Anterior skin numbness after total knee arthroplasty: A prospective comparison study between diabetic and non-diabetic patients

Ong-art Phruetthiphat^{a,*,**}, Rit Apinyankul^b, Malee Chanpoo^c, Thanainit Chotanaphuti^a, Weerachai Kosuwan^b, John J. Callaghan^d

^a Department of Orthopaedics, Phramongkutklao Hospital and College of Medicine, Bangkok, Thailand

^b Department of Orthopaedics, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand

^c Department of Anatomy, Phramongkutklao Hospital and College of Medicine, Bangkok, Thailand

^d Department of Orthopaedic Surgery and Rehabilitation, University of Iowa Hospital and Clinics, Iowa City, IA, USA

ARTICLE INFO

Keywords:

Anterior skin numbness

TKA

Diabetic

Non-diabetic

Prospective study

Recovery

ABSTRACT

Background: Anterior skin numbness from injury of the infrapatellar branch of saphenous nerve (IPBSN) and/or the anterior-inferior branch of the femoral cutaneous nerve (AIBFN) has been reported after TKA. A recent study has demonstrated no difference in skin numbness between minimally invasive and standard approach TKA. The purpose of our study was to compare the area of skin numbness following TKA in the diabetic and non-diabetic patient.

Material and methods: 120 patients (41 type II diabetic and 74 non-diabetic) undergoing TKA were evaluated. Five diabetic patients with preoperative skin numbness were excluded. Area of anterior skin numbness was periodically evaluated with a minimum 2-year follow-up (FU).

Results: Clinically, there was no difference in prevalence of skin numbness (73.2% vs 68.9%, $p = 0.36$) and warmth (97.6% vs 97.3%, $p = 1.00$) between diabetics and non-diabetics. Average area of numbness was comparable. However, duration of numbness recovery was significantly longer in diabetics (8.6 vs 5.3 months, $p = 0.001$). Diabetics had a higher rate of global anterior numbness (48.3% vs 22.9%, $p = 0.045$). Prevalence of supero-lateral skin numbness (2.6%, $n = 3$) correlated with the skin incision extended proximally above upper pole of patella at least 4.0 cm

Conclusion: The duration of numbness recovery following TKA was significantly longer in diabetic patients.

1. Introduction

Anterior skin numbness from injury of the infrapatellar branch of saphenous nerve (IPBSN) and/or the anterior-inferior branch of the femoral cutaneous nerve (AIBFN) have been reported as a common occurrence after TKA, and may affect the patient outcomes.^{1–5} A few studies demonstrated that the anterolateral skin incision had a significantly smaller area of skin numbness postoperatively between 6 weeks until one year compared to the anterior midline incision^{8,9} while another study showed that there was no difference in skin numbness between minimally invasive and standard approach TKA.⁶ Additionally, no studies have evaluated the recovery time of numbness after TKA between diabetic and non-diabetic groups.

To our knowledge, no study has compared the skin numbness including warmth between diabetic patients and non-diabetic patients

undergoing TKA. The purpose of our study was to 1) compare the prevalence of skin numbness between diabetic patients and non-diabetic patients undergoing TKA, 2) compare the numbness recovery time after TKA between groups, and 3) identify the association of proximally extended skin incision above upper pole patella and supero-lateral skin numbness.

2. Material & method

After Institutional Review Board approval, a prospective study of 120 patients underwent TKAs at our arthroplasty center was performed between June 2015 and December 2017. Exclusion criteria was 1) severe osteoarthritic (OA) knee in a diabetic patient with numbness on the affected knee before undergo TKA, 2) poor controlled diabetes (hemoglobin A1C was more than 7.0 mg per deciliter), and 3) patients

* Corresponding author. Phramongkutklao Hospital and College of Medicine, Bangkok, Thailand.

