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Clin Orthop Relat Res (2020) 478:2020-2033
DOI 10.1097/CORR.0000000000001035

Clinical Orthopaedics and Related Research®
A Publication of The Association of Bone and Joint Surgeons®

Selected Proceedings from the 2019 European Knee Society Meeting
(Guest Editor Emmanuel Thienpont MD, MBA, PhD)

Does Circumferential Patellar Denervation Result in Decreased Knee Pain and Improved Patient-reported Outcomes in Patients Undergoing Nonresurfaced, Simultaneous Bilateral TKA?

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Received: 15 June 2019 / Accepted: 14 October 2019 / Published online: 30 October 2019

Abstract

Background Anterior knee pain, which has a prevalence of 4% to 49% after TKA, may be a cause of patient dissatisfaction after TKA. To limit the occurrence of anterior knee pain, patellar denervation with electrocautery has been proposed. However, studies have disagreed as to the efficacy of this procedure.

Questions/purposes We evaluated patients undergoing bilateral, simultaneous TKA procedures without patellar resurfacing to ask: (1) Does circumferential patellar cauterization decrease anterior knee pain (Kujala score) postoperatively compared with non-cauterization of the patella? (2) Does circumferential patellar cauterization result in better functional outcomes based on patient report (VAS score, Oxford knee score, and Knee Injury and Osteoarthritis Outcome Score) than non-cauterization of the patella? (3) Is there any difference in the complication rate (infection, patellar maltracking, fracture, venous thromboembolism, or reoperation rate) between cauterized patellae and non-cauterized patellae?

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Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.
This work was performed at Medistra Hospital, Jakarta, Indonesia.

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All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research®* editors and board members are on file with the publication and can be viewed on request.

Wolters Kluwer

Methods Seventy-eight patients (156 knees) were included in this prospective, quasi-randomized study, with each patient serving as his or her own control. Patellar cauterization was always performed on the right knee during simultaneous, bilateral TKA. Five patients (6%) were lost to follow-up before the 2-year minimum follow-up interval. A single surgeon performed all TKAs using the same type of implant, and osteophyte excision was performed in all patellae, which were left unresurfaced. Patellar cauterization was performed at 2 mm to 3 mm deep and approximately 5 mm circumferentially away from the patellar rim. The preoperative femorotibial angle and degree of osteoarthritis (according to the Kellgren-Lawrence grading system) were measured. Restoration of the patellofemoral joint was assessed using the anterior condylar ratio. Clinical outcomes, consisting of clinician-reported outcomes (ROM and Kujala score) and patient-reported outcomes (VAS pain score, Oxford knee score, and Knee Injury and Osteoarthritis Outcome Score), were evaluated preoperatively and at 1 month and 2 years postoperatively. Preoperatively, the radiologic severity of osteoarthritis, based on the Kellgren-Lawrence classification, was not different between the two groups, nor were the baseline pain and knee scores. The mean femorotibial angle of the two groups was also comparable: 189° ± 4.9° and 191° ± 6.3° preoperatively (p = 0.051) and 177° ± 2.9° and 178° ± 2.1° postoperatively (p = 0.751) for cauterized and non-cauterized knees, respectively. The preoperative (0.3 ± 0.06 versus 0.3 ± 0.07; p = 0.744) and postoperative (0.3 ± 0.06 versus 0.2 ± 0.07; p = 0.192) anterior condylar ratios were also not different between the cauterized and non-cauterized groups.

Results At the 2-year follow-up interval, no difference was observed in the mean Kujala score (82 ± 2.9 and 83 ± 2.6 for cauterized and non-cauterized knees, respectively; mean difference 0.3; 95% confidence interval, -0.599 to 1.202; p = 0.509). The mean VAS pain score was 3 ± 0.9 in the cauterized knee and 3 ± 0.7 in the non-cauterized knee (p = 0.920). The mean ROM was 123° ± 10.8° in the cauterized knee and 123° ± 10.2° in the non-cauterized knee (p = 0.783). There was no difference between cauterized and non-cauterized patellae in the mean Knee Injury and Osteoarthritis Outcome Score for symptoms (86 ± 4.5 versus 86 ± 3.9; p = 0.884), pain (86 ± 3.8 versus 86 ± 3.6; p = 0.905), activities (83 ± 3.2 versus 83 ± 2.8; p = 0.967), sports (42 ± 11.3 versus 43 ± 11.4; p = 0.942), and quality of life (83 ± 4.9 versus 83 ± 4.7; p = 0.916), as well as in the Oxford knee score (40 ± 2.1 versus 41 ± 1.9; p = 0.771). Complications were uncommon and there were no differences between the groups (one deep venous thromboembolism in the cauterized group and two in the control group; odds ratio 0.49, 95% CI, 0.04-5.56; p = 0.57).

Conclusions Patellar cauterization results in no difference in anterior knee pain, functional outcomes, and complication rates compared with non-cauterization of the patella in patients who undergo non-resurfaced, simultaneous, bilateral, primary TKA with a minimum of 2 years of follow-up. We do not recommend circumferential patellar cauterization in non-resurfaced patellae in patients who undergo TKA.

Level of Evidence Level II, therapeutic study.

Introduction

Anterior knee pain is a common patient complaint not only before TKA, but also after TKA. It was found in 4% to 49% of patients after TKA, resulting in dissatisfaction, morbidity, and potential revision surgery [3, 4, 6, 7, 11, 16, 26, 27, 34, 47]. Several studies have investigated the possible sources of anterior knee pain after TKA, including patellofemoral degenerative changes, patellar maltracking, overstuffing, prosthesis design, and preoperative gait patterns, but a single cause or mechanism has not been determined [19, 28, 30, 33, 36, 40].

The patella is innervated by a network of superficial sensory nerves including the anterior femoral cutaneous nerve, lateral and medial femoral cutaneous nerves, and lateral and medial retinacular nerves [23]. Dye [13] revealed that the peripatellar soft tissue, which is rich in substance P nerve fibers, was a possible source of anterior knee pain. Theoretically, if these nerve fibers are cauterized with electrocautery, denervation of the anterior knee region and relief of patellofemoral pain might be achieved, and a number of studies have tested this premise [19, 21, 23–27].

