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CLINICAL ARTICLE

Stretching Force of Incision Affects Early Clinical Results After Primary Total Knee Arthroplasty: A Retrospective Study

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Objective: To investigate the impact of different skin incisions on recovery from total knee arthroplasty (TKA).

Methods: This is a retrospective study conducted in a tertiary hospital. A total of 1210 patients accepted primary and unilateral total knee arthroplasty (TKA) at the authors' affiliated institutions between January 2015 and January 2019. Patients who accepted primary and unilateral TKA due to OA under epidural anesthesia were included. Excluded cases included patients who had no completed follow-up; preoperative flexion contracture greater than 15° and preoperative flexion less than 90°; paresthesia in lower limb; scar within the knee area; patella alta or baja. We recorded and analyzed the following data, including each patient's characteristics, incision stretching index (IS index), perioperative information, and follow-up assessments. Patients were grouped by trisecting the range of IS index we observed in the present study. The primary outcome measure was the visual analog scale (VAS) pain score rated on a scale of 0–10 from no pain to severe pain. Secondary outcome measures include knee girth reflecting postoperative swelling, knee range of motion (ROM), sensory testing, and the strength of quadriceps. These measures were completed 2 weeks postoperatively.

Results: A total of 1089 patients undergoing primary and unilateral TKA in our two institutions were screened for final analysis, and 121 ones were excluded. The patients were followed up for an average of 13.3 months postoperatively. The mean length of FL was 28.3 cm (range: 21.0–38.8 cm). The mean IS index was 2.7 cm (range: 0.4–5.1 cm). We found no significant difference in those data among groups ($P > 0.05$). VAS pain scores among group IS A, IS B, and IS C were significantly different (2.3 ± 0.6 *vs* 3.4 ± 1.6 *vs* 3.9 ± 1.5, $P = 0.0001$). Similar situations were seen in knee circumference, ROM, area of abnormal sensation, and quadriceps strength among groups (all $P < 0.05$). With the increase in the IS index, VAS pain score, knee circumference, area of abnormal sensation, and incision problems were significantly increased ($P < 0.05$). At the same time, ROM and the strength of quadriceps decreased ($P < 0.05$). With the increase in the IS index, the number of patients with incision problems was increased significantly ($P < 0.05$). Besides, no significant difference in PJI and DVT among groups was observed ($P > 0.05$).

Conclusions: Proper incision stretching can improve postoperative pain relief, surgical swelling, ROM, sensory disturbance of the knee, and the strength of quadriceps with reduced risk of incision complications.

Key words: Incision stretching index (IS index); Range of motion; Total knee arthroplasty; Visual analogue scale

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Introduction

Total knee arthroplasty (TKA) is regarded as a successful surgical method to treat the severe degenerate tibiofemoral joint. In the United States, more than 500,000 TKAs are performed each year, and according to current trends, more than 3.5 mn knee arthroplasties will be done annually within the next 25 years[1]. In general, rates of surgical "success" exceed 80% in terms of complete pain relief, although success is rarely so defined[2]. Generally, we can evaluate, qualitatively and quantitatively, how much patients benefit from TKA by using Short-Form 36 and Western Ontario and McMaster Universities (WOMAC) questionnaire, which cover pain relief, functional recovery, and improvement in the quality of life. A successful TKA depends on multiple factors, such as patient and prosthesis selection, surgical technique, pain management, and functional exercise. While total knee arthroplasty has long been judged primarily by implant survivorship, the focus is increasingly on patient-reported outcomes[1]. Reconstructive surgeons use several methods to improve patient outcomes following TKA, which include surgical closure[2, 3], cocktail therapy[4], use of tranexamic acid[5, 6], and cryotherapy[7]. Those are effective treatments to achieve improved outcomes, according to previous studies.

