

Are There Any Clinical and Radiographic Differences Between Quadriceps-sparing and Mini-medial Parapatellar Approaches in Total Knee Arthroplasty After a Minimum 5 Years of Follow-up?

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Abstract

Background: Although the early clinical outcomes of total knee arthroplasty (TKA) using minimally invasive surgery techniques have been widely described, data on the mid- to long-term outcomes are limited. We designed a retrospective study to compare the two most common TKA techniques – The modified quadriceps-sparing (m-QS) approach and the mini-medial parapatellar (MMP) approach – In terms of the clinical and radiographic parameters, over a minimum follow-up period of 5 years.

Methods: The m-QS approach was used in 31 knees and the MMP approach, in 36 knees. Knees in both groups were compared for component position and alignment, knee alignment, length of the skin incision, range of motion, Visual Analog Scale score, muscle torques, Knee Society Score, Western Ontario and McMaster Universities Osteoarthritis Index, and number of complications.

Results: There were no major intergroup differences in any of the clinical and radiographic outcomes assessed at the final follow-up examination.

Conclusions: On the basis of numbers studied, the m-QS group, which requires more technique, showed equivalent results with the MMP group in the postoperative 5 years. Preservation of the extensor mechanism in the m-QS approach could not ensure any improvement in the clinical outcomes during the mid-term follow-up duration.

Key words: Minimally Invasive Surgery; Quadriceps-sparing; Total Knee Arthroplasty

INTRODUCTION

Over the past few decades, the traditional medial parapatellar approach has regained considerable popularity as the most effective technique for total knee arthroplasty (TKA).^[1] However, concern has been expressed regarding patient dissatisfaction with this technique, despite its effectiveness,^[2,3] possibly due to the associated anterior knee pain and poor functional recovery. Various minimally invasive surgery (MIS) techniques for TKA have been developed and improved with a view to enhancing postoperative functional recovery by preserving the function of the extensor mechanism and improving overall patient satisfaction.^[4,5] The MIS approaches developed thus far are the mini-medial parapatellar (MMP),^[6] mini-midvastus,^[7] quadriceps-sparing (QS),^[8] mini-subvastus, and minimally invasive lateral^[9] approaches.

Unlike traditional TKA surgery, which mandates extensive surgical exposure of the operative region, MIS approaches are characterized by their means of tissue dissection, arthrotomy technique, and tibiofemoral joint dislocation. MIS techniques for TKA have been shown to afford a better early range of motion (ROM) in the knee, quicker functional recovery, and shorter hospital stays than the traditional TKA surgery.^[6,10] However, some studies have shown that minimally invasive techniques of TKA require longer surgical times and pose a higher risk of component malalignment than traditional procedures.^[11-13] The MMP and QS are the two most commonly used approaches to MIS for TKA.^[14,15] Although a few prospective randomized studies have compared both the approaches, neither of them has been established as the superior one; furthermore, most of these studies were based on follow-up for only 2 years.^[8,16] Apparently, more long-term studies are necessary to identify the better approach.

Thus, in this study, we sought to compare the clinical and radiographic outcomes of a modified-QS (m-QS) approach

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and the MMP approach, over a minimum follow-up period of 5 years. We hypothesized that both approaches would yield similar outcomes in terms of clinical and radiographic parameters.

METHODS

The investigation was designed as a retrospective comparative study based on data collected from the medical records of patients who underwent TKA at our hospital between March 2005 and June 2006. The study protocol was approved by the institutional review board, and informed consent was obtained from all the enrolled patients. The inclusion criteria for this study were as follows: Diagnosis of primary osteoarthritis of the knee, with Ahlback grade of ≥ 2 (symptoms persisting after conservative treatment for at least 3 months); a minimum of 5 years of follow-up; knee deformity with varus of $<20^\circ$ or valgus of $<15^\circ$; body mass index (BMI) of <35 ; and treatment with the m-QS or MMP approaches. The exclusion criteria were inflammatory arthritis, restricted motion (flexion contracture of $>25^\circ$), patella alta (Insall-Salvati ratio of <0.6), and history of previous knee surgery. On the basis of the abovementioned criteria, 67 knees of 58 patients were included for further

analysis. A flow chart depicting the study design has been provided in Figure 1. Data regarding the following demographic characteristics were analyzed: Sex, age, height, and weight at the time of surgery. In all, 27 patients (31 knees) were included in the m-QS group and 31 patients (36 knees) in the MMP group.

Surgical technique

All the surgeries were performed by the same senior surgeon (JKY) who has performed more than 500 MIS TKA procedures. The Nexgen Legacy Posterior Stabilized-flex Prosthesis (Zimmer, Warsaw, Indiana, USA) was used for both groups. The m-QS approach used in this study has been previously described by Aglietti *et al.*,^[17] and the MMP approach, by Tenholder *et al.*^[6]

For the m-QS approach, the knee of the patient was flexed to 30° ; a medial curvilinear skin incision was made and extended along the medial edge of the patella from the upper pole of the patella to the medial edge of the tibial tubercle. The quadriceps tendon was divided for a length of 2 cm. The vastus medialis obliquus muscle was divided if its insertion was at the medial edge of the patella. The approach used in this study was not exactly identical to the one described by Tria and Coon.^[8] MIS

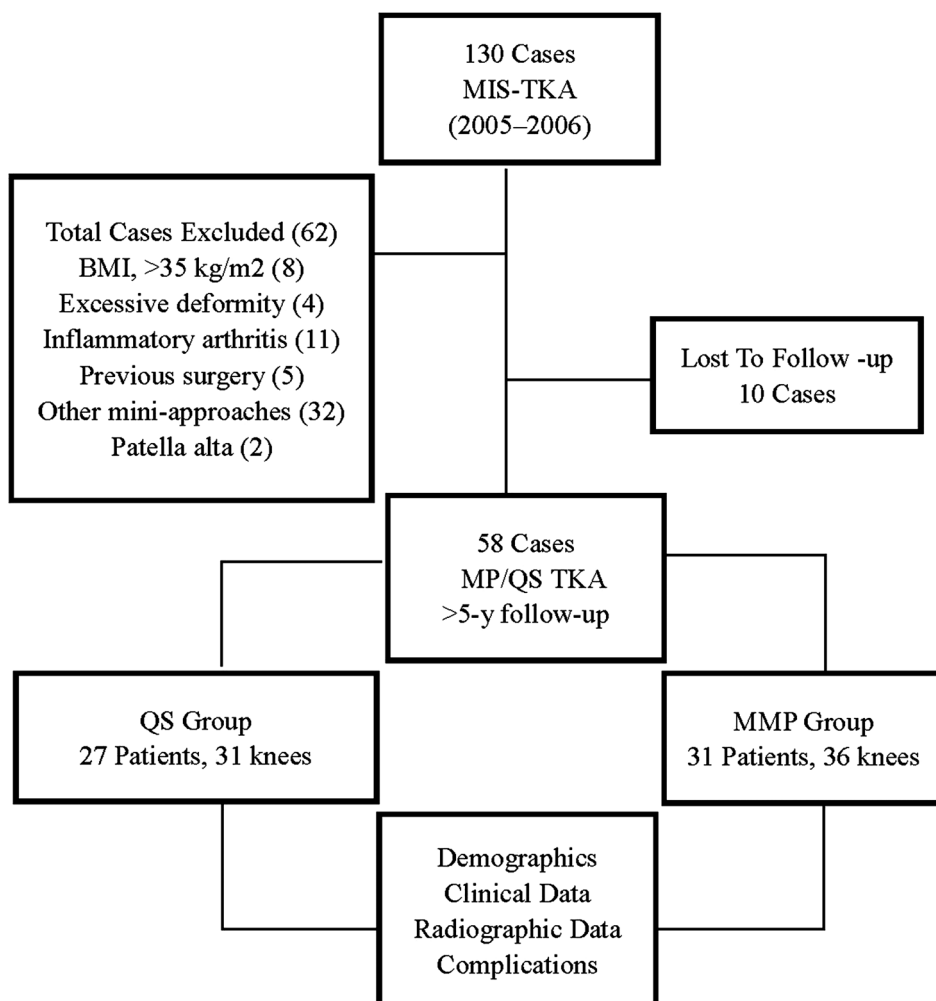


Figure 1: Flow chart depicting the study design.

QS instruments (Zimmer) were used. First, patellar resection was performed, and the metal patellar protector was used to avoid the pressing of the bone-cutting surface by the patellar retractor. Second, the distal femoral cutting block, used specially for this approach, was placed on the medial aspect of the distal end of the femur; then, resection was performed on the medial side (Zimmer) in an intramedullary fashion. Finally, the proximal tibial bone was resected, along with the medial side, by using the tibial cutting block specific for this approach, in an extramedullary manner, without anterior dislocation of the tibia. The patella was subluxed laterally but was not everted during the operation. For the MMP approach, standard MIS instruments (Zimmer) were used. Compared to the m-QS procedure, the MMP procedure differed in the following aspects: The skin incision was made at the center of the frontal aspect of the knee; the arthrotomy extended into the quadriceps tendon to a point located 5 cm above the upper pole of the patella; the patella was everted at the start of the femoral resection and remained everted until the completion of the prosthesis implantation; the resurfacing of the patella was performed last; the distal femoral cutting guide was placed above the distal portion of the femur, with the knee in 90° flexion, and distal femoral resection was performed in a vertical direction; proximal tibial resection was performed by placing the standard proