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RESEARCH ARTICLE

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The efficacy of patellar denervation on prognosis and kneeling capacity after unicompartmental knee arthroplasty: a randomized clinical trial

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Abstract

Objective The aim of this study was to investigate the effect of patellar denervation (PD) on pain, function and ability to kneel after unicompartmental knee arthroplasty (UKA).

Methods Patients with medial knee osteoarthritis who underwent UKA were prospectively selected. Patients were randomly divided into PD and non-PD groups based on whether patellar denervation was performed. Clinical assessment was performed using the Hospital for Special Surgery (HSS) knee score, Kujiala score, visual analogue scale (VAS) and forgotten joint score (FJS-12), as well as postoperative complications were recorded. The patients' postoperative self-perception and actual ability to perform different kneeling positions were assessed in the two groups.

Results UKA patients treated with PD achieved better Kujiala scores and FJS-12 scores, reduced anterior knee pain and improved kneeling ability postoperatively, validating the effectiveness of PD in UKA. Perception and actual performance of kneeling remained mismatched in PD patients, but performance during different kneeling activities was generally better than in non-PD patients.

Trial registration Clinical Trial Registration: ChiCTR1900025669.

Conclusion Patellar denervation can safely and effectively improve patellofemoral joint function, pain and kneeling ability in the early postoperative period after UKA.

Keywords Unicompartmental knee arthroplasty, Patellar denervation, Anterior knee pain, Kneel

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Introduction

Unicompartmental knee arthroplasty (UKA) is a minimally invasive procedure for the treatment of end-stage osteoarthritis of the medial compartment of the knee, allowing for the preservation of more anatomical structures and proprioception [1–4]. Kneeling is a movement that Asians often perform in their daily life and religious activities and plays a crucial role in postoperative satisfaction and quality of life [5, 6]. Although it has been shown that knee flexion range after UKA did not correlate well with the ability to kneel, kneeling was still a difficult challenge for many early UKA patients [7, 8]. More than 50% of patients with knee arthroplasty consider kneeling to be the most important and common activity in their lives, and more than 70% of patients consider kneeling to be the most difficult activity [8]. Artz et al. [7] found that 32% of UKA patients were still unable to kneel 2 years postoperatively due to pain, and that only 11% of patients were able to kneel easily.

Several neurohistological studies have suggested that two nociceptive afferent fibres extending around the patella located in the vastus medialis and vastus lateralis were closely associated with anterior knee pain (AKP) [9, 10]. Patellar denervation (PD) is used to reduce AKP by damaging the peripatellar innervation through peripatellar electrocautery [11, 12]. The use of PD in total knee arthroplasty has been shown to reduce the risk of postoperative AKP by 32–70% [13–15]. Therefore, more and more orthopaedic surgeons are applying denervation techniques to knee arthroplasty, but reports on its use in UKA are rare [11, 12, 16].

There is a lack of evidence that UKA combined with PD is effective in improving joint function and reducing pain during flexion and kneeling. Therefore, the primary objective of this study was to investigate the effects of PD on pain, joint function, and kneeling ability after UKA. The secondary objective was to validate the efficacy and safety of PD for use in UKA. We hypothesised that peripatellar electrocautery denervation would be an effective and safe method to improve joint function, reduce pain, and improve patients' ability to kneel postoperatively.

Materials and methods

Patient selection

This study was a randomized clinical trial. Based on the selection criteria, we recruited 132 patients who underwent UKA at our hospital between September 2019 and December 2022. This study followed the principles of the Declaration of Helsinki, and all patients were provided preoperative informed consent. This study was approved by the Ethics Committee and has been registered in the Chinese Clinical Trial Registry (ChiCTR1900025669).

