was observed in 87 knees (51.5%) at six weeks postoperatively. Although 69 knees improved over time, 18 knees showed no improvement to the latest follow-up. The level of skin incision showed a significant association with lateral numbness on univariate and multivariate analyses: the higher the level of skin incision, the greater the degree of estimated numbness.

Conclusions: About half the patients reported postoperative lateral numbness in the lower leg following MOWHTO. Of the patients with lateral numbness, approximately one-fifth remained symptom until the last follow-up. The level of skin incision might be a risk factor for lateral numbness. Pre-operative patient education concerning the likelihood of lateral numbness is recommended.

Level of evidence: Level IV, case series.

1. Introduction

Surgical approaches around the knee joint can cause sensory nerve injury [1,2]. Moreover, following knee surgeries, numbness of the skin lateral to the knee joint and lower leg can occur as a complication [3–5]. Injury to the infrapatellar branch of the saphenous nerve usually results in lateral skin numbness on the proximal lower leg [2,6,7]. Although there have been reports concerning lateral numbness as a complication following knee arthroplasty, tibial nailing or arthroscopic knee surgery, no specific

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study could be found on lateral numbness as a complication following high tibial osteotomy (HTO) [1,3,6–9]. Considering the course of this nerve, there may be an increased possibility of nerve injury during medial open-wedge high tibial osteotomy (MOWHTO). Despite the frequent incidence of lateral numbness of the lower leg following MOWHTO in the authors' practice, there is a lack of literature regarding the incidence of this complication.

The purpose of this study was to investigate the incidence, degree, and natural course of lateral numbness following MOWHTO. It also evaluated which predisposing factors could affect the development of lateral numbness following MOWHTO. It was hypothesised that there may be a frequent incidence of lateral numbness of the lower leg due to injury of the infrapatellar branch of the saphenous nerve during MOWHTO.

2. Materials and methods

2.1. Patient demographic characteristics

From February 2008 to December 2015 a consecutive series of 201 knees in 163 patients underwent MOWHTO with a medial locked plate system. All the operations were performed by a senior author. Inclusion criteria for this study were patients: (1) with symptomatic medial compartment osteoarthritis with varus malalignment; (2) with a minimum follow-up of three years after MOWHTO; and (3) who underwent continuous evaluation for lateral skin numbness during the study period. Exclusion criteria were patients: with peripheral neuropathy that could present as lateral numbness of the lower leg, haemophilia, and those who underwent cosmetic surgery for congenital genu varum (Figure 1). The protocol was approved by the hospital Institutional Review Board. All patients gave informed consent before participating in this study.

2.2. Surgical technique

Arthroscopic procedures – including exploration of the intra-articular structures, irrigation of debris, and partial meniscectomy of degenerative complex tears – were concomitantly performed at the time of MOWHTO in all patients. A three-centimetre transverse incision was made two centimetres proximal to pes anserinus and centred on the medial side of the proximal tibia, which was the major incision of this minimally invasive procedure (Figure 2) [10]. The incision was carried through the skin and subcutaneous tissue. Two parallel guide pins were inserted just above the pes anserinus tendon. The horizontal osteotomy was performed just below two guide pins using a standard saw blade (Depuy Synthes, blade width 18 mm, cut thickness one millimetre). The second ascending cut was performed at an angle of 120° to the horizontal osteotomy plane using a sagittal saw blade (Depuy Synthes, blade width 14 mm, cut thickness 0.6 mm) [10,11]. After the osteotomy gap and measurement of final alignment were confirmed under image intensification, the medial locked plate (TomoFix; Depuy Synthes, Solothurn, Switzerland) was fixed in