E-mail addresses: ongart-phr1@hotmail.com (O.-a. Phruetthiphat), ritap@kku.ac.th (R. Apinyankul), mchanpoo@yahoo.com (M. Chanpoo), tanainit@hotmail.com (T. Chotanaphuti), weera_ko@kku.ac.th (W. Kosuwan), callaghan@uiowa.edu (J.J. Callaghan).

<https://doi.org/10.1016/j.jor.2020.03.017>

Received 10 February 2020; Accepted 23 March 2020

Available online 25 March 2020

0972-978X/ © 2020 Professor P K Surendran Memorial Education Foundation. Published by Elsevier B.V. All rights reserved.

with follow up less than 2 years. Five patients had numbness on the affected knee prior to TKA and were excluded from the study. Finally, 115 patients undergoing TKAs were recruited in this study. Patients were divided into 2 groups: 74 patients were in the primary OA knee without diabetes cohort and 41 patients were in the primary OA knee with well controlled diabetes cohort. The former group had normal blood sugar and were not diabetics while the latter group had type II diabetes mellitus with well controlled blood sugar before undergoing surgery (Fasting blood sugar was less than 180 mg per deciliter and hemoglobin A1C was less than 7.0 mg per deciliter).

Primary OA knee was defined as osteoarthritis of the knee which has no specific cause. Patients variables reviewed were demographic data, comorbidity including American Society Anesthesiologist (ASA) classification and Charlson comorbidity index (CCI), preoperative alignment, preoperative visual analogue scale (VAS), and University of California and Los Angeles (UCLA) Score.⁷ Patient's comorbidities were reviewed from the medical record: 1) Diabetes mellitus was grossly classified into two major types (Non-Insulin Dependent Diabetes Mellitus and Insulin Dependent Diabetes Mellitus), 2) Hypertension, 3) Dyslipidemia, 4) Lung disease (Pulmonary disease), 5) Heart disease was classified into 5 types (coronary artery disease, valvular heart disease, cardiomyopathy, arrhythmias, and heart infection), 6) Liver disease, 7) Kidney disease and 8) Dementia. Additionally, all TKA patients had the Charlson Comorbidity Index (CCI) calculated.

3. Surgical procedure

Before TKA, all patients had a standardized preoperative radiographic evaluation, including anteroposterior, lateral, and merchant radiographs. Skin incision was done at midline of patellar bone from superior pole of patella to tibial tubercle. The skin incision may be extended proximally above upper pole of patella in some patients with inadequate exposure.

A standard medial parapatellar approach was routinely performed by only one well-trained adult hip and knee reconstruction orthopedic surgeon. Medial soft tissue was released. Anterior cruciate ligament and posterior cruciate ligament were sacrificed. All osteophytes around the knee were removed. Tibial bone cut was done perpendicular to the mechanical axis of the tibia. AP Whiteside line and epicondylar axis were used for femoral bone cut consideration, and we further cut the femoral bone perpendicular to the mechanical axis of the femur. Both femoral and tibial components were cemented, and the patella was resurfaced. Depending on the ligament balancing after bone cuts, a condylar TKA with a posterior cruciate ligament–substituting insert was used.

4. Measurement of skin numbness

Area of skin numbness was measured by Semmes Weinstein Monofilaments (10 g) on the affected knee postoperatively at 2 weeks, 6 weeks, 3 months, 6 months, 9 months, one year and at 2 years (11). Area of anterior skin numbness (Square centimeters; Sq.cm.) was periodically evaluated and was compared between the two groups, to a minimum 2-year follow-up (FU). Measurements of numbness was performed by two physicians who were not involved in the surgery. Measurements by the 2 physicians were averaged. We also measured global anterior numbness that was a subjective symptom from all patients. Generally, some patients experienced numbness over the whole area of the lateral aspect of skin while others only experienced numbness in a scattered distribution. The global anterior numbness defined as the numbness over the whole area of the lateral aspect of the skin.

Additionally, paresthesia was evaluated by Semmes Weinstein Monofilaments (10 g) and it was separated into 6 areas adjacent to the patella: Superior-Lateral (SL), Mid-Lateral (ML), Inferior-Lateral (IL), Superior-Medial (SM), Mid-Medial (MM), and Inferior-Medial (IM) as shown in Fig. 1. The vertical line is an imaginary line created by the

Fig. 1. Measurement of paresthesia correlate to patellar bone and distribution of Infrapatellar branch of saphenous nerve. There was 3 from 23 cases (13.0%) associated with Superolateral numbness (This group was proximally extended skin incision above upper pole of patella ≥ 4 cm.) while another group with proximally extended skin incision above upper pole of patella < 4 cm was 0% of superolateral numbness (0 from 92 cases) ($p = 0.007$).

Table 1
Demographics and Comorbidities between Diabetic and Non-Diabetic groups.

Parameters	Diabetic group (n = 41)	Non-Diabetic group (n = 74)	P-value
Age	66.6 $\pm$ 6.8	69.4 $\pm$ 8.5	0.072
Gender			0.561
Female	36 (87.8%)	62 (83.8%)	
Male	5 (12.2%)	12 (16.2%)	
Body weight (Kg)	73.5 $\pm$ 14.1	63.7 $\pm$ 12.3	< 0.001
Height (cm)	157.1 $\pm$ 7.6	156.4 $\pm$ 7.1	0.623
BMI (kg/m ²)	29.9 $\pm$ 5.3	26.0 $\pm$ 4.5	< 0.001
Side for TKA			0.879
Right	21 (51.2%)	39 (52.7%)	
Left	20 (48.4%)	35 (47.3%)	
Length of stay (Day)	5 (4–16)	5 (4–29)	0.072
Hypertension			0.108
Yes	26 (63.4%)	58 (78.4%)	
No	15 (36.6%)	16 (21.6%)	
Dyslipidemia			0.404
Yes	26 (63.4%)	41 (55.4%)	
No	15 (36.6%)	33 (44.6%)	
ASA class			0.078
1	2 (5.1%)	14 (19.4%)	
2	27 (69.2%)	47 (65.3%)	
3	10 (25.6%)	11 (15.3%)	
CCI**	3 (2–6)	3 (0–6)	0.004

American Society Anesthesiologist (ASA) classification; Charlson comorbidity index (CCI); Chi-Square test presented n (%); Independent *t*-test presented mean $\pm$ SD.

** Mann-Whitney *U* test (median)(minimum-maximum) was applied for uneven distribution.

symmetrical bisection of patellar bone. Horizontal line 1 is a line at the upper pole of patellar bone and perpendicular to the vertical line while horizontal line 2 is a line at the lower pole of patellar bone and perpendicular to the vertical line. The red line demonstrated the route of Infrapatellar branch of saphenous nerve. The measurement of proximal one third of numbness was done along the lower thigh medially/laterally above upper pole patella until normal sensation occurred while the distal one third of numbness measurement was performed from the lower pole of patella medially/laterally until the lower border of tibial tubercle as shown in Fig. 1.

Table 2
Comparison Skin incision, Area of Skin numbness (Square centimeters) and Their Recovery Time between Diabetic and Non-Diabetic Groups.

Parameters	Diabetic group (n = 41)	Non-Diabetic group (n = 74)	P-value
Skin Incision	12.5 ± 1.3	12.4 ± 1.2	0.470
Numbness*#			0.522
No	12 (29.3%)	26 (35.1%)	
Yes	29 (70.7%)	48(64.9%)	
Recovery of numbness (months)			0.001
Mean ±SD	8.6±6.3	5.3±4.8	
Median (Min-Max)**	11 (0–20)	6 (0–18)	
Area of skin numbness**			
6 weeks	30.6 (6–86)	36.9 (12–100)	0.604
3 months	24.5 (6–73)	32.7 (11–99)	0.189
6 months	16.7 (5–103)	22.6 (6–63)	0.141
One year	9.4 (2–25)	11.5 (1–30)	0.720
Global anterior numbness*	14 (48.3%)	11 (22.9%)	0.045

*Chi-square: n (%); Independent *t*-test presented mean±SD.

**Mann-Whitney *U* test: Median (Min-Max), zero means no numbness after TKA.

No comparison of skin numbness at 2 years follow up because the last patient had complete numbness recovery at 20 months postoperatively.

#The prevalence of superolateral skin numbness occurred 2.6% (n = 3) from 115 patients.

5. Measurement of skin warmth

Skin warmth was examined by two aspects (subjective and objective). Subjective measurement was done by asking each patient the feeling of warmth compared to a contralateral knee. The objective measurement was performed by two physicians who were not involved in the surgery. Examiners grabbed on both knees (surgical knee and normal knee). The positive result was feeling of warmth when compare to the normal knee. Warmth from surgical site infection was excluded in this study.

6. Data management and statistical analysis

Data description was based on means and standard deviation for

Table 3
Comparison Rate of Skin numbness and Their Recovery Time between Diabetic and Non-Diabetic Groups.

Parameters	Diabetic group (n = 41)	Non-Diabetic group (n = 74)	P-value
Numbness*#			0.522*
No	12 (29.3%)	26 (35.1%)	
Yes	29 (70.7%)	48 (64.9%)	
Rate of numbness recovery			NA
6 weeks			
Numbness Remain (%)	29(70.7%)	48(64.9%)	
Numbness Recovery (%)	0 (0.0%)	0 (0.0%)	
3 months			
Numbness Remain (%)	27 (65.9%)	46(62.2%)	0.629†
Numbness Recovery (%)	2 (4.8%)	2 (2.7%)	
6 months			0.015*
Numbness Remain (%)	24(58.5%)	28(37.8%)	
Numbness Recovery (%)	3 (7.3%)	18 (24.3%)	
9 months			0.001*
Numbness Remain (%)	19 (46.3%)	9 (12.2%)	
Numbness Recovery (%)	5 (12.2%)	19 (25.7%)	
One year			0.417†
Numbness Remain (%)	8 (19.5%)	2 (2.7%)	
Numbness Recovery (%)	11 (26.8%)	7 (9.5%)	
1.5 year			NA
Numbness Remain (%)	0 (0.0%)	1 (1.4%)	
Numbness Recovery (%)	0 (0.0%)	1 (1.4%)	

*Chi-square: n (%); †Fisher's Exact test: n (%); NA: Not analysis.

No comparison of skin numbness at 2 years follow up because the last patient had complete numbness recovery at 20 months postoperatively.

continuous variables and absolute and relative frequencies for categorical variables. A standard student's *t*-test was used for continuous variables while the Chi-Squared test was applied for categorical variables. Mann-Whitney *U* test was applied for comparison among diabetic patients and non-diabetic patients underwent TKA for uneven distribution. Statistical analysis was performed using STATA/MP 12 with statistical significance set to $P < 0.05$.

7. Results

Patient's demographics and comorbidities were identified in Table 1. There was no significant difference in age, gender, height, affected knee, length of hospital stays, hypertension, dyslipidemia, and ASA classification. However, diabetic group had significantly higher body weight ($p < 0.001$) and body mass index ($p < 0.001$) and higher CCI ($p = 0.004$) than non-diabetic group.

There was no difference in prevalence of skin numbness (70.7% vs 64.9%, $p = 0.522$) and area of skin numbness in both groups. The average numbness (sq.cm.) was comparable between groups at 2 weeks, 6 weeks, 3 months, 6 months, and 1 year. However, duration of numbness recovery after TKA in diabetic group was significantly longer than the non-diabetic group (Median 11.0 vs 6.0 months, $p = 0.001$) (Mean 8.6 vs 5.3 months) (Table 2). Additionally, the rate of numbness recovery by time was significantly higher in non-diabetic group at 6 months and 9 months as shown in Table 3 and Fig. 2. Moreover, the characteristic of skin numbness was significantly different between groups. The former group had a higher rate of global anterior numbness compared to the latter group (48.3% vs 22.9%, $p = 0.045$).

There was no difference in both prevalence of warmth (97.6% vs 97.3%) and duration of warmth recovery (6.0 vs 6.0 months) after TKA between groups. The rate of wound complications, knee stiffness, and venous thromboembolism were not significant difference (Table 4). Moreover, Preoperative and postoperative pain score, range of motion, and the activity measured by UCLA in both groups were shown in Table 5. There was comparable VAS score, ROM, and UCLA pre-operatively and postoperatively between diabetic and non-diabetic groups.

Fig. 2. Comparison Rate of Skin numbness and Their Recovery between Diabetic (DM) and Non-Diabetic (non DM) Groups (* means significance in statistics).

Table 4

Postoperative complications after TKA.

Parameters	Diabetic group (n = 41)	Non-Diabetic group (n = 74)	P-value
Warmness*			1.00
Yes	40 (97.6%)	72 (97.3%)	
No	1 (2.4%)	2 (2.7%)	
Full recovery of warmness (months)**	6 (0–9)	6 (0–9)	0.34
Wound complication*			1.00
Wound dehiscence	0 (0.0%)	0 (0.0%)	
Superficial infection	0 (0.0%)	1 (1.4%)	
Deep infection	1 (2.4%)	0 (0.0%)	
Knee stiffness*	1 (2.4%)	0 (0.0%)	
Venous thromboembolism*	0 (0.0%)	0 (0.0%)	

*Chi-square: n (%); **Mann-Whitney U test: Median (Min-Max); No case of warmness related to surgical site infection.

Table 5

Preoperative and Postoperative Pain Score and Activity between Diabetic and Non-diabetic groups.

Parameters	Diabetic group (n = 41)	Non-Diabetic group (n = 74)	P-value
VAS**			0.45
Preoperative	8 (4–10)	8 (5–10)	
Postoperative	0 (0–3)	0 (0–3)	
ROM**			0.34
Preoperative	110 (85–135)	112.5 (40–125)	0.54
Flexion	110 (90–135)	117.5 (80–125)	0.79
Extension	0 (0–5)	0 (0–40)	0.27
Postoperative	120 (90–145)	120 (80–135)	0.32
Flexion	120 (90–145)	120 (90–135)	0.33
Extension	0 (0–5)	0 (0–20)	0.38
ROM Change	5 (0–15)	10 (5–40)	0.59
UCLA**			0.47
Preoperative	4 ^{3–6}	4 ^{2–7}	
Postoperative at 1 year	6 ^{4–7}	6 ^{5–8}	0.71
Postoperative at 2 years	6 ^{5–7}	6 ^{5–8}	0.10

VAS = Visual analogue scale; ROM = range of motion; University of California and Los Angeles (UCLA) Score; **Mann-Whitney U test: Median (Min-Max).

8. Discussion

Anterior skin numbness from injury to the infrapatellar branch of saphenous nerve (IPBSN) and/or the anterior-inferior branch of the

femoral cutaneous nerve (AIBFN) has been reported as a common occurrence after TKA, which may affect patient outcomes.^{1–5} To our knowledge, no study has compared the skin numbness including warmness between diabetic patients and non-diabetic patients undergoing TKA. Moreover, no study has explained the variability of superolateral skin numbness following the procedure. The purpose of our study was to 1) compare the prevalence of skin numbness between diabetic patients and non-diabetic patients undergoing TKA, 2) compare the numbness recovery time after TKA between groups, and 3) identify the association of proximally extended skin incision above upper pole patella and supero-lateral skin numbness. A previous study demonstrated that the anterolateral skin incision had a significantly smaller area of skin numbness postoperatively between 6 weeks until one year compared to the anterior midline incision, but the functional score and knee range of motion were comparable in both groups.^{8,9} Additionally, Tanavalee et al. showed that there was no difference in skin numbness measured by pin prick sensation between minimally invasive and standard approach TKA.⁶ The current study evaluated skin numbness including warmness between diabetic patients and non-diabetic patients undergoing TKA. There was no difference in prevalence of skin numbness (73.2% vs 68.9%, $p = 0.36$) and warmness (97.6% vs 97.3%, $p = 1.000$) between groups. The average numbness area (sq.cm.) was comparable in both groups at all time intervals (2 weeks, 6 weeks, 3 months, 6 months, and 1 year). However, diabetic patients had a higher rate of global anterior numbness (48.3% vs 22.9%, $p = 0.045$).