A variety of surgical approaches are used in TKA, including medial parapatellar, sub-vastus, mid-vastus, and lateral techniques[8–11]. These approaches are typically applied through incisions up to 20–30 cm in length and offer optimal exposure of the entire knee joint[12]. Minimally invasive procedures for TKA (MIS TKAs) have become popular and often require specialized training, modified retractors, and modular implants. Numerous studies of MIS TKAs have shown decreased postoperative pain, earlier return to function, shorter length of stay (LOS) in the hospital, and decreased need for a stay in a skilled nursing facility during the postoperative period[13–15]. However, other factors, such as increased operative times, variations in the use of radiology services, and improper MIS component position may prevent the putative clinical benefits from translating into decreases in hospital costs or patient charges. These factors are closely associated with whether the exposure is clear or unclear. No matter what approach the surgeon uses, a certain amount of skin stretching occurs to adequately expose the knee[16, 17].

The tension of the incision is not only related to the length of the incision but is also associated with the thickness of the patient's subcutaneous fat, the suture method of muscle and other soft tissues, the direction of the skin pattern, the internal hemostasis, and the flexion and extension angle of the knee when sutured[16, 17]. As is known to us, pain, edema, muscle spasm, hemorrhage, and inflammation in the perioperative tissues are common problems in the immediate postoperative phase of TKA[6, 9]. These factors interfere with postoperative functional rehabilitation and thus influence ultimate results after surgery[8, 10]. In addition, postoperative pain and dysesthesia arising from cutaneous and subcutaneous tissues are also likely to cause discomfort and affect patient rehabilitation and postoperative clinical scores. León-Muñoz *et al.* advocate placing the skin incision 1 cm medial to the tibial tubercle to facilitate exposure and avoid direct loading of the incision when kneeling[18]. Several retrospective studies with variable follow-ups ranging from 5 weeks to 8 years suggested that the persistence of an area of hypesthesia at the anterior aspect of the knee in 55% to 100% of patients after TKA using the midline skin incision[19–21]. This complication may persist for several months or even remain permanent following the surgery, leading to dissatisfaction with surgical results. It is reported that discomfort and pain affecting activities of daily living occurred in about one in 10 cases[18]. These symptoms are caused by surgical trauma induced to the sensory nerves, namely to the infrapatellar branch of the saphenous nerve or its terminal branches, which cross the midline skin incision[22]. Recently, the core idea of enhanced recovery after surgery (ERAS) is to reduce surgical stress response, alleviate pain during the perioperative period, reduce the incidence of complications, accelerate functional recovery, and improve patient satisfaction. Application of the ERAS program in TKA is beneficial for patients, doctors, and hospitals[17, 18]. Decreasing hospital length of stay may reduce hospitalization costs and increase bed turnover. The incision problem is a part of ERAS. However, whether the tension of the incision for the TKA determines the surgical trauma has never been investigated. Therefore, in the present study, we intend to: (i) investigate the relationship between the length of skin incision and incision stretching; (ii) understand the impact of different skin incisions on recovery from TKA; and (iii) determine the optimal incision length, that is, appropriate incision stretching in patients undergoing primary TKA. To our knowledge, this is the first study to quantitatively compare the tension of the incision of TKA. We hypothesized that patients with a large tension of the incision would have worse clinical outcomes and higher complication rates.

Patients and Methods

Study Design and Study Population

This is a retrospective study conducted in a tertiary hospital. A total of 1210 patients accepted primary and unilateral TKA at the authors' affiliated institutions between January 2015 and January 2019. This study had been approved by the ethics committee of the authors' affiliated institutions and is in accordance with the Declaration of Helsinki.

Inclusion criteria for the case group included: (i) the diagnosis of osteoarthritis (OA) following the International Classification of Diseases 9th Revision (ICD-9); (ii) undergoing primary and unilateral TKA; (iii) had a completed data including clinical evaluation and examination used for comparison; (iv) a retrospective study.

Exclusion criteria included: (i) preoperative flexion contracture greater than 15° and preoperative flexion less than 90°; (ii) paresthesia in lower limb; (iii) scar within the knee area; (iv) patella alta or baja. The patients were followed up for an average of 13.3 months postoperatively.

We recorded and analyzed the following data, including each patient's characteristics, perioperative information, and follow-up assessments. These data were completed and evaluated by respective experienced therapists who were blinded to this research based on uniform standards.

Clinical Assessment

Incision Stretching Index (IS Index)

We calculated the incision stretching index (IS index), which is defined as FL-EL in the present study (Fig. 1). FL represented the length of surgical incision when the knee was flexed at 120°. EL represented the length of surgical incision when the knee was extended at 0°. The length of surgical incision was measured intraoperatively using a sterile tape with care taken to avoid crinkling. Patients were grouped by trisecting the range of IS index we observed in the present study.

Visual Analog Scale (VAS)

The primary outcome measure was the visual analog scale (VAS) pain score rated on a scale of 0–10 from no pain to severe pain. This measure was completed 2 weeks postoperatively.

Knee Girth

Knee girth was measured on the proximal pole of the patella using a tape. Patients were required to lie on their back on the bed. This measure was completed 2 weeks postoperatively.

Range of Motion (ROM)

ROM was measured using a standard hand-held goniometer with a patient in a supine position. The goniometer was placed over joint space with one arm aligned with fibular head and lateral malleolus and the other in line with the greater trochanter. The knee was flexed maximally at the patient's best, and then the angle was measured in degrees.

Sensory Testing

In the sensory testing, all patients were examined for the area of altered sensations to "light touch" using a pin-prick over the front of the knee based on Appendix Table A1. After mapping the margins of the area of abnormal sensation, the surgeon's assistant measures that using a plastic tape. Patients were required to indicate abnormal sensation from anesthesia to hypersensitivity (see Appendix Table A1), and we measures its area using a purpose-designed grid 6 months postoperatively[1]. Each sensory test was performed twice, and the mean value was finally analyzed.

Quadriceps Strength (QS)

The isokinetic strength of quadriceps (QS) was assessed using a ConTrex System Dynamometer (ConTrex MJ; CMV AG, Dübendorf, Switzerland) preoperatively and 2 weeks postoperatively at 60°/s. When evaluated, the patient exerted maximum effort for two attempts, and then the peak torque values of quadriceps were obtained. All the assessments mentioned above were completed 2 weeks postoperatively.

Complications

Significant complaints and complications over the study period would be reported to respectively experienced orthopaedists, which were then determined whether to be analyzed. Incision problems include delayed union, nonunion, and skin necrosis. Doppler ultrasonography was arranged to confirm the presence or absence of deep vein thrombosis (DVT) after surgery and before discharge. All patients who performed the assignments mentioned above were blinded to the final analysis.

Surgical Procedure

All operations were performed by one surgical team in respective institutions using epidural anesthesia.

An anterior midline skin incision and a medial parapatellar approach were used, and the patella was everted. A measured resection technique was used to balance the extension and flexion gap. A distal femoral cut was performed with an intramedullary instrumentation setting of 6° of the anatomic valgus. Referring to the surgical transepicondylar axis, the femoral external rotation cut was performed. Extramedullary instrumentation was used to achieve a target tibial cut of 90° relative to the mechanical axis in the coronal plane and of 3° to 5° relative to the posterior slope in the sagittal plane.

Cruciate-retaining (CR) prosthesis (Gemini MK-II, Link, Germany) or DePuy (Warsaw, Ind) Sigma posterior-stabilized (PS) with patellar resurfacing was used for all patients in this study. All components were cemented.

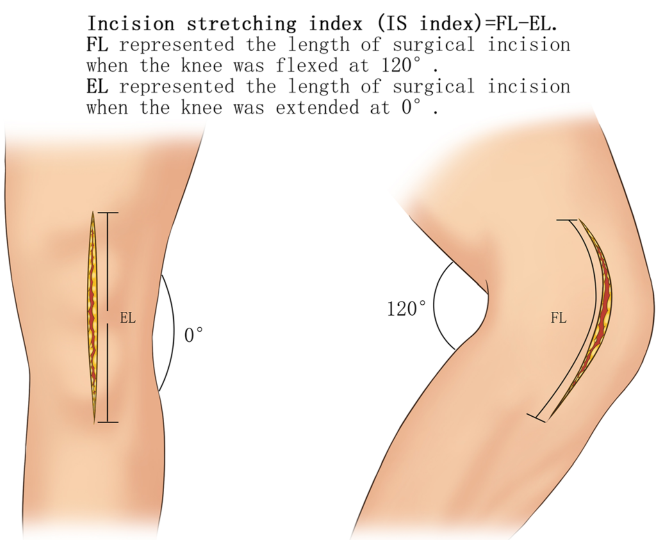

Fig. 1 Representation of the incision stretching index (IS index).

During the operation, no intravenous dexamethasone, tranexamic acid, or "cocktail" therapy was used. Wounds were closed in the same manner for each knee with two 1/8-inch suction drains in each knee. The recollected blood was filtered and washed in the recovery room and then transfused into the patient within 6 hours following surgery. The drainage tube was promptly extracted within 24 hours postoperatively. The pneumatic tourniquet was generally applied at 300 mm Hg. It was used from the beginning of femur osteotomy to the end of tibia osteotomy and then released following the joint capsule's closure.

All patients were routinely administered with prophylactic cefotaxime (1 g, iv, tid) before the skin incision. Patients were connected to a patient-controlled analgesia (PCA) pump during the postoperative 48 hours. For relieving postoperative pain, all patients would receive diclofenac sodium (50 mg, po, tid) routinely orally during the hospital stay and tramadol (100 mg, po, tid) after discharge if they needed that. Preventive anticoagulant therapy (10 mg rivaroxaban every day or 2850 international units [IU] low-molecular-weight heparin [LMWH] [body weight < 90 kg] or 5700 IU [bodyweight >90 kg]) began within 12 hours after the operation and continued for 14 days.

Statistical Analysis
By trisecting the IS index, patients were grouped and compared. Continuous data in this study were normally distributed and were listed as mean ± standard deviation (SD), respectively. They were analyzed *via* the Analysis of Variance (ANOVA) and Tukey's *post hoc*. Countable variables were listed as percentages and compared *via* the chi-square test and Fisher exact test. The statistical significance and the power analysis were required with P-value ≤0.05 and 1-ß = 0.8. Using G Power 3.1.9.2, the study power was calculated for the effect size of 0.3, error of the first type 0.05, and the total number of respondents with the number of 358 patients undergoing TKA. The calculated study power equals 95.45%, which indicates good study power. We performed statistics analysis by SAS 9.2 (SAS Institute Inc., Cary, NC, USA) and Excel 2003, version 11 (Microsoft, Redmond, Washington).

Results

General Results
A total of 1089 patients undergoing primary and unilateral TKA in our two institutions were screened for final analysis. Specifically, patients who had no completed follow-ups (n = 32), preoperative flexion contracture greater than 15° and preoperative flexion less than 90° (n = 34), paresthesia in the lower limb (n = 34), scar within the knee area (n = 10), patella alta or baja (n = 8), and death after surgery (n = 3) were excluded.

Demographic Profiles
A total of 78.1% of included patients were female (n = 851), and their mean ages were 66.0 (SD: 4.8) years. Perioperative information was detailed in Table 1. We found no significant difference in mean age, gender, and BMI (all $P > 0.05$) among groups (Table 1).

Other Preoperative Data of the Patients
The mean length of EL was 23.2 cm (range: 16.5–33.5 cm). The mean length of FL was 28.3 cm (range: 21.0–38.8 cm). The mean IS index was 2.7 cm (range: 0.4–5.1 cm). The range of IS index of groups A, B, and C was 0–1.7 cm, 1.7–3.4 cm (including 1.7 cm), and 3.4–5.1 cm (including 3.4 cm), respectively. Clinical parameters in each group were detailed in Table 1. We found no significant difference in prosthesis type, surgery time, tourniquet time, intraoperative bleeding, and transfusion among groups (all $P > 0.05$) (Table 1).