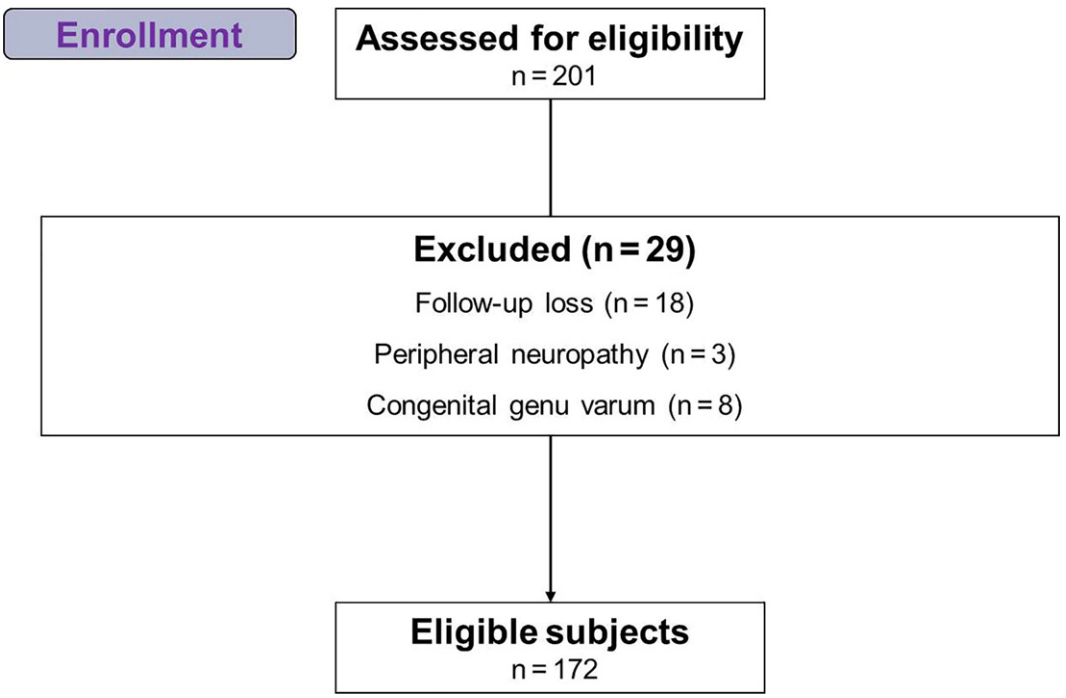


Figure 1. Flow diagram showing patient enrollment (numbers of knees).

Figure 2. An intraoperative photograph of medial open-wedge high tibial osteotomy in the right knee using the horizontal incision.

place with screws. The correction target was determined by aiming for the mechanical axis near or slightly less than a point at 62.5% of the tibial plateau from the medial edge, according to the cartilage status assessed by concomitant arthroscopy [12].

2.3. Sensory assessment of the lower leg

Lateral numbness of the lower leg was assessed pre-operatively, and postoperatively at six weeks, three months, six months, one year and subsequent yearly follow-ups. Based on a previously reported study, sensory loss was assessed with the light-touch method using a cotton wool ball compared with the medial side of the contralateral leg [13]. The method scanned the lateral area of the lower leg (Figure 3a. purple cross-stripes), preventing excessive pressure. Patients were classified into groups based on a scale of −2 to 1 according to grading of sensation to light touch [13]. Sensory grades were defined as follows: (i) −2, complete sensory loss to light touch (anaesthesia); (ii) −1, decreased sensation to light touch (hypoesthesia); (iii) 0, no change in sensation (normal); and (iv) +1, increased sensation to light touch (hypersensitive). Moreover, to assess the degree of improvement of lateral numbness, the degree of sensation in the lateral side of the lower leg was investigated using a sensory score between 0 and 100 compared with the medial side of the contralateral leg with the light-touch method. Higher scores implied more sensory recovery. The changing aspects of lateral numbness were evaluated at every follow-up visit. To improve reliability in the measurement of sensory loss, two independent board-certified orthopaedic surgeons examined at least twice. The intra-observer and inter-observer reliabilities of the measurements were assessed with intra-class and inter-class correlation coefficients.

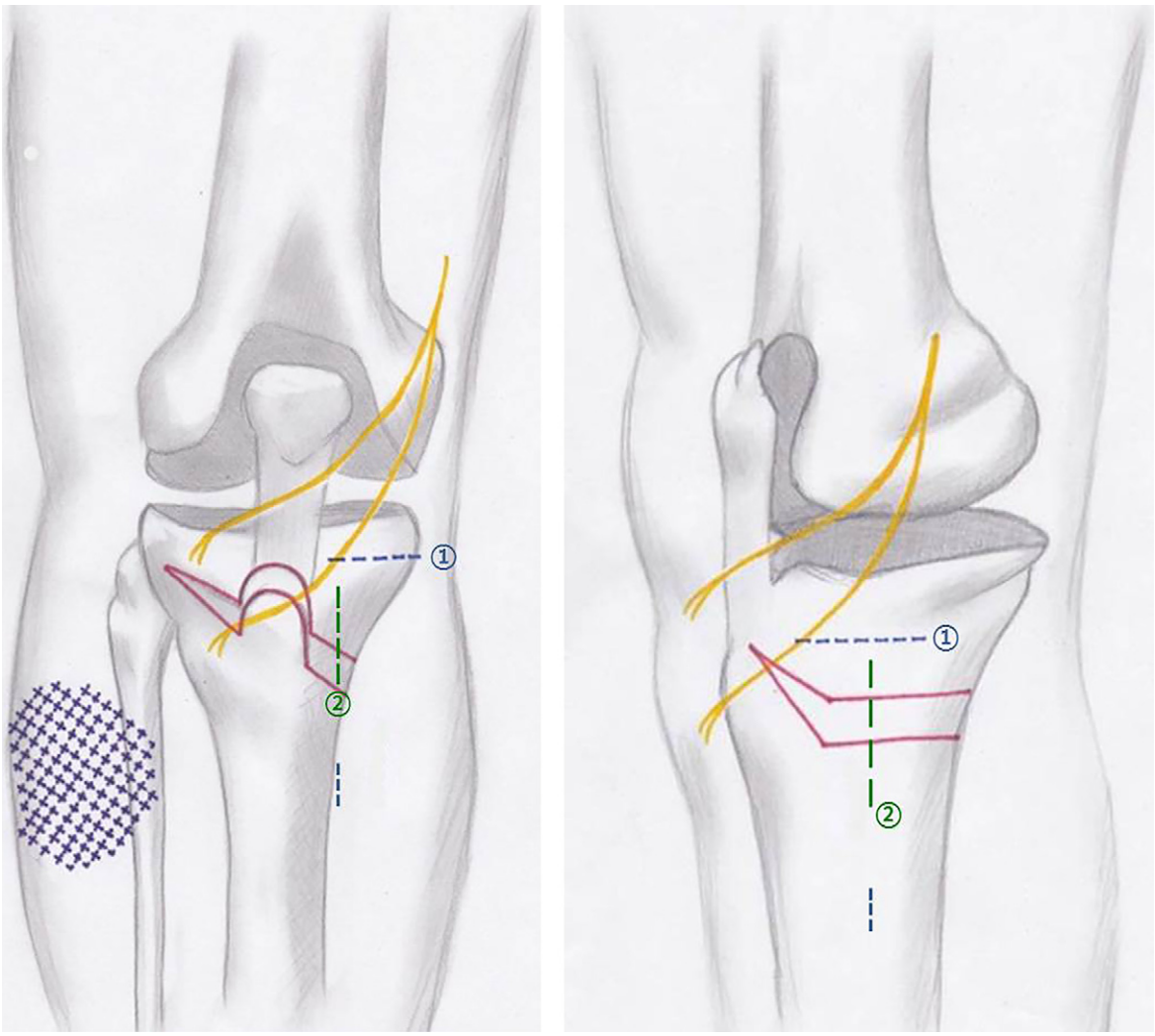


Figure 3. Schematic illustrations of the right knee. Distribution of the infrapatellar branch of the saphenous nerve (yellow line), area of lateral skin numbness (purple cross stripes), biplanar osteotomy line (red line), and localisation of the skin incisions [① horizontal incision (blue dotted line), ② vertical incision (green dotted line)] are presented. a. Anteroposterior view of the right knee. b. Oblique lateral view of the knee from the medial aspect.