No studies have evaluated the recovery time of numbness after TKA between diabetic and non-diabetic groups. Our study demonstrated that duration of numbness recovery in the diabetic patients was significantly longer than the non-diabetic group (median 11.0 vs 6.0 months, $p = 0.001$) (Mean 8.6 vs 5.3 months). This could be related to the effects of diabetes mellitus on peripheral nerves.

Even though the prevalence of skin numbness after TKA was comparable between diabetic and non-diabetic patients, the duration of numbness recovery was significantly longer in the diabetic group. The prevalence and area of numbness decreased with time which has also been shown by other authors.^{3,4,6,8,9}

Our clinical study suggests that skin incisions greater than 4 cm above the upper pole of the patella should be avoided to minimize supero-lateral skin numbness. This study should help surgeons characterize the prevalence, and postoperative extent and duration of anterior knee numbness following TKA.

This characterization should help physicians in counseling TKA patients preoperatively as to the anterior knee numbness problem and the likely course of the symptoms so that they can better understand

and deal with the problem if it occurs.

9. Conclusion

The duration of numbness recovery following TKA was significantly longer in diabetic patients. The skin incisions greater than 4 cm above the upper pole of the patella should be avoided to minimize superolateral skin numbness.

Declaration of competing interest

The authors have no competing interests.

No funds were received in support of this study.

The manuscript submitted does not contain information about medical device(s)/drug(s).

No benefit(s) in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.

The project has been reviewed by the Institution Research Board of Royal Thai Army for Human Research on the Declaration of Helsinki and the ICH Good Clinical Practice Guidelines. The study has been

approved with a code of **S041h/58** since September 2015.

References

1. Borley NR, Edwards DV, Villar RN. Lateral skin flap numbness after total knee arthroplasty. *J Arthroplasty*. 1995;10(1):13.
2. Johnson DF, Love DT, Love BR, et al. Dermal hypoesthesia after total knee arthroplasty. *Am J Orthoped*. 2000;29(11):863.
3. Hopton BP, Tommichan MC, Howell FR. Reducing lateral skin flap numbness after total knee arthroplasty. *Knee*. 2004;11(4):289.
4. Sundaram RO, Ramakrishnan M, Harvey RA, et al. Comparison of scars and resulting hypoesthesia between the medial parapatellar and midline skin incisions in total knee arthroplasty. *Knee*. 2007;14(5):375.
5. Subramanian S, Lateef H, Massraf A. Cutaneous sensory loss following primary total knee arthroplasty. A two years follow-up study. *Acta Orthop Belg*. 2009;75(5):649.
6. Tanavalee A, Limtrakul A, Veerasethsiri P, et al. Area of skin numbness after total knee arthroplasty: does minimally invasive approach make any difference from standard approach? *J Arthroplasty*. 2016;31:2499–2503.
7. Zahiri CA, Schmalzried TP, Szuszczewicz ES, et al. Assessing activity in joint replacement patients. *J Arthroplasty*. 1998;13(8):890–895.
8. Rajesh NM, Tushar S, Arun N, et al. A prospective randomized study in 20 patients undergoing bilateral TKA comparing midline incision to anterolateral incision. *J Orthop Traumatol*. 2017;18:325–333.
9. Laffosse JM, Potapov A, Malo M, et al. Hypoesthesia after anterolateral versus midline skin incision in TKA. *Clin Orthop Relat Res*. 2011;469:3154–3163.