The inclusion criteria of the study were as follows: ① diagnosis of osteoarthritis of the medial compartment; ② a complete lateral intercompartment gap and anterior cruciate ligament; and ③ the Iwano grade [17] for patellofemoral joint imaging was stage I-II. ④ Flexion contracture < 15°, knee mobility ≥ 90°, and internal and external valgus deformity < 15°. The exclusion criteria were ① acute osteonecrosis, and inflammatory arthritis such as rheumatoid arthritis, ankylosing spondylitis, gouty arthritis or infectious arthritis; ② a history of knee surgery in the past or during the follow-up period; ③ waist, hip or foot pain on the operative side; and ④ incomplete clinical or follow-up data.

Sample size calculation

The sample size was calculated using G*Power (version 3.1.9.7). The power (1-β) was 80%, the effect size was 0.5, and the two-tailed α was 0.05. The number of samples from at least 53 patients in each group was calculated. We assumed that the loss to follow-up rate was 20%. Therefore, 66 patients were included in each group.

Method of randomization

Subjects were recruited and randomly assigned by two independent physicians. A randomized grouping scheme was kept in 132 opaque envelopes, which were opened in order of enrollment, and the grouping of patients was determined according to the allocation scheme in the envelopes. The envelopes were not opened until the patient entered the operating room. Patients were categorized into PD group and non-PD group based on whether they received PD.

Surgical treatment

All surgeries were performed by the same experienced orthopedic team. All patients underwent Oxford mobile-bearing medial UKA (Zimmer Biomet, America) according to the manufacturer's instructions. The patients were placed in the supine position under general anaesthesia, a tourniquet was applied to the thigh, the leg was suspended in a lower limb brace, the hip was flexed at 30° with mild abduction, the calf was naturally lowered, and the knee could be flexed to a minimum of 110°. The joint cavity was opened via a medial parapatellar approach, part of the infrapatellar fat pad was resected, and the osteophytes were removed. According to the principle of flexion-extension balance, tibial plateau and distal femur osteotomies were carried out sequentially, and after installing the trial mould to test the joint movement and stability, the appropriate type of prosthesis was selected, fixed and installed with bone cement. In the PD group, the end of the electrotome was bent 3 mm. In the extended knee position, the medial aspect of the patella was slightly externally turned. Circumferential electrocautery denervation of the patella was performed using an electrocautery knife, especially on the medial-superior and lateral-superior edges of the patella. The depth of electrocautery was 2 to 3 mm. The soft tissues around the knee joint of the two groups were routinely injected with "cocktail" analgesic solution. After the instruments and dressings were counted, one drainage tube was placed, and the wound was closed layer by layer.

Postoperative management

Standardized protocols were used for all postoperative management. From 12 h to 2 weeks after the operation, an oral anticoagulant (apexaban)were taken to prevent thrombosis. The drainage tube was removed within 24 h after surgery, and the patients were encouraged to walk with the aid of walkers. The patients were instructed to exercise the ankle pump, actively contract the quadriceps femoris and perform straight leg elevation exercises. Patients were asked to follow up in an outpatient clinic at 1, 6 and 12 months after surgery.

Clinical evaluation

Patellar function was evaluated using the Kujiala score [18], and knee function was evaluated using the Hospital for Special Surgery (HSS) knee score [19]. The HSS score and Kujala score ranged from 0 to 100, with higher scores indicating better function. Visual analogue scale (VAS) was used to evaluate the degree of postoperative knee pain [20]. The degree of postoperative prosthesis self-adaptation was assessed using the Forgotten Joint Score (FJS-12) [21, 22] at the last follow-up after surgery, with higher scores indicating a better subjective feeling. Complications that occurred during the perioperative period and follow-up were recorded.

Kneeling evaluation

At 12 months after surgery, an independent investigator assessed the patients' perceived and actual ability to kneel. Patients were asked in advance if they thought they could kneel at 90° or 120° on the cushion and floor, and their perception of kneeling was assessed according to whether they answered "yes" or "no". We assessed patients' actual ability to kneel with reference to question 7 of the Oxford Knee Score (score 0–4) [23]. To simplify the statistical analysis, a score of 0 indicates "impossible", 1–2 indicates "poor", and 3–4 indicates "good".

Data analyses

The statistical software used was SPSS 26.0. Continuous variables are expressed as the mean±standard deviation (SD) and were analysed using Student's t test. Noncontinuous variables are expressed as numbers and percentages (%) and were analysed using the Chi-square test. Mann-Whitney U test was used to compare the grade data of the two groups. α=0.05 was used as the test criterion for all parameters, and $P<0.05$ was considered to indicate a statistically significant difference.

Results

There are 58 patients (58 knees) in the PD group and 62 patients (62 knees) in the non-PD group included in the analysis (Fig. 1). All baseline characteristics were comparable between the two groups, and there were no significant differences in preoperative demographics, American Society of Anesthesiologists (ASA) grade, Charlson comorbidity index (CCI), patellar morphology, degree of patellofemoral joint degeneration and clinical scores were not significantly different (Table 1).

Clinical outcomes

The clinical outcomes showed statistically significant differences in postoperative Kujala scores, VAS and FJS-12 scores between the two groups; there was no statistically significant difference in postoperative HSS scores between the two groups (Table 2).

Kneeling outcomes

There was statistically significant difference in the actual ability to kneel in the postoperative period between the two groups (Table 3). The highest percentage of "good" actual kneeling ability was "90° kneeling on the cushion in the PD group (55.2%) " and the lowest percentage of "good" actual ability was "120° kneeling on the floor in the non-PD group (16.1%)". The highest percentage of actual inability to kneel was "on the floor in the non-PD group (24.2%)", and the lowest percentage was "on the cushion in the PD group (6.9%)".

There was significant difference between the perceived and actual performance of the two groups (Figs. 2 and 3). The highest concordance between patients' actual kneeling performance being "good" and perceiving that they could kneel was "120° kneeling on the cushion in the PD group (89.7%) ", and the worst concordance was "90° kneeling on the floor in the non-PD group (69.2%) ". The highest concordance between patients' actual inability to kneel and their perceived inability to kneel was "kneeling on the cushion in the PD group (100%)", and the worst concordance was "kneeling cushion in the non-PD group (80%)".

Postoperative complications

During the perioperative period, the intervention group and conventional group had 3 cases of lower extremity vein thrombosis (1 and 2, respectively), 1 case of hematoma (1 and 0, respectively) and 3 cases of poorly healed skin incisions (1 and 2, respectively). The patients were cured after symptomatic treatment, and none of them underwent secondary surgical revision. The incidence of postoperative complications was 5.2% (3/58) in the

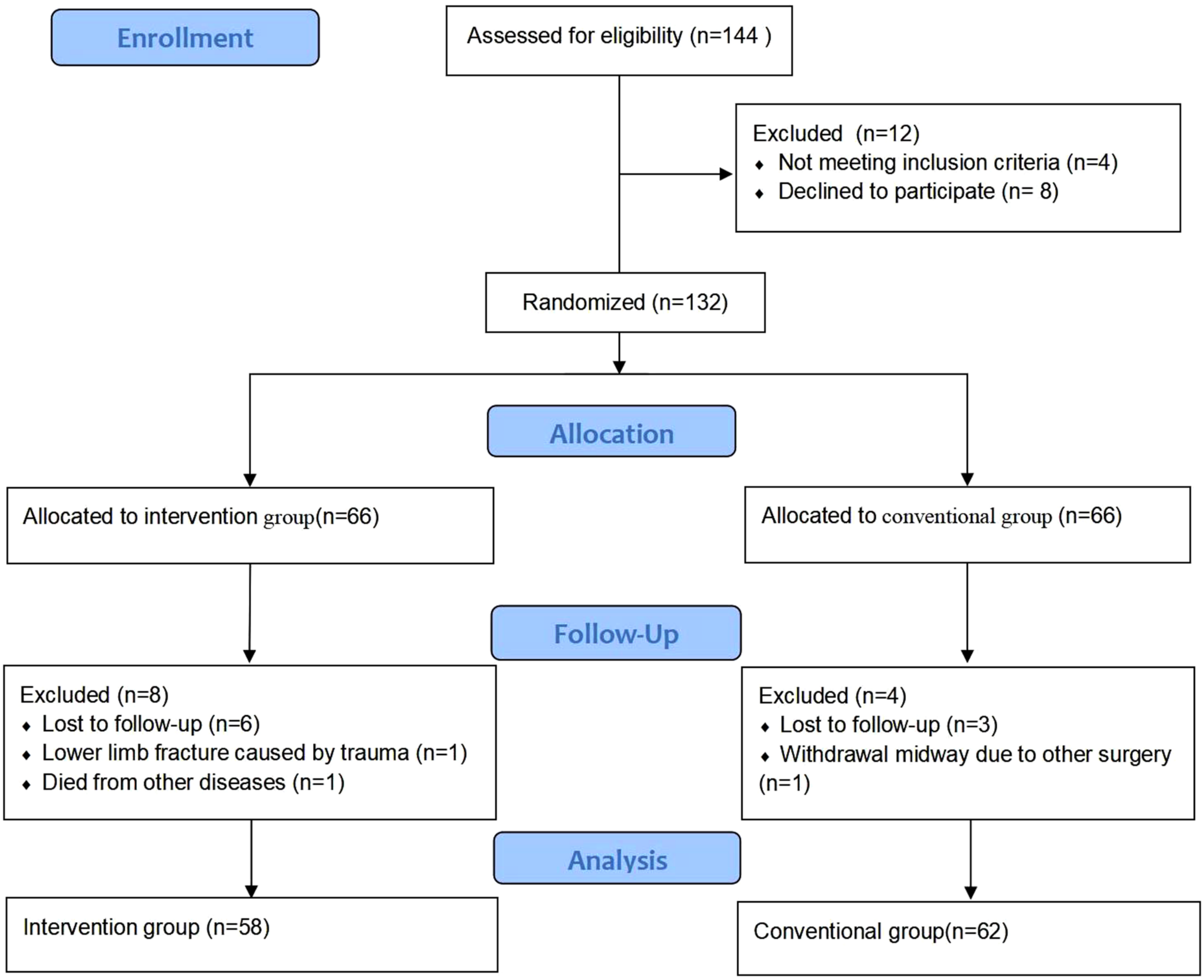

Fig. 1 CONSORT flow diagram showing the enrollment of the patients, the allocation of treatment, and the completion of the study

PD group and 6.5% (4/62) in the non-PD group. The difference between the two groups was not statistically significant ($P=0.537$). There were no postoperative complications, such as infection, fracture, patellar necrosis, or implant loosening, in either group during the follow-up period.

Discussion

The findings in this study were consistent with the hypothesis. UKA patients treated with PD achieved better Kujiala scores and FJS-12 scores, reduced anterior knee pain and improved kneeling ability postoperatively, validating the effectiveness of PD in UKA. Perception and actual performance of kneeling remained mismatched in PD patients, but performance during different kneeling activities was generally better than in non-PD patients. No postoperative complications due to peripatellar electrocautery were found in UKA patients who underwent PD treatment, indicating the safety of PD in UKA.

PD can effectively reduce postoperative AKP, but the pathogenesis of postoperative AKP has not been fully elucidated, and it is generally believed that substance-p nerve fibres in the peripatellar soft tissue are the main cause. Substance P, an nociceptive neurotransmitter found in afferent nerve fibres, is predominantly found in the the patellar retinaculum, fat pad, periosteum, and cartilage affected by degenerative diseases [9, 24]. Therefore, pain receptor desensitization through peripatellar electrocautery can reduce pain transmission. In addition, peripatellar soft tissue traction or bony structure compression may cause nerve fibre edema and degeneration, as well as intraoperative traction and suturing may easily produce peripheral neuralgia, increasing the risk of postoperative pain. The denervation technique can partially terminate the potential pain pathway and reduce the occurrence of pain.

The effectiveness of PD is currently controversial. Our study revealed that patients who underwent PD had

Table 1 Demographic data

	PD ($n=58$)	Non-PD ($n=62$)	P-Value
Age (y)	62.3 ± 7.2	63.4 ± 7.3	0.413
Sex (%)			0.220
Man	23 (39.7)	18 (29.0)	
Woman	35 (60.3)	44 (71.0)	
BMI (kg/m^2)	25.8 ± 3.4	26.2 ± 2.7	0.401
CCI (%)			0.219
Grade I	36 (62.1)	45 (72.6)	
Grade II	22 (37.9)	17 (27.4)	
ASA grade (%)			0.156
Grade I	28 (48.3)	40 (64.5)	
Grade II	22 (37.9)	18 (29.0)	
Grade III	8 (13.8)	4 (6.5)	
Wiberg classification (%)			0.276
Type I	10 (17.2)	18 (29.0)	
Type II	35 (60.3)	30 (48.4)	
Type III	13 (22.4)	14 (22.6)	
Iwano stage (%)			0.378
Stage I	40 (69.0)	38 (61.3)	
Stage II	18 (31.0)	24 (38.7)	
Preoperative HSS score	52.6 ± 6.8	53.8 ± 6.1	0.321
Preoperative Kujala score	46.7 ± 5.8	48.5 ± 6.0	0.110

BMI, body mass index; CCI, Charlson comorbidity index; ASA, American Society of Anesthesiologists

Table 2 Comparison of postoperative clinical outcomes between the two groups

	PD ($n=58$)	Non-PD ($n=62$)	P-Value
HSS score			
At 6 months	88.2 ± 4.2	86.8 ± 4.8	0.102
At 12 months	90.3 ± 4.2	89.3 ± 4.3	0.171
Kujala score			
At 6 months	80.5 ± 4.2	76.7 ± 5.2	**< 0.001**
At 12 months	83.8 ± 3.9	81.5 ± 4.4	**0.004**
VAS			
At 6 months	1.3 ± 0.6	1.7 ± 0.8	**0.007**
At 12 months	1.2 ± 0.4	1.4 ± 0.6	**0.027**
FJS-12	73.8 ± 6.5	70.4 ± 5.8	**0.003**
Cushion Kneeling perception (Yes / No)	34/24	32/30	0.441
Floor Kneeling perception (Yes / No)	26/32	25/37	0.618

HSS, the hospital for special surgery; FJS-12, the Forgotten Joint Score. Bold values indicate statistically significant values ($P<0.05$)

better patellar scores, greater joint forgetting and less pain. However, some studies have suggested that these improvements may not be durable. However, some studies have suggested that these improvements may not be long-lasting. A meta-analysis by Yuan et al. [15] showed that the effective effect of PD was limited to 12 months postoperatively, but a meta-analysis by Duan et al. [25] demonstrated that the effect of PD can extend beyond 12 months. As severe patellofemoral joint degeneration (PFJD) is widely considered a contraindication to UKA, all the patients included in this study did not have severe PFJD. However, a prospective study by Suwankomonkul et al. [12] showed that UKA patients with severe PFJD who received PD also had favourable outcomes in the short term. It is worth noting that Pongcharoen et al. [26] conducted a prospective comparison of patients with severe and non-severe PFJD treated with UKA, and the results showed that patients with severe PFJD had poorer knee joint scores. In addition, Hamilton et al. [27] reported up to 15 years of follow-up in UKA patients that severe PFJD may have a negative impact on descending stairs. Considering the unsustainable effectiveness of PD and the long-term adverse outcomes of severe PFJD, UKA in combination with PD is not recommended as the preferred option for patients with bicompartmental lesions.

Table 3 Comparison of postoperative kneeling scores for question 7 of the Oxford knee score

	Impossible	Poor	Good	P-Value
90° Kneeling (Cushion)				**0.029**
PD	4 (6.9)	22 (37.9)	32 (55.2)	
Non-PD	10 (16.1)	29 (46.8)	23 (37.1)	
120° Kneeling (Cushion)				**0.018**
PD	4 (6.9)	25 (43.1)	29 (50.0)	
Non-PD	10 (16.1)	33 (53.2)	19 (30.6)	
90° Kneeling (Floor)				**0.038**
PD	7 (12.1)	31 (53.4)	20 (34.5)	
Non-PD	15 (24.2)	34 (54.8)	13 (21.0)	
120° Kneeling (Floor)				**0.031**
PD	7 (12.1)	34 (58.6)	17 (29.3)	
Non-PD	15 (24.2)	37 (59.6)	10 (16.1)	

Bold values indicate statistically significant values ($P<0.05$)

PD patients showed significant improvement in kneeling ability after surgery. The results also further confirm the findings of the Artz et al. [7] study that there is a correlation between kneeling ability, pain and function. The causes of kneeling difficulties are multifaceted; in addition to pain and function, numbness, fear of injury to the prosthesis, comorbidities and third-party recommendations can all contribute to limitations in kneeling [28–31]. Many healthcare professionals advise patients not to kneel due to concerns about the safety of kneeling, but there is no clinical evidence of an association between kneeling and prosthesis loosening. This and other studies have found discrepancies between patients' self-perceived ability to kneel and their actual ability to observe [32, 33]. Although some patients may perceive an inability to kneel, many patients actually have the potential to kneel after appropriate rehabilitation training and instruction [28, 30, 34]. Therefore, while PD improves the ability to kneel by improving the patient's function and reducing AKP, there is still a need for acquired help to build confidence and overcome kneeling difficulties

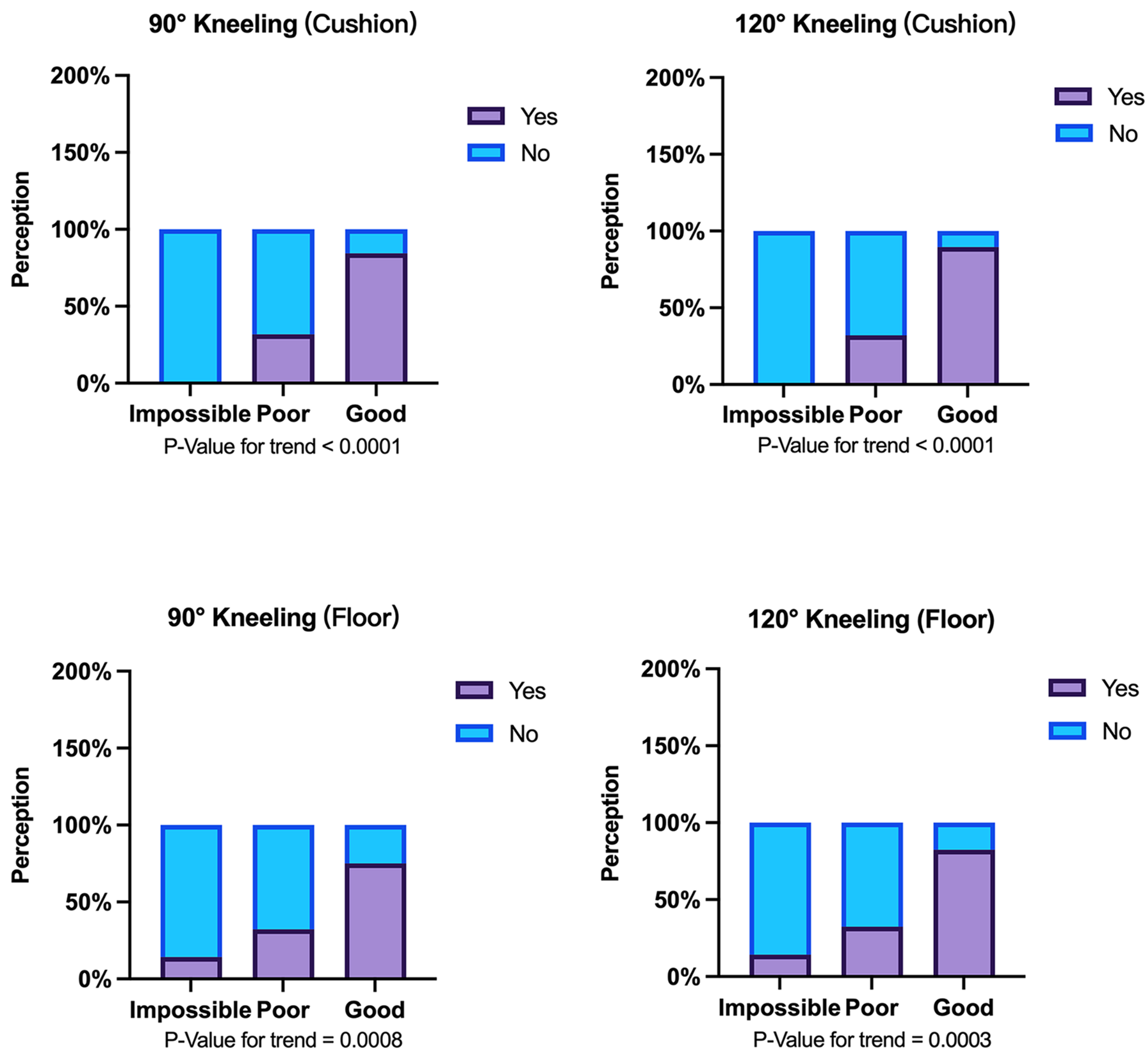

Fig. 2 Matching self perception and actual ability of PD patients in four kneeling positions

through a comprehensive rehabilitation programme, individualized education and advice, and effective physiotherapy.

In this study, the application of PD in UKA was not found to increase the occurrence of related complications. However, during electrocautery denervation in the peripatellar region, it may cause damage to the nutrient vessels around the patella, increasing the risk of patellar necrosis and fracture [10, 35]. Therefore, the operator should be familiar with the distribution of the peripatellar nerves and master the range and depth of electrocautery. Before peripatellar electrocautery, we bent the metal tip of the electrotome tip by 3 mm. This not only prevents the patella from completely turning over, but also controls the depth of electrocautery and avoids damage caused by nerve regeneration and excessive electrocautery.

This study inevitably has several limitations. First, the short follow-up period of this study did not allow for observation of long-term outcomes or complications. Second, this study transformed the five-categorical variables into three-categorical variables in assessing the ability to kneel. Although the multicategorical transformation can simplify model building and interpretation, it may cause limitations in the reliability and interpretability of the results. In addition, this study was evaluated only through four simple kneeling activities and lacked multidimensional tests of kneeling ability. Therefore, there is still a need for long-term prospective studies to validate PD in UKA and more comprehensive tests to assess kneeling ability in the future.

Conclusion

Patellar denervation can safely and effectively improve patellofemoral joint function, pain and kneeling ability in the early postoperative period after UKA.

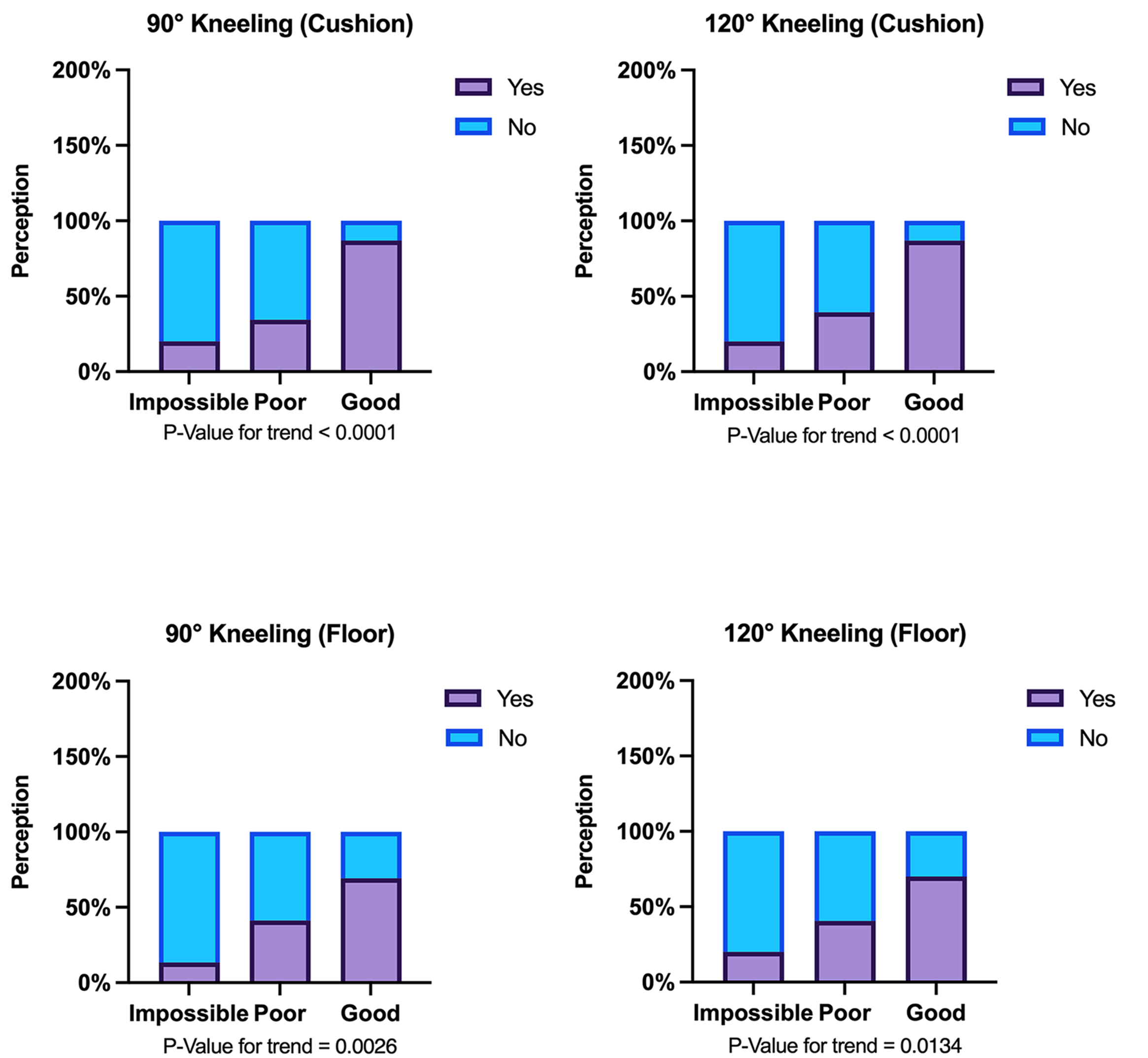

Fig. 3 Matching self perception and actual ability of non-PD patients in four kneeling positions

Abbreviations

UKA	Unicompartmental Knee Arthroplasty
PD	Patellar Denervation
HSS	Hospital for Special Surgery
VAS	Visual Analogue Scale
FJS-12	Forgotten Joint Score
AKP	Anterior Knee Pain
PFJD	Patellofemoral Joint Degeneration
ASA	American Society of Anesthesiologists
CCI	Charlson Comorbidity Index

Author contributions

SYJ and LN analyzed the data and wrote the manuscript. HL was responsible for data collection and collation. CXY provided supervision and guidance on the content of research topics. FS and WJT made significant contributions to the conception and design of the study, critically revised the manuscript and provided crucial theoretical support to help the team interpret the result. All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study has been approved by the Ethics Committee of Xuzhou Medical University Affiliated Hospital.

Consent for publication

All eligible participants signed an informed consent form prior to surgery.

Competing interests

The authors declare no competing interests.

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