2.4. Analysis of risk factors for lateral numbness

To assess the predisposing factors that may affect the development of lateral numbness, the relationship between lateral numbness and other variable factors such as age, gender, tourniquet time, diabetes mellitus, pre-operative hip–knee–ankle (HKA) angle (with varus alignment as a negative value), amount of correction angle, and level of the skin incision was analysed. The distance from the medial joint line to the transverse skin incision was measured as the level of the skin incision.

Radiologic and clinical evaluations were carried out pre-operatively, and postoperatively at six weeks, three months, six months, one year and subsequent yearly follow-ups. Standard pre-operative and postoperative full-length weight-bearing radiographs were assessed to determine the axial alignment of the limb. The HKA angle and femorotibial angle (FTA, with varus alignment >180°) were evaluated [14]. The American Knee Society Score (AKSS) and knee range of motion were also assessed for clinical evaluation [15].

2.5. Statistical analysis

Statistical analyses were performed using SPSS software version 23.0 (IBM Corp., Armonk, NY, USA). All dependent variables were tested for normality of distribution and equality of variances using the Kolmogorov–Smirnov test, and were analysed using parametric or non-parametric tests according to the appropriate normality tests. A paired *t*-test was used to compare continuous data before and after the index operation. For changes in lateral numbness, the repeated-measures ANOVA test was used to evaluate the serial changes in values between the groups during the follow-up period.

Univariate and multivariate logistic regression analyses with stepwise variable selection were performed to determine the influence of risk factors. Simple regression analysis was used to estimate the degree of lateral skin numbness based on identified risk factors. For all tests, *P*-values <0.05 were considered statistically significant. For univariate and multivariate analyses, odds ratios and 95% confidence intervals (CI) were calculated.

3. Results

In total, 169 knees in 142 patients (129 women and 13 men) were finally enrolled in this study. The demographic data are shown in Table 1. The mean HKA angle and FTA were significantly corrected at last follow-up. Moreover, clinical outcomes were significantly improved at last follow-up (Table 2).

None of the patients reported obvious numbness in their lower limb before the index operation. Eighty-seven knees (51.5%) had lateral numbness at six weeks postoperatively (Table 3). Of the patients with lateral numbness, 39 knees (44.8%) improved completely and 30 knees (34.5%) showed partial improvement. The remaining 18 knees (20.7%) had no improvement until the latest follow-up. Sensory scores significantly improved from 41.9 ± 2.5% (mean ± standard deviation) at six weeks postoperatively to 55.7 ± 2.3% at latest follow-up ($P < 0.001$) (Figure 4). The intraclass and interclass correlation coefficients for measurements indicated almost perfect, with Kappa values of 0.90 and 0.86, respectively [16].

Age, gender, diabetes mellitus, pre-operative HKA angle, tourniquet time, type of anaesthesia, and correction angle had no association with lateral numbness; however, the level of skin incision showed a significant association with development of lateral numbness in univariate and multivariate analyses ($P < 0.001$) (Table 4). In the transverse incision of MOWHTO, the higher the level of skin incision (the nearer the distance to the joint line), the greater the degree of estimated numbness ($P < 0.001$) (Table 5).

4. Discussion

The most important finding of this study was that about half of the patients (87 of 169, 51.5%) showed varying degrees of lateral lower leg numbness following MOWHTO. Furthermore, a transverse skin incision level closer to the knee joint line was associated with development of lateral numbness in univariate and multivariate analyses.

It is believed that the incidence of lateral numbness has been underestimated, possibly due to this complication being disregarded as a minor problem or because both surgeons and patients were unaware of the likelihood of developing numbness

Table 1
Patients' demographic characteristics.

	Data
Age, years[a]	56.1 (42–67)
Sex (male/female), n[b]	13/129
BMI, kg/m^{2}[a]	26.3 (19.9–33.9)
Follow-up period, months[a]	76.7 (36–132)
Anaesthesia (general/regional)[b]	105/64
Tourniquet time, minutes[a]	49.9 (38–72)

BMI, body mass index.
Regional anaesthesia included spinal anaesthesia or combined spinal-epidural anaesthesia.
[a] Data are presented as mean with range.
[b] Data are presented as numbers.

Table 2
Radiological and clinical outcomes.[a]

	Pre-operative	Last follow-up	P^b
HKA angle (°)	−7.4 (−3.4 to −13.0)	2.0 (−3.5 to 8.3)	<0.001
FTA (°)	181.9 (178.7 to 191.1)	172.2 (165.4 to 180.9)	<0.001
AKSS			
Knee score	60.2 (30 to 80)	93.4 (80 to 100)	<0.001
Function score	61.6 (30 to 80)	95.2 (70 to 100)	<0.001
ROM (°)			
FC	1.4 (0 to 15)	0.3 (0 to 5)	<0.001
FF	136.1 (12 to 140)	139.2 (125 to 140)	<0.001

HKA angle, hip–knee–ankle angle (with varus alignment as a negative value); FTA, femorotibial angle (with varus alignment >180°); AKSS, American Knee Society Score; ROM, range of motion (the level of full flexion was set at 140°); FC, flexion contracture; FF, further flexion.
The mean HKA angle and FTA were significantly corrected at last follow-up.
AKSS scores and ROM of the knee joint were significantly improved at last follow-up.
The level of statistical significance was set at $P < 0.05$.
[a] Data are presented as mean (range).
[b] The paired *t*-test or Wilcoxon signed rank test was used to compare pre-operative and last follow-up values.

following MOWHTO. In this study, approximately four-fifths (69 of 87, 79.3%) of the patients with lateral numbness improved over time, but the remaining one-fifth (18 of 87, 20.7%) persisted. Some patients particularly complained about their lateral numbness after MOWHTO and were disappointed with this complication, regardless of a successful result of MOWHTO. Therefore, patients should be informed about the high incidence and natural course of this complication pre-operatively.

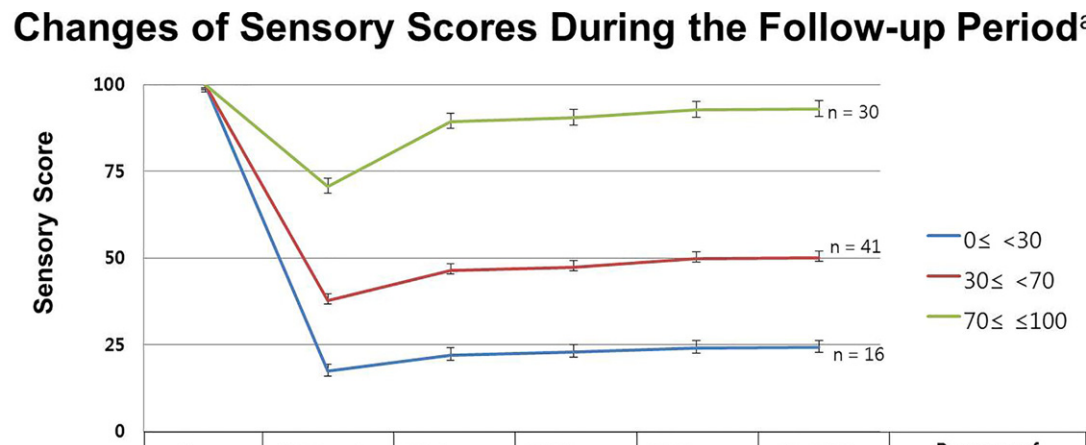
The infrapatellar branch of the saphenous nerve is a sensory nerve that is usually divided into two branches that transverse the patella tendon just below the inferior pole of the patella or just above the tibial tubercle (Figure 3) [7,17]. Although the nerve location is highly variable, it is located in an oblique direction and the measured mean distance of the infrapatellar branch has been reported to be 70 mm medial to the patellar apex and 28 mm medial to the tibial tubercle [2]. Many variations of the infrapatellar branch have been reported, with single, double, and triple branches identified in different directions [18]. This nerve could be jeopardised through a skin incision or osteotomy near to its location [2]. However, there is a lack of literature concerning lateral numbness following MOWHTO. In contrast, there are numerous reports regarding lateral numbness following total knee arthroplasty (TKA) or anterior cruciate ligament (ACL) surgery. Moreover, lateral numbness is well known to be a possible complication resulting from injury to the infrapatellar branch of the saphenous nerve due to the skin incision for TKA [1,3,13,19]. In a study involving 113 TKAs, two-thirds of patients were reported to have subjective numbness, 20% of patients were reported to have been concerned that something had gone wrong with the surgery, and 4.5% of patients reported significant problems with performing activities of daily living [3]. Other studies reported between 55 and 86% of patients presenting with lateral numbness after TKA, which is a higher incidence compared with the current study [1–3]. After performing a transverse incision, an incidence of 51.5% concerning lateral numbness following MOWHTO was identified.

Age, gender, diabetes mellitus, the pre-operative and postoperative HKA angle, operation time, correction angle, and level of skin incision were included as possible risk factors of lateral numbness. No association was found between these risk factors and lateral numbness except for the level of skin incision. The patient group with a transverse skin incision nearer the joint line presented with a higher incidence and degree of lateral numbness ($P < 0.001$). As the infrapatellar branch is located in an oblique direction from medial to apex of the patella to the tibial tubercle, a proximal skin incision near the joint line could increase the risk of injury. Since the MOWHTO incision is located more medially and distally than TKA or arthroscopic ACL surgery, a vertical skin incision for MOWHTO may show different incidence of lateral numbness (Figure 3). Similarly, in a study comparing the incidence of lateral numbness according to incision pattern for harvest site in ACL surgery, the horizontal incision showed less risk of injury to the infrapatellar branch of the saphenous nerve [20]. However, there have been few studies regarding the incidence of lateral numbness according to incision pattern following MOWHTO. Therefore, further research comparing the incision pattern in MOWHTO would be necessary.

Table 3
Sensory grading according to light-touch method [13].[a]

Sensory scale	Group	Knees, n (%) at 6 weeks	Knees, n (%) at last follow-up	P^b
−2	Anaesthesia	3 (1.8)	–	<0.001
−1	Hypoesthesia	84 (49.7)	48 (28.4)	
0	Normal	82 (48.5)	121 (71.6)	
+1	Hypersensitive	–	–	
Total		169 (100.0)	169 (100.0)	

Light-touch method used a cotton wool ball compared with the medial side of the contralateral leg.
Grade −2, complete sensory loss to light touch; Grade −1, decreased sensation to light touch; Grade 0, no change in sensation; Group +1, increased sensation to light touch.
The level of statistical significance was set at $P < 0.05$.
[a] Data are presented as numbers.
[b] As analysed with the Wilcoxon signed rank test, there was a significant difference in changes of lateral numbness during the follow-up period.



	Preop	PO 6 weeks	PO 1 year	PO 2 years	PO 3 years	Last F/U	Recovery of sensory loss	P[b]
0≤ <30	100	17.4 ± 2.2	22.1 ± 2.4	23.9 ± 2.0	24.1 ± 1.7	24.2 ± 1.4	6.8 ± 2.5	0.014
30≤ <70	100	37.8 ± 2.7	46.4 ± 1.9	48.9 ± 1.7	49.8 ± 1.5	50.0 ± 1.2	12.2 ± 2.7	<0.001
70≤ ≤100	100	70.6 ± 4.9	89.3 ± 3.8	91.8 ± 3.2	92.7 ± 2.3	92.9 ± 1.8	22.3 ± 5.3	<0.001

Figure 4. Changes in sensory scores during the follow-up period. PO, postoperative; preop, pre-operative; F/U, follow-up. Light touch method was also used to investigate the sensory score. Sensory scores are presented using a score between 0 and 100 compared with the medial side of the contralateral leg with light touch (score 0, complete loss; score 100, normal). Higher score means more sensory recovery. [a]Data are presented as mean with standard deviation. [b]The Wilcoxon signed rank test was used to compare the sensory scores between postoperative six weeks and last follow-up. The level of statistical significance was set at $P < 0.05$.

In the early days of HTO procedure, a uniplanar osteotomy technique was performed. However, a biplanar osteotomy technique provides more space for proximal fixation and provides stability as a buttress [10,11]. The ascending cut is performed between 1.5 and 2.0 cm behind the tibial tubercle, parallel to the anterior margin of tibia, and the cutting plane is near to the inferior branch of the infrapatellar branch. Although the skin and soft tissue are retracted to avoid injury, this osteotomy procedure using a saw blade may involve a risk of injury to the infrapatellar branches. The authors recommend caution in performing this ascending cut as it could result in lateral numbness or patellar tendon injury. Moreover, a reverse pattern of biplanar osteotomy (descending cut of tibial tubercle area) might lower the incidence of lateral numbness [21,22]. Further comparative research would be interesting.

Despite the informative results, this study had some limitations. First, there may have been a lack of objectivity in assessing lateral numbness. Although nerve conduction studies can be considered to evaluate the objective sensory deterioration, the infrapatellar branches are not only diverse but also very fine, so it may be difficult to effectively apply in a clinical setting. Therefore, the relatively simple grading system reported in a previous study was applied [13]. Second, since this study was a retrospective study without a comparative group, additional studies with vertical incision or lateral closing-wedge HTO with similar demographic characteristics would be necessary. The incidence would be different in cases with a vertical incision or other osteotomy procedures. Finally, a nearly five-fold higher female predominance was observed for MOWHTO in this study; however, females consistently comprise 80% of MOWHTO in Korea and the results are similar to those observed in another study [23].

Table 4
Univariate and multivariate analysis of the risk factors for lateral numbness.[a]

Predisposing factors	Univariate analysis		Multivariate analysis	
	P	Odds ratio (95% CI)	*P*	Odds ratio (95% CI)
Age	0.200	1.054 (0.973–1.142)		
Gender	0.715	0.841 (0.332–2.131)		
Diabetes mellitus	0.654	1.321 (0.392–4.451)		
Pre-operative HKA	0.545	1.044 (0.908–1.200)		
Correction angle	0.884	0.992 (0.888–1.108)		
Tourniquet time	0.293	1.011 (0.991–1.031)		
Type of anaesthesia	0.952	1.253 (1.143–1.372)		
Level of skin incision	<0.001[a]	1.336 (1.210–1.476)	<0.001[a]	1.398 (1.228–1.591)

HKA, hip–knee–ankle angle (indicating varus alignment as a negative value); CI, confidence interval.
[a] Univariate and multivariate logistic regression analysis showed that the level of skin incision was found to be a predisposing risk factor for lateral numbness ($P < 0.001$).

Table 5
Simple linear regression analysis between the level of skin incision and lateral numbness.

z	B	SE	P[a]	R square[b]	SEE
Numbness at postoperative 6 weeks					
(Constant)	134.47	18.825	<0.001	0.862	3.120
Level of skin incision	−3.047	0.529	<0.001		
Numbness at last follow-up					
(Constant)	76.851	13.105	<0.001	0.815	2.468
Level of skin incision	−1.747	0.369	<0.001		

SE, standard error; SEE, standard error of the estimate.
Regression equation:
[Estimated numbness $= B_{[constant]} + B_{[level\ of\ skin\ incision]} \times \chi$ (level of skin incision, mm)]
I. Estimated $numbness_{[6\ weeks\ postoperatively]} = 134.470 - 3.047 \times \chi$ (level of skin incision, mm)
II. Estimated $numbness_{[last\ follow\text{-}up]} = 76.851 - 1.747 \times \chi$ (level of skin incision, mm)
Level of skin incision indicated the distance from the medial joint line to the incision site.
[a] This equation was statistically significant ($P < 0.001$).
[b] The descriptive power was 86.2% and 81.5%, respectively.

5. Conclusions

About half of the patients reported postoperative lateral numbness in the lower leg following MOWHTO. Of the patients with lateral numbness, approximately one-fifth remained symptom until the last follow-up. The level of skin incision might be a risk factor for the development of lateral numbness. Pre-operative patient education concerning the likelihood of lateral numbness is recommended.

Declaration of Competing Interest

There are no conflicts of interest.

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