TABLE 1 Clinical parameters in each group

Clinical characteristics (Number = 1089)	IS A (n = 355)	IS B (n = 416)	IS C (n = 318)	P value
Age(years)	66.3 ± 4.8	65.8 ± 5	66.0 ± 5.1	0.3774
Gender(female) (n, percentage)	287(80.8)	325(78.1)	239(75.2)	0.2042
BMI > 25 kg/m^2 (n, percentage)	278(78.3)	337(81.0)	245(77.0)	0.3974
Prosthesis type (CR/PS) (n, percentage)	220/135(62.0%/38.0%)	248/168(60.0%/40.0%)	207/111(65.1%/34.9%)	0.3173
Surgery time (min)	58.9 ± 5.8	38.8 ± 6.8	38.7 ± 7.1	0.3791
Tourniquet time (min)	39.2 ± 7.2	36 ± 7.6	36 ± 7.6	0.6095
Intraoperative Bleeding (mL)	183.5 ± 43.8	190.6 ± 52.6	186.6 ± 50.2	0.1330
Transfusion (n, percentage)	108(30.4)	138(33.2)	93(29.2)	0.4917
VAS pain score	3.0 ± 1.6	3.1 ± 1.8	2.9 ± 1.8	0.3012
Knee girth(cm)	32.4 ± 3.0	32.7 ± 3.3	32.2 ± 3.5	0.1125
ROM (°)	103.2 ± 12.5	101.5 ± 14.7	103.8 ± 13.6	0.0578
Strength of quadriceps(Nm)	30.9 ± 13.6	32.4 ± 12.4	31.2 ± 14.0	0.2500

BMI, body weight index; CR, Cruciate-retaining; PS, Posterior cruciate ligament-substitute; ROM, range of motion; VAS, visual analogue scale.; * Significant difference among groups.

TABLE 2 Clinical comparisons among different IS index groups

Clinical characteristics (Number = 1089)	1:IS A (*n* = 355)	2:IS B (*n* = 416)	3:IS C (*n* = 318)	*P* value
VAS pain score	2.3 ± 0.6	3.4 ± 1.6	3.9 ± 1.5	1–2:<0.001* 1–3: <0.001* 2–3: <0.001*
Knee girth(cm)	33.9 ± 3.5	35.8 ± 3.1	37.4 ± 3.5	1–2: <0.001* 1–3:<0.001* 2–3:0.001*
ROM(°)	115.2 ± 10.8	105.5 ± 9.6	100.7 ± 14.6	1–2: <0.001* 1–3: <0.001* 2–3:0.001*
Sensory testing(cm^2)	36.2 ± 5.4	40.4 ± 6.5	44.6 ± 6.8	1–2: <0.001* 1–3: <0.001* 2–3:<0.001*
QS(Nm)	28.4 ± 12.2	23.0 ± 12.5	20.5 ± 9.8	1–2: <0.001* 1–3: <0.001* 2–3:<0.001*
Incision problems (*n*, percentage)	9 (2.5)	15(3.6)	31(9.7)	1–2: <0.001* 1–3: <0.001* 2–3:<0.001*
PJI (*n*, percentage)	3(0.8)	5(1.2)	3(0.9)	1–2:0.2134 1–3: 0.2454 2–3:0.2323
DVT (*n*, percentage)	1(0.3)	2(0.5)	1(0.3)	1–2:0.3432 1–3: 0.2348 2–3:0.3246

DVT, deep venous thrombosis; PJI, periprosthetic joint infection; QS, strength of quadriceps; ROM, range of motion; VAS, visual analogue scale.; * Significant difference among groups.

Visual Analog Scale Pain Score

There was no significant difference in VAS pain score among group IS A, IS B, and IS C before surgery ($P = 0.3012$). However, with the increase in the IS index, the VAS pain score was significantly increased postoperatively (2.3 ± 0.6 *vs* 3.4 ± 1.6 *vs* 3.9 ± 1.5, $P < 0.001$) (Table 2).

Knee Circumference

There was no significant difference in knee circumference among group IS A, IS B, and IS C before surgery ($P = 0.1125$). However, with the increase in the IS index, knee circumference was significantly increased postoperatively (33.9 ± 3.5 *vs* 35.8 ± 3.1 *vs* 37.4 ± 3.5, $P \leq 0.001$) (Table 2).

Range of Motion (ROM)

There was no significant difference in ROM among group IS A, IS B, and IS C before surgery ($P = 0.0578$). However, with the increase in the IS index, ROM was significantly decreased postoperatively (115.2 ± 10.8 *vs* 105.5 ± 9.6 *vs* 100.7 ± 14.6, $P \leq 0.001$) (Table 2).

Abnormal Sensation Area

With the increase in the IS index, the area of abnormal sensation was significantly increased postoperatively (36.2 ± 5.4 *vs* 40.4 ± 6.5 *vs* 44.6 ± 6.8, $P < 0.001$) (Table 2).

Quadriceps Strength

There was no significant difference in the strength of quadriceps among group IS A, IS B, and IS C before surgery ($P = 0.2500$). However, with the increase in the IS index, the strength of quadriceps was significantly decreased postoperatively (28.4 ± 12.2 *vs* 23.0 ± 12.5 *vs* 20.5 ± 9.8, $P < 0.001$) (Table 2).

Complications

With the increase in the IS index, the number of patients with incision problems was increased significantly (2.5% *vs* 3.6 *vs* 9.7, $P < 0.001$) (Table 2). Besides, no significant difference in PJI and DVT among groups was observed ($P > 0.05$) (Table 2).

Discussion

In this study, we investigated the outcome related to the amount of stretch placed on the skin incision as measured by the gap between the incision length in flexion and that in extension in patients undergoing primary TKA. Furthermore, we included the IS index as an assessment criterion to determine how the difference between EL and FL affected TKA outcomes. We compared VAS pain score, ROM, QS, knee circumference, and incision problems among groups. The present study revealed that pain feeling, ROM, QS, swelling, and incision problems improved two weeks after TKA with a decrease in the IS index. These results showed that the closer the gap between EL and FL was, the less the incision stretching was, which benefit outcomes after TKA. Our present results suggested IS A was the optimal range between flexion and extension length in patients undergoing primary TKA. Given the above, during the study we observed that in such an incision (IS A) TKA results could be improved if the quadriceps tendon was incised 4 cm proximally above the upper border of the patella and distally along the medial side of the patellar tendon to the tubercle of the tibia.

There are primarily three reasons that explain the above findings. Firstly, the strength of the quadriceps is decreased by up to 60% after TKA due to the cutting of quadriceps muscle, eversion of the patella, and extreme knee flexion during TKA[23–26]. In addition to that, Chareancholvanich *et al.* reported a significant effect of the length of surgical incision on the postoperative strength of quadriceps[24]. Furthermore, incision size directly affects pain feeling and swelling as a larger incision produces more inflammatory factors[25]. Less pain decreased swelling, and better strength of quadriceps made patients relatively comfortable while performing the functional exercise. Finally, IS C represents the highest stretch level in comparison to IS A and B, which make surrounding tissue tolerate the largest tensile force, especially as the knee is in an extreme flexion intraoperatively. Made up of a complex network of collagen and elastin fibers, the skin has elastic characteristics and mechanical strength within its physiological limits[25]. However, previous studies indicated that the acute, purely reversible elastic response of stretched skin tissue, which is similar to the stretching process of the incision during TKA, would be impaired to a certain extent if we extended it beyond its physiological limits[25]. This impairment by releasing inflammatory elements and strain injury of nerves showed pain feelings, paresthesia, and tissue edema. Therefore, the information above can explain why IS A is the optimal gap between the incision length in flexion and in extension in patients undergoing primary TKA.

Clinically, more incision problems, even including skin necrosis, occurred as the incision was at higher stretch levels. Therefore, to avoid these problems, a decrease in incision stretching force by increasing its length in extension, which improves microcirculation of surrounding tissue, leads to better incision healing. Hence, it is clinically meaningful. Our results may provide clinical evidence and basic data of the obvious effects of incision stretching on key outcomes after TKA, such as pain, ROM, QS, and swelling. Furthermore, our results reveal a greater surface area of sensory change in the front of the knee following TKA occurs in patients with an incision at higher stretch level, since nerves around the knee which were stretched beyond physiological limits were shown to be impaired more widely due to the characteristic of the extensibility of the axon[1]. This greater alteration in skin sensation discounted the ability to kneel due to the fear of harming the prosthesis[1]. It combined a negative effect on subjective feelings such as titillation, resulting in patient dissatisfaction following TKA. This study suggests that the length of incision, in extension, is possibly an effective treatment method, especially when patients perform the painful exercise, as appropriate incision stretching makes them comfortable with less pain and improved strength of quadriceps. It is conceivable and desirable that there were medical costs saved due to earlier recovery. Therefore, the present study's findings suggest selecting the optimal gap between the incision length in flexion and that in extension, which determines incision stretching and would be significant in the clinical practice.

To our best knowledge, there are merely two studies involving the incision length in primary TKA, and their results have limitations. Chareancholvanich's report only investigated the effect of the range of knee incision in full extension on quadriceps strength[24]. Despite elaborate data regarding quadriceps strength following TKA in his report, only different incision length in extension was discussed. However, incision length in flexion, namely the problem of incision stretching, was not studied. By contrast, Roidis's study paid close attention to the incision stretching in patients undergoing primary TKA[22]. He reported that the incision length was 5.7 cm longer in flexion than extension. The surgical incision site stretched an average of 23.6% in flexion compared to in extension[22]. However, the impact incision stretching could have on clinical outcomes after TKA, such as pain, ROM, and swelling, have not yet been investigated. Based on these two studies, our study further deepens the significance of incision stretching, and this is the first study to investigate that topic. A comprehensive understanding of the impact of incision stretching on TKA results may help surgeons to optimize clinical practice. This study's findings can guide surgeons to attach importance to the length of incision in extension, which determines the stretching force of your incision. Despite being a seemingly minor problem, it is a real concern that requires attention. Less incision stretching becomes a good treatment for fast recovery from TKA. We hope the present results could be helpful in optimizing this technqiue and perfecting clinical outcomes.

Limitation

Several limitations in this study warrant discussion. First, our data of incision stretching was obtained by calculating the self-designed formula FL-EL, and thus the examination of its real size was indirectly and relatively inaccurate. Second, no pathological examination was applied. However, that serves as the golden criterion, which demonstrates that incision stretching can be observed as changes in the microscopic structure, such as the disruption of skin collagen bundles. Third, our study employs many different combinations, and this made pain score evaluations accurate to a certain extent. Finally, a relatively small sample results in less persuasive conclusions. Therefore, in future studies, we intend to quantitatively evaluate changes in the tissue under different stretching forces *via* microscopic examination and objective measurements such as a mechanical sensor.

Conclusions

In the present study, there was a significant impact of incision stretching on clinical results after TKA. Appropriate incision stretching mainly depended on the length of full extension of the knee, which can benefit postoperative pain, surgical swelling, ROM, abnormal sensation, strength of quadriceps, and patient's perception of recovery from TKA with the decreased risks of incision complications.

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APPENDIX

TABLE A1 Grading of sensation to pin-prick and light touch testing

Definition	Terminology
Absent sensation to pin-prick/light touch	Anesthesia
Diminished sensation to light touch blunt sensation to pin-prick	Hypoesthesia
Normal sensation	Normal
Abnormal but tolerable sensation to pin-prick/light touch	Sensitive
Marked/unbearable sensation to pin-prick/light touch	Hypersensitive