Rationale

Although some studies have indicated that patellar denervation may decrease the incidence of anterior knee pain [2, 10, 37], others have found that patellar denervation had no substantial effect during follow-up [3, 29, 38, 45]. Several meta-analyses have been performed to compare cauterized and non-cauterized patellae. Nevertheless, controversy still exists, which is partly related to provided evidence. One meta-analysis did not provide a quality assessment of analyzed articles [15], while another showed a moderate risk of bias [22] and others showed a low risk of bias [9, 44, 46]. Zhang et al. [46] showed there was a decrease in the incidence of anterior knee pain but no difference in patellar scores. Cheng et al. [9] combined randomized and non-randomized controlled trials in their meta-analysis, which may have caused bias, and also showed no clinical difference between cauterized and non-cauterized patellae. Furthermore, their meta-analysis had heterogenous implants and surgical techniques (for example, different implants and techniques of cauterization and limited data on the depth of cauterization). This will cause bias in comparing results. Additionally, most studies were performed in unilateral TKA, introducing a difference in pain perception between patients, which is known to be large. Only two studies compared cauterized and non-cauterized unresurfaced patellae in patients undergoing simultaneous, bilateral TKA. One of these two studies did not evaluate scoring of anterior knee pain and used a mid-vastus approach [2], and both studies had small samples and short follow-up periods [2, 45]. To the best of our knowledge, no study has evaluated the effect of patellar denervation on the presence of anterior knee pain in unresurfaced patellae undergoing simultaneous, bilateral TKA with mid-term follow-up. We hypothesized that patellar circumferential cauterization will not result in less pain, a better outcome, or difference in complication rate in patients who undergo TKA with non-resurfaced patellae.

Research Questions

We evaluated patients undergoing bilateral, simultaneous TKA procedures without patellar resurfacing to ask: (1) Does circumferential patellar cauterization decrease anterior knee pain (Kujala score) postoperatively compared with non-cauterization of the patella? (2) Does circumferential patellar cauterization result in better functional outcomes based on patient report (VAS score, Oxford knee score, and Knee Injury and Osteoarthritis Outcome Score) than non-cauterization of the patella? (3) Is there any difference in the complication rate (infection, patellar maltracking, fracture, venous thromboembolism, or reoperation rate) between cauterized patellae and non-cauterized patellae?

Patients and Methods

Study Design and Setting

This was a prospective study of 78 consecutive patients who underwent simultaneous, bilateral primary TKA between February 2015 and October 2016 at Medistra Hospital, Jakarta. During simultaneous, bilateral TKA, cauterization of the patella was performed on all right knees. Thus, a quasi-randomized study design was used in which each patient served as his or her own control, with the right leg in each patient receiving circumferential denervation. The research study was approved by our institutional review board. All patients gave informed consent for participation in the study.

Participants

The inclusion criteria were patients with primary, bilateral patellofemoral knee osteoarthritis (minimum Kellgren-Lawrence Grade 3) who underwent simultaneous, bilateral TKA. Patients with rheumatoid arthritis, infected or septic arthritis, other inflammatory arthritis, secondary or traumatic osteoarthritis, preexisting or congenital bony deformities, severe knee deformities (a varus or valgus deformity) greater than 15°, flexion contracture greater than 10°, patellar dislocation, or preexisting comorbidities (such as diabetes mellitus or chronic heart disease) were excluded. Patients were followed for a minimum of 2 years (mean 30 ± 5.9 months; range 24-45 months).

Study Flow

A total of 78 patients (156 knees) were included in this study, based on the inclusion and exclusion criteria. However, 6% (five of 78) were lost to follow-up (Fig. 1). Sixty-seven women and six men with a mean age of 66 years (range 45-83 years) and a mean BMI of 28 kg/m^2 (range 22–38.1 kg/m^2) participated in this study.

Variables, Clinical Outcome Measures, Data Sources, and Bias

Anterior knee pain was evaluated using the Kujala score [20], which has been shown to have high internal consistency (0.83-0.91) [18]. Functional outcome was evaluated using ROM, VAS score for pain while walking, Knee Injury and Osteoarthritis Outcome Score, and Oxford knee score. Clinical outcomes were evaluated preoperatively and at 1 month and 2 years postoperatively by a single orthopaedic surgeon (KN), who was not a part of the main surgical team. Patients were blinded about which side underwent patellar denervation. The evaluator was not involved in providing the interventions and was blinded to group allocation until the end of the study.

There were no differences in preoperative clinical outcome assessments (ROM, VAS, Knee Injury and Osteoarthritis Outcome Score, Oxford knee score, and Kujala score), femoral anterior condylar ratio, mechanical femorotibial angle, and radiologic severity (determined with the Kellgren-Lawrence grading system) between knees with circumferential electrocauterization of the patellar rim and those without (Table 1). There were no differences in the anterior condylar ratio (0.3 ± 0.1 versus 0.2 ± 0.1; $p = 0.192$) or in the mechanical femorotibial angle (177° ± 3° versus 178° ± 2°; $p = 0.751$) between the two groups postoperatively.

Radiographic Assessment

Bilateral knee and long-leg standing radiographs were taken before surgery, and another radiograph was taken

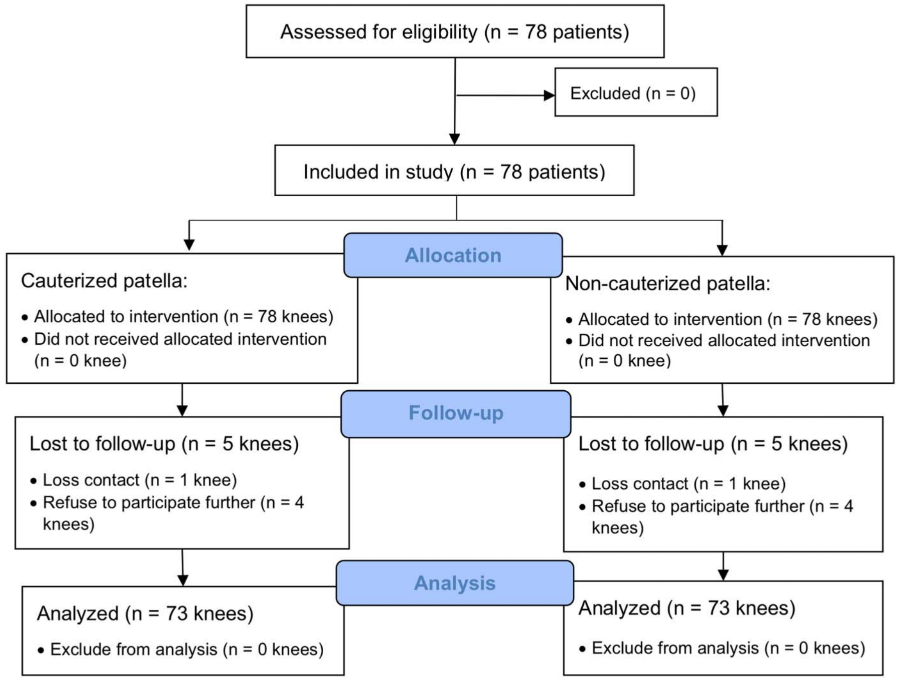

Fig. 1 This figure shows a flowchart of patients selected for inclusion in the study.

24 hours after surgery. The mechanical femorotibial angle of both knees was measured using the long-leg standing radiograph. True lateral-knee radiographs were used to analyze the femoral anterior condylar ratio using digital image viewer software (General Electric Centricity Digital Imaging and Communications in Medicine Viewer 3.1.4., Chicago, IL, USA). The anterior condylar ratio was used to assess restoration of the patellofemoral joint and evaluate overstuffing of the patellofemoral joint. Overstuffing of the patellofemoral joint occurs when there is an increase in the thickness of the patellofemoral joint. It has been reported to lead to maltracking and wear, stretching of the medial patellofemoral ligament, anterior knee pain, and limited ROM of the knee [5]. Overstuffing might change the patella-to-femur distance, leading to change in the moment arm of the quadriceps, which might be evaluated using the anterior condylar ratio. The femoral anterior condylar ratio is the ratio between the femoral anterior condyle's height and the femoral shaft's diameter, as measured 5 cm above the superior pole of the patella (Fig. 2). An independent radiologist (SI) performed all radiographic evaluations.

Description of Surgical Procedure

A single experienced surgeon (NCB) performed all surgeries. The implanted prosthesis was the ATTUNE cruciate-retaining prosthesis (DePuy Synthes, Warsaw, IN, USA) with a fixed-bearing insert. All patients were intravenously administered 8 mg of dexamethasone 1 hour before surgery to reduce postoperative pain and nausea, as well as 750 mg of tranexamic acid 1 hour before and 6 hours after the procedure to reduce bleeding. A tourniquet was used during the procedure. The operation was always performed first on the right side, regardless of the severity of arthritis, through a standard medial parapatellar approach. A tibial cut was made perpendicular to the mechanical axis using an extramedullary alignment guide with the slope set at 7°. A distal femoral cut was made in 6° of valgus using an intramedullary femoral alignment guide, and the extension gap was measured using spacer blocks. Femoral rotation and the posterior femoral condyle cut were determined using a hybrid method, a combination of the measured resection technique and gap-balancing technique. The flexion gap was measured using spacer blocks. The posterior femoral osteophytes were excised; subsequently, trial implants were inserted to assess the joint space; varus and valgus stability, patellar tracking, and ROM were measured; and the pull-out lift-off test [32] was performed. Osteophytes of the patella were excised, and no patellae in any knee were resurfaced. Circumferential electrocautery denervation was always performed on the right patellar rim, regardless of the severity of patellar arthritis, but electrocautery was not performed in the left patella (Fig. 3). Electrocautery was performed using a Valleylab electrocautery unit (Valleylab Inc., Boulder, CO, USA) with monopolar

Table 1. Patient demographics and clinical outcome scores

Characteristics	Patellar Denervation Mean ± SD	Control Mean ± SD	p value
Age (years)	66 ± 7	66 ± 7	
BMI (kg/m^2)	28.3 ± 4	28.3 ± 4	
Gender, n (%)			
Women	67 ± 92	67 ± 92	
Men	6 ± 8	6 ± 8	
Preoperative KOOS for symptoms	45 ± 12	44 ± 12	0.787
Preoperative KOOS for pain	46 ± 12	46 ± 12	0.918
Preoperative KOOS for activities of daily living	46 ± 14	45 ± 14	0.841
Preoperative KOOS for sports and recreation	13 ± 8	13 ± 8	0.879
Preoperative KOOS for quality of life	25 ± 9	25 ± 9	0.730
Preoperative Oxford knee score	23 ± 3	24 ± 3	0.712
Kujala preoperative	40 ± 9	41 ± 9	0.707
Preoperative VAS	8 ± 1	8 ± 1	0.410
Preoperative ROM (°)	101 ± 19	100 ± 20	0.662
Preoperative femorotibial angle (°)	189 ± 5	191 ± 6	0.051
Postoperative femorotibial angle (°)	177 ± 3	178 ± 2	0.751
Preoperative anterior condylar ratio	0.3 ± 0.1	0.3 ± 0.1	0.744
Delta anterior condylar ratio (difference between preoperative and postoperative anterior condylar ratios)	0.05 ± 0.1	0.06 ± 0.1	0.548
Postoperative anterior condylar ratio	0.3 ± 0.1	0.2 ± 0.1	0.192
Kellgren-Lawrence grade, n (%)			0.606
3	25 ± 34.2	28 ± 38.4	
4	48 ± 65.8	45 ± 61.6	

KOOS = Knee Injury and Osteoarthritis Outcome Score.

coagulation diathermy of 50 W at a depth of 2 mm to 3 mm and approximately 5 mm circumferentially away from the patellar rim. Patellar tracking was assessed using a "no-thumb test" with the tourniquet deflated and the medial capsule left open. If the knee was stable with no tightness in flexion and extension and no patellar maltracking, based on a tibial and femoral trial evaluation, then the tibial and femoral components were implanted. No patellar maltracking or ligament imbalance was found during the intraoperative evaluation. The wound was closed, and a vacuum drain was used. The same technique was used in the contralateral knee, without circumferential patellar cauterization. The patients were blinded to the cauterized and non-cauterized sides.

Postoperative Care and Rehabilitation

Physiotherapy and exercises were performed as soon as the patient returned to the ward. The vacuum drain was removed at a maximum of 24 hours after surgery. ROM and straight-leg raising exercises were performed continuously during the first day in the ward. A continuous passive motion device was also used while performing ROM exercises twice per day from the first day. An isometric quadriceps strengthening exercise and assisted weightbearing ambulation using a walker were performed on the second day. Antithrombotic prophylaxis using an oral direct-factor Xa inhibitor (rivaroxaban) was administered to all patients for 14 days postoperatively. The postoperative care and rehabilitation were identical for both knees.

Statistical Analysis

The statistical analysis was performed using IBM Statistical Package for the Social Sciences version 21.0 (SPSS Inc., Chicago, IL, USA). Paired t-tests were used to compare preoperative and postoperative values.

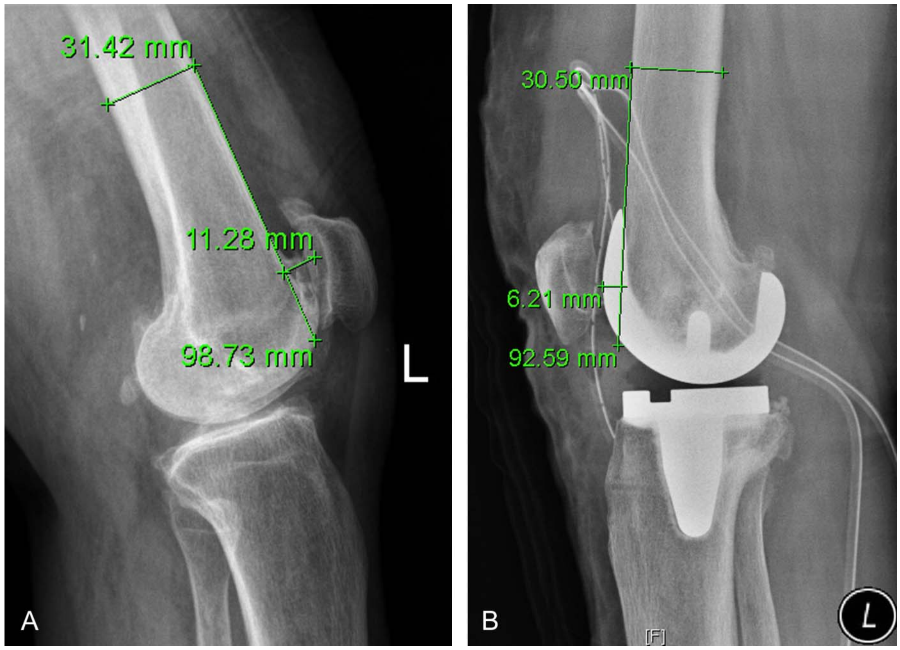

Fig. 2 This figure shows a lateral knee radiograph for measurement of the anterior condylar ratio, which was obtained by dividing the peak anterior condyle's height by the diameter of the femur (**A**) preoperatively and (**B**) postoperatively.

Independent t-tests were used to compare the results of knees with circumferential cauterization of the patellar rim and the results of those without. Tests of the correlation between the anterior condylar ratio and VAS score, Kujala score, and Knee Injury and Osteoarthritis Outcome Score for pain were performed to observe any meaningful correlation that could confound the results of the groups. A p value of 0.05 was considered statistically significant. Based on previous studies, the effect size of the Kujala patellofemoral scale ranges from 0.34 to 0.54. Using an α of 0.05, β of 20%, and power of 80%, the total sample size was 115 knees, or 58 knees in each group.

Results

Does Circumferential Patellar Cauterization Decrease Anterior Knee Pain?

There were no differences in the mean Kujala score between the cauterized and non-cauterized groups at 2 years of follow-up (82 ± 2.9 versus 83 ± 2.6; mean difference 0.3; 95% confidence interval, -0.6 to 1.2; p = 0.509) (Table 2). The mean difference between preoperative and 2-year postoperative scores was 42.1 ± 7.5 (95% CI, -43.9 to -40.3; $p < 0.001$) and 41.7 ± 7.7 (95% CI, -43.5 to -39.9; $p < 0.001$) for the cauterized and non-cauterized groups, respectively.

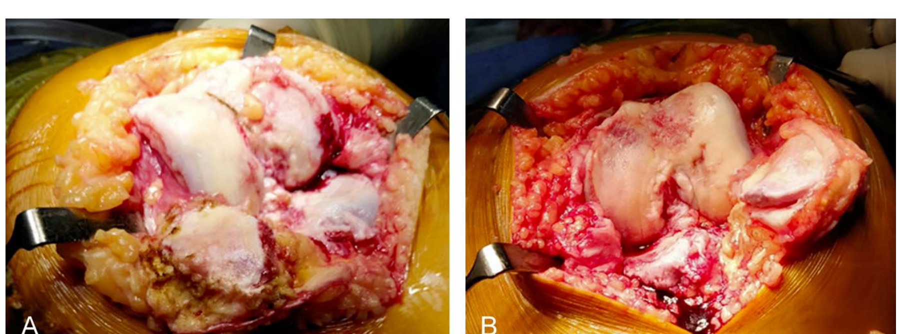

Fig. 3 This figure shows the patella after (**A**) circumferential cauterization and peripatellar soft-tissue excision and (**B**) peripatellar soft-tissue excision only in patients undergoing non-resurfaced, simultaneous, bilateral TKA.

Table 2. Comparison of delta (difference) between baseline (preoperative) and postoperative Kujala scores

	Kujala score			
Timepoint	Patellar denervation	Control	Mean difference between groups (95% CI)	p value (between groups)
1 month	36.5 ± 8.0	36.2 ± 8.3	-0.3 (-3.0 to 2.3)	0.808
2 years	42.1 ± 7.5	41.7 ± 7.7	-0.3 (-2.8 to 2.2)	0.803

There were no baseline differences between the groups. Data are presented as the mean difference between baseline and 1 month and 2 years.

The postoperative Kujala scores of both knees improved at 1 month and 6 months postoperatively but not at 2 years of follow-up (Fig. 4). Moreover, no association was observed between the femoral anterior condylar ratio and anterior knee pain as represented by the VAS score, Kujala score, and Knee Injury and Osteoarthritis Outcome Score (Table 3).

Does Circumferential Patellar Cauterization Result in Better Functional Outcomes Scores?

No differences were found in the mean VAS score between the cauterized and non-cauterized knees (3 ± 0.9 versus 3 ± 0.7; p = 0.920) (Table 4). The mean difference in the preoperative and 2-year postoperative scores was 5.1 ± 0.8 (95% CI, 4.9-5.3; p < 0.001) for the cauterized group and 5.0 ± 1.0 (95% CI, 4.8-5.3; p < 0.001) for the non-cauterized group (Table 4). The postoperative VAS score of both knees decreased at 1 month and 6 months postoperatively but not at 2 years of follow-up (Fig. 5). There were no differences in ROM between cauterized and non-cauterized knees postoperatively (123° ± 10.8° versus 123° ± 10.2°; mean difference -0.4; 95% CI, -3.9 to 2.9; p = 0.783) at 2 years of follow-up (Table 4). The mean difference in ROM preoperatively and 2 years postoperatively was 21.8° ± 16.2° (95% CI, -25.6 to -18.0;

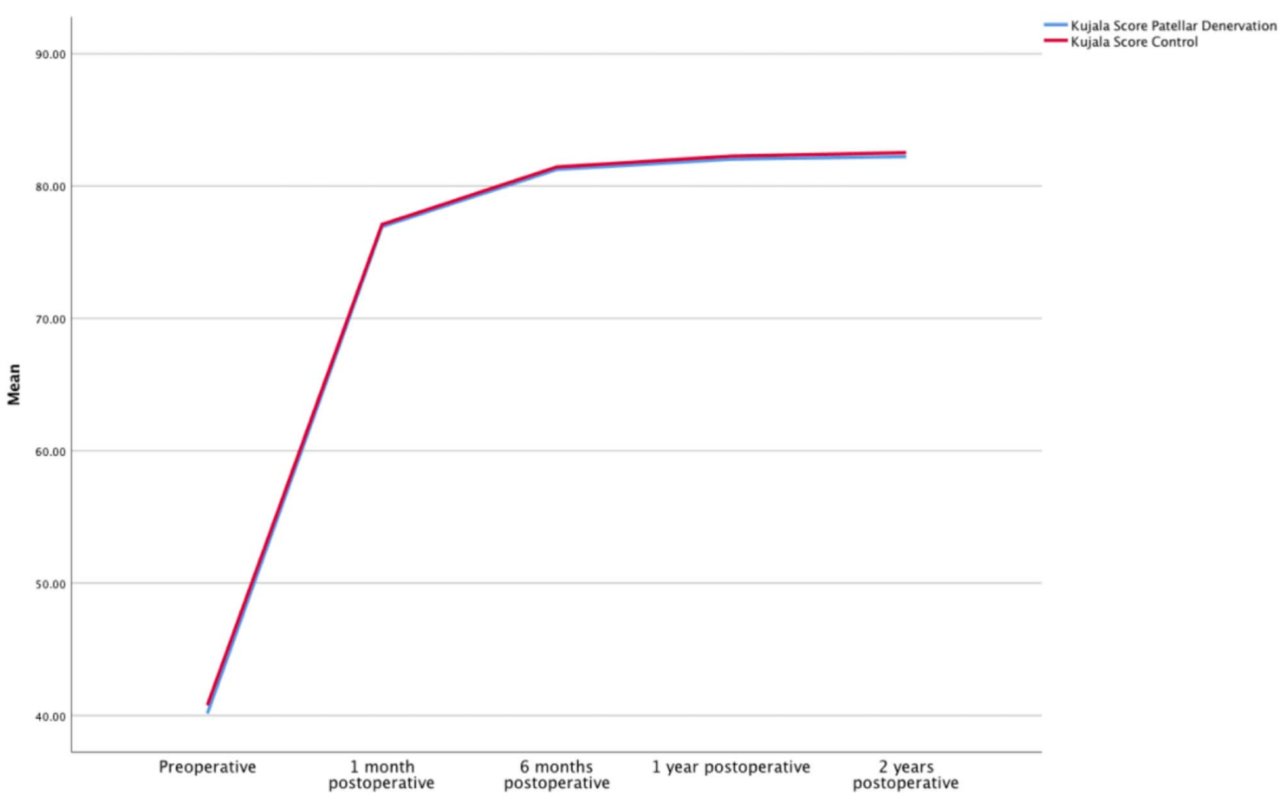

Fig. 4 This figure shows the postoperative Kujala score of both knees over time.

Table 3. Correlation of the delta femoral anterior condylar ratio with the Knee Injury and Osteoarthritis Outcome Score, pain score, Kujala score for anterior knee pain, and VAS scores for the left and right knees

Parameter	Patellar denervation		Control	
Anterior condylar ratio correlation	Correlation coefficient	p value	Correlation coefficient	p value
Knee Injury and Osteoarthritis Outcome Score for pain	-0.093	0.432	-0.057	0.630
Kujala score	-0.040	0.737	-0.067	0.576
VAS score	-0.027	0.818	-0.016	0.893

Delta is the mean difference between baseline and 2 years postoperatively.

p < 0.001) in the cauterized group and 23.2° ± 16.9° (95% CI, -27.1 to -19.3; p < 0.001) in the non-cauterized group. There was also no difference in the Oxford knee score (40 ± 2.1 and 41 ± 1.9; p = 0.771) between cauterized and non-cauterized patellae, respectively, at 2 years postoperatively (Table 4). The mean difference in the Oxford knee score between preoperatively and 2 years postoperatively was 17.0 ± 2.9 (95% CI, -17.7 to -16.3; p < 0.001) and 16.9 ± 3.0 (95% CI, -17.7 to -16.3; p < 0.001) in the cauterized and non-cauterized groups, respectively.

There were no differences in all parameters of the Knee Injury and Osteoarthritis Outcome Score between the two groups (p > 0.05) (Table 2). There were no differences in the mean Knee Injury and Osteoarthritis Outcome Scores for symptoms (86 ± 4.5 versus 86 ± 3.9; mean difference -0.101; 95% CI, -1.478 to 1.275; p = 0.884), pain (86 ± 3.8 versus 86 ± 3.6; mean difference -0.074; 95% CI, -1.291 to 1.144; p = 0.905), activities of daily living (83 ± 3.2 versus 83 ± 2.8; mean difference 0.021; 95% CI, -0.965 to 1.006; p = 0.967), sports and recreation (42 ± 11.3 versus 43 ± 11.4; mean difference 0.137; 95% CI, -3.577 to 3.851; p = 0.942), and quality of life (83 ± 4.9 versus 83 ± 4.7; mean difference -0.085; 95% CI, -1.673 to 1.503; p = 0.916) for cauterized and non-cauterized patellae. Postoperative ROM, Oxford knee scores, and Knee Injury and Osteoarthritis Outcome Score improved in both knees at 1 month postoperatively but not at 2 years of follow-up (Table 4) (Fig. 6).

Is There Any Difference in the Complication Rate of Cauterized Patella ?

No complications were associated with infections; patellar fracture, dislocation, subluxation, or maltracking; or extensor mechanism disruption. No revision or reoperation was required for any reason in either group. However, late deep venous thromboembolism was observed in two patients (one knee in the cauterized group and two in the control group) (odds ratio 0.49; 95% CI, 0.04-5.56; p = 0.57). These were observed at 6 months postoperatively and were treated successfully. No difference in the complication rate was found between the cauterized and non-cauterized groups.

Discussion

Persistent anterior knee pain after TKA is likely caused by multiple factors that are not always easily identifiable;

Table 4. Comparison of delta (difference) between baseline (preoperative) and postoperative clinical outcomes

	1 month after surgery				2 years after surgery			
Score	Patellar denervation	Control	Mean difference (95% CI)	p value	Patellar denervation	Control	Mean difference (95% CI)	p value
VAS activity	3.7 ± 0.9	3.6 ± 0.9	-0.1 (-0.4 to 0.2)	0.417	5.1 ± 0.8	5.0 ± 1.0	-0.08 (-0.4 to 0.2)	0.594
KOOS symptoms	37.1 ± 11.5	37.8 ± 10.9	0.7 (-2.9 to 4.4)	0.699	40.6 ± 10.8	41.4 ± 11.2	0.7 (-2.8 to 4.4)	0.675
KOOS pain	36.8 ± 10.6	36.8 ± 10.1	-0.03 (-3,4 to 3.4)	0.988	40.1 ± 10.7	39.9 ± 10.2	-5.9 (-18.1 to 6.1)	0.332
KOOS ADL	33.1 ± 13.2	34.2 ± 13.4	1.02 (-3.3 to 5.4)	0.645	36.4 ± 13.8	37.3 ± 13.7	0.8 (-3.6 to 5.4)	0.7
KOOS sports and recreation	25.8 ± 11.0	25.5 ± 10.9	-0.4 (-4.0 to 3.2)	0.822	29.2 ± 11.1	30.0 ± 11.4	0.8 (-2.8 to 4.5)	0.661
KOOS QoL	55.6 ± 9.5	55.2 ± 9.5	-0.4 (-3.5 to 2.7)	0.789	57.7 ± 9.6	57.6 ± 9.9	-0.07 (-3.3 to 3.1)	0.963
OKS	15.8 ± 3.1	15.5 ± 3.0	-0.3 (-1.3 to 0.7)	0.522	17.0 ± 2.9	16.9 ± 3.0	0.07 (-1.04 to 0.9)	0.889
ROM (°)	14.8 ± 17.7	15 ± 18.7	0.1 (-5.8 to 6.09)	0.964	21.8 ± 16.2	23.2 ± 16.9	1.4 (-4.1 to 6.8)	0.619

There were no baseline differences between the groups. Data are presented as the mean difference from baseline to 1 month and 2 years. KOOS = Knee Injury and Osteoarthritis Outcome Score; ADL = activities of daily living; QoL = quality of life; OKS = Oxford Knee Score.

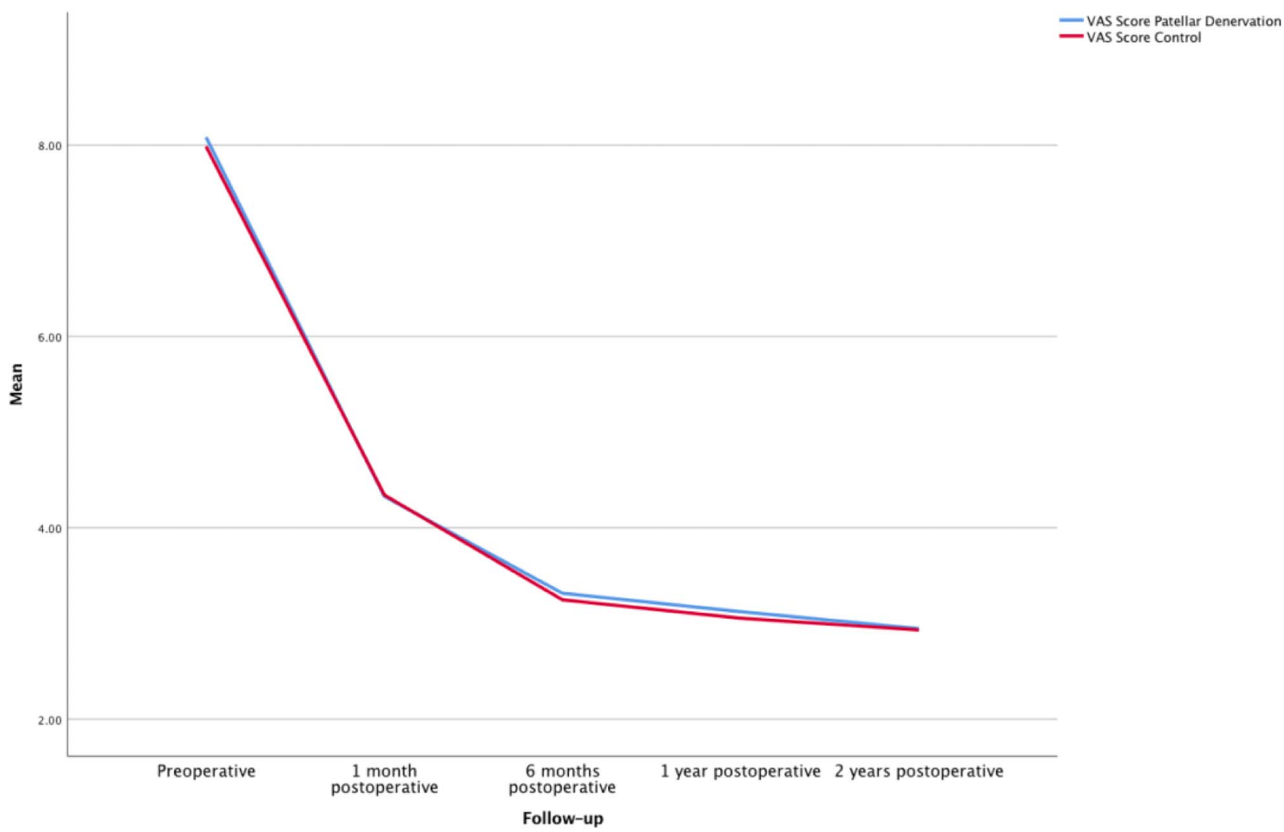

Fig. 5 This figure shows the postoperative VAS pain score of both knees over time.

hence, its management remains difficult [11]. Patellar resurfacing, leaving the patella unresurfaced, and patellar circumferential denervation (or not) are advocated as management options for anterior knee pain in patients who undergo TKA [12, 31]. Patellar resurfacing is not routinely performed in Southeast Asian patients. This is because Asian people have a smaller stature and thinner patellae than other individuals do, and the resurfacing procedure tends to cause patellar fracture and associated complications. Second, patellar resurfacing results in additional costs to the patient because of limited national or private healthcare insurance [1, 8]. In this study, we sought to answer the question of whether circumferential patellar denervation in unresurfaced patellae would result in decreased anterior knee pain, improved function, and different complication rates in Southeast Asian patients who undergo simultaneous, bilateral TKA and found it offered no benefit.

Limitations

Our study has several limitations: First, our study was quasi-randomized rather than formally randomized; that is, all patients had the intervention (patellar denervation) in the right knee, while the left knee served as a control. Between-limb differences such as right-sided limb dominance, which is more common [39], could have favored the treatment group. Despite this, there were no between-group differences. A possible explanation is that these patients were all Asian, and in Asia, a floor-based lifestyle is culturally normative. Because these people squat, kneel, and hyperflex with both knees, it is possible that limb dominance is not as strong a factor in this population as it is in other populations (such as people from the United States and Europe). To minimize evaluation bias, we blinded patients as to which knee was cauterized, and we assigned a different assessor who was blinded to group allocation and not involved in the intervention or surgical team to evaluate the results. Because the patient was unaware which side underwent patellar denervation, the patient-reported outcome scores were not biased. We reasoned that because the patient's perception of pain was the dominant outcome, the major advantage of this study is that we included only bilateral knees, compared with studies including unilateral knees in a randomized design.

Second, a small sample size increases the risk that we will falsely accept the null hypothesis that anterior knee pain between treatment groups was not different (Type II

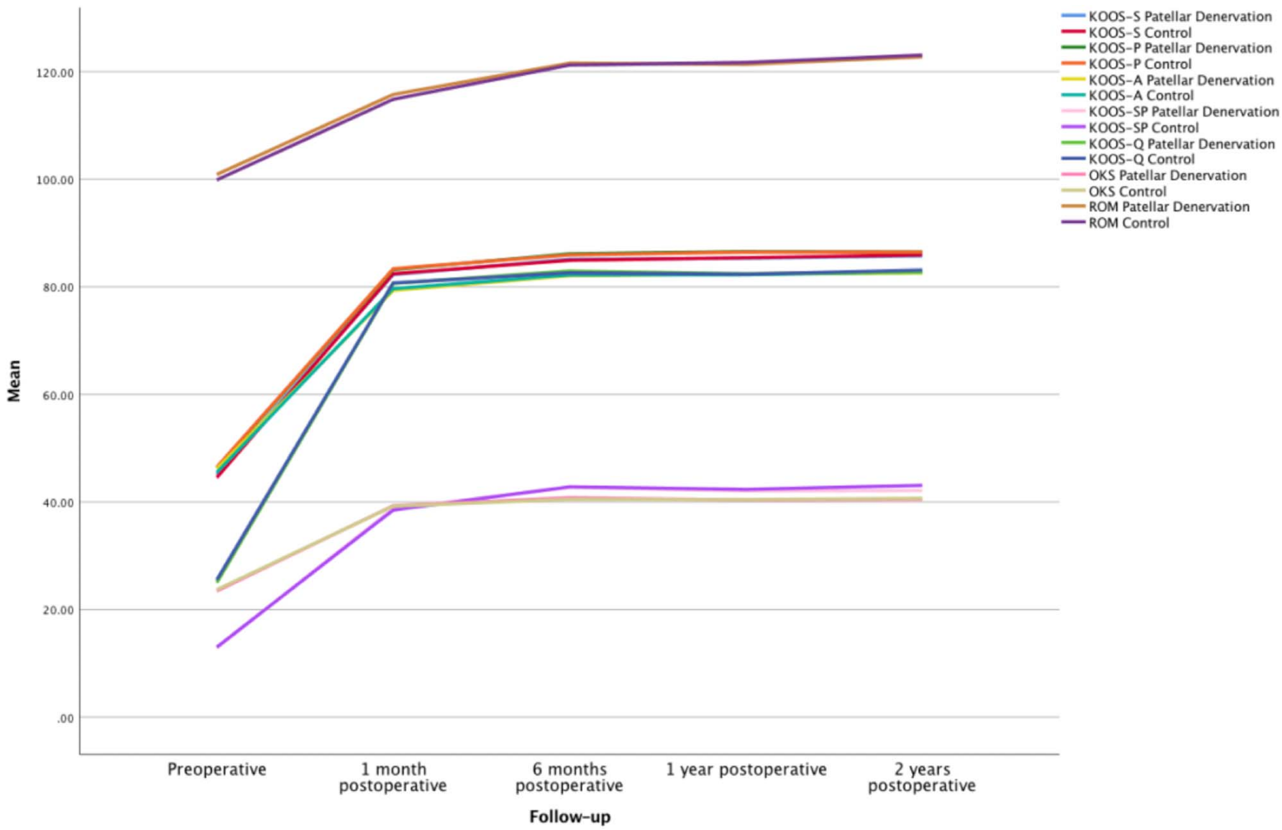

Fig. 6 This figure shows the postoperative clinical outcome assessment of both knees over time.

error). The minimal clinically important difference for the Kujala score is 3, which is higher than our delta mean values. Circumferential cauterization did not improve anterior knee pain clinically.

Third, we used a cauterization depth of 2 mm to 3 mm. No meta-analysis or even comparative study has compared the cauterization depth. However, one study [14] showed the effectiveness of performing cauterization at a depth of 1 mm to 3 mm in reducing anterior knee pain in patients undergoing TKA.

Fourth, a single independent radiologist interpreted the radiograph results, with no intraobserver reliability. This also might cause bias (intrinsic errors) in radiograph interpretation regarding the femorotibial angle, anterior condyle ratio, and radiographic osteoarthritis. However, because radiologic measurements were performed using digital software with precise landmarks, the possibility of intrinsic errors could be minimized. Generally, bilateral TKAs are performed less often than unilateral TKAs are, and studies comparing the outcome of circumferential cauterization of the patella in patients undergoing simultaneous, bilateral, non-resurfaced TKA are limited. Comparing clinical outcomes with those of the contralateral knees in the same individual undergoing simultaneous, bilateral TKA may eliminate confounders such as differences in pain and subjective perceptions between individuals.

Does Circumferential Patellar Cauterization Decrease Anterior Knee Pain?

Our study found no difference in anterior knee pain between circumferential patellar cauterization and non-cauterization of non-resurfaced patellae in our population at 1 month, 6 months, 1 year, or 2 years after surgery. Similarly, two studies on electrocauterization of the patella compared with non-cauterization had similar results in terms of relief of anterior knee pain after TKA [3, 29]. A prospective randomized controlled trial [21] compared electrocautery with non-electrocautery and found no substantial differences in pain at 3 months, 6 months, or 5 years of follow-up in patients undergoing non-resurfaced TKA, and similar results were also observed in several other studies [2, 3, 29, 45]. However, different outcomes were shown by van Jonbergen et al. [37]; there were improvements in postoperative WOMAC total and function scores in the cautery group compared with the scores of patients in the non-cautery group, but improvements in postoperative WOMAC pain scores were not seen at 1 year of follow-up.

However, these differences were not observed at the 3.7-year follow-up interval [38]. The differences in early functional outcome in that study, compared with our result, may be because of differing implant designs. We used a fixed-bearing cruciate-retaining implant, while van Jonbergen et al. used a fixed-bearing, posterior-stabilized implant. At least one study has shown that fixed-bearing, cruciate-retaining designs have better clinical outcomes and lower revision rates than fixed-bearing, posterior-stabilized designs [43]. The differences in the depth of cauterization (1 mm versus 2 mm to 3 mm) may also play a role in the early result. A meta-analysis [14] has revealed that circumferential patellar cauterization could result in improved knee function scores but did not decrease anterior knee pain. However, even this study showed there was functional improvement; there was no improvement clinically based on the minimal clinically important difference. Two additional meta-analyses [44, 46] revealed that patellar cauterization did not decrease anterior knee pain or improve clinical outcomes at 12 months of follow-up. Despite this, Xie et al. [44] recommended circumferential cauterization because of its good safety profile. However, Li et al. [22] and Zhang et al. [46] showed there was improvement, but did not clearly recommend cauterization (Table 5). Other meta-analyses [9, 15] showed no improvement and did not recommend patellar cauterization in patients undergoing TKA. However, these meta-analyses had relatively short follow-up intervals and used different patellar cauterization depths, types of implants, and operative techniques, and some of these studies compared cauterization with non-cauterization in resurfaced patellae.

Does Circumferential Patellar Cauterization Result in Better Functional Outcomes Scores?

In our study, there was no difference in functional outcome scores at 1 month, 6 months, 1 year, or 2 years after surgery between circumferential patellar cauterization and non-cauterization of non-resurfaced patella in patients undergoing simultaneous, bilateral TKA. A study comparing patelloplasty only and patelloplasty combined with circumferential cautery found no major differences in pain and functional outcomes 3 years after surgery [17]. Spencer et al. [35] compared resurfaced patellae without denervation with unresurfaced patellae with denervation and found no substantial differences in pain and functional scores after 2 years of follow-up. Consistent with these studies, the reason for our findings are as follows: first, we used "patella-friendly" components in this study. The patella-friendly implant has an extended anterior flange with a deeper and wider trochlear groove. TKA implants with a patella-friendly design might lower the reoperation rate because of patellofemoral problems and postoperative anterior knee pain [25, 42]. Second, there is no consensus regarding the standard circumferential patellar cauterization technique. In our study, patellar cauterization was performed at 2 mm to 3 mm deep and approximately 5 mm circumferentially away from the patellar rim, without damaging the cartilage. Fan et al. [14] recommended patellar electrocauterization of the synovial soft-tissue layer within 1 cm of the circumference of the patella and at a depth of not greater than 1 mm to 3 mm, with 50 W of monopolar diathermy. Third, we excised the peripatellar soft tissues such as the synovium and infrapatellar fat pad in both groups. Peripatellar soft tissue, according to some studies, contains pain-sensitive nerve-end fibers responsible for postoperative anterior knee pain [14, 23, 27, 36, 37, 41, 44]. Finally, many other factors contribute to anterior knee pain, and some patients experience anterior knee pain after TKA regardless of their preoperative condition [1, 8, 27].

Is There Any Difference in the Complication Rate of Cauterized Patella ?

Similar to other previous studies, our study did not reveal a difference in complications between the two groups [17, 21, 36, 45, 46]. Specifically, no complications were associated with patellar fracture, dislocation, subluxation, and maltracking, or an extensor mechanism injury. Revision surgery for pain or a patellofemoral problem was not required. Although not seen in our study, several complications after non-resurfaced patellar cauterization have been described: chondrolysis because of progression of osteoarthritis or mechanical factors [27]; proprioceptive disturbance after electrocauterization, causing patellar degeneration owing to gait or altered joint loading that could not be detected because of diminished proprioception [17]; thermal injury to the patellar tendon, which is an entry point of the patellar vessel that supplies the patella and could lead to osteonecrosis and damage to the extensor mechanism; and direct cartilage damage [24, 36].

Conclusions

We found no difference in anterior knee pain, functional outcomes, and complication rates up to 2 years postoperatively between circumferential cauterization and non-cauterization of the patella in patients who underwent non-resurfaced, simultaneous, bilateral TKA. We therefore do not recommend circumferential patellar cauterization in patients undergoing non-resurfaced TKA.

Table 5. Meta-analyses comparing patellar denervation and non-patellar denervation

Study	Sample size		Outcome	Mean difference	95% CI	Interpretation
	PD	NPD				
Zhang et al. [46]	235	231	Incidence of AKP	0.65[a]	0.42-1.00	No difference
	98	98	VAS	-0.31	-0.81 to 0.19	No difference (I^2 = 62%)
	98	98	Patellar score	1.00	-0.10 to 2.10	No difference (I^2 = 58%)
	154	157	OKS	-0.21	-2.53 to 2.11	No difference (I^2 = 57%)
	98	98	ROM	4.27	1.95-6.60	Better in denervation group
	98	98	KSS knee score	2.50	0.34-4.67	Better in denervation group
	98	98	KSS function score	4.07	1.34-6.80	Better in denervation group
	258	261	Incidence of complication	0.31[a]	0.05-2.06	No difference
	361	360	Incidence of revision	0.56[a]	0.20-1.59	No difference
Cheng et al. [9]	222	225	Incidence of AKP	0.71[b]	0.47-1.06	No difference
	148	144	Patellar score	1.14	0.38-1.89	Better in denervation group
	166	166	KSS knee score	2.51	0.71-4.30	Better in denervation group
	166	166	KSS function score	3.12	1.01-5.22	Better in denervation group
	327	327	Incidence of Complication	1.05[b]	0.15-7.40	No difference (I^2 = 53%)
Xie et al. [44]	304	307	Incidence of AKP (< 12 months)	0.63[a]	0.44-0.88	Higher incidence in non-denervation group
	154	155	VAS (< 12 months)	-0.83	-1.10 to -0.56	No difference
	154	157	Patellar score (< 12 months)	1.60	0.87-2.33	Better in denervation group
	194	194	KSS knee score (< 12 months)	2.18	0.16-4.21	Better in denervation group
	194	194	KSS function score (< 12 months)	2.16	0.26-4.06	Better in denervation group
	63	63	ROM (< 12 months)	3.50	0.90-6.10	Better in denervation group
	229	225	Incidence of AKP (> 12 months)	0.69[a]	0.46-1.04	No difference
	189	190	VAS (> 12 months)	-0.16	-0.34 to 0.02	No difference
	148	147	Patellar score (> 12 months)	-0.41	-1.19 to 0.38	No difference
	201	196	KSS knee score (> 12 months)	1.06	-0.65 to 2.76	No difference
	201	196	KSS function score (>12 months)	1.73	-0.08 to 3.55	No difference
	146	143	ROM (> 12 months)	1.94	-0.09 to 3.98	No difference
Li et al. [25]	201	201	Incidence of AKP	0.67[a]	0.46-0.99	Higher in non- denervation group
	126	129	VAS	-0.63	-0.97 to -0.29	Better in denervation group
	85	85	Patellar score	1.15	0.74-1.55	Better in denervation group
	216	216	KSS function score	1.88	0.41-3.34	Better in denervation group
	181	181	WOMAC	3.79	1.88-5.69	Better in denervation group
	151	151	Infection	1.00[a]	0.20-5.11	No difference
	151	151	Complication related to patella	1.41[b]	0.27-7.27	No difference
Findlay et al. [15]	166	166	KSS	0.25	-3.51 to 13.67	No difference
Fan et al. [14]	146	143	Patellar score	0.63	0.13-1.13	Better in denervation group
	352	352	Incidence of AKP	0.78	0.55-1.12	No difference (I^2 = 70%)
	152	152	OKS	1.78	0.24-3.32	Better in denervation group
	181	181	WOMAC	3.76	1.71-5.81	Better in denervation group
	279	278	KSS knee score	2.09	0.69-3.50	Better in denervation group
	279	278	KSS function score	1.93	-1.57 to 5.43	No difference (I^2 = 80%)
	146	143	ROM	3.50	1.82-5.18	Better in denervation group

[a]Indicates the odds ratio.
[b]Indicates the relative risk. PD = patellar denervation/cauterization; NPD = non-patellar denervation; AKP = anterior knee pain; FTA = femorotibial angle; OKS = Oxford knee score; KSS = Knee Society Score; ADL = activity of daily living score; UCLA = University of California and Los Angeles score.

Acknowledgments We thank Sri Inggriani MD for her assistance in performing all radiologic readings and measurements in our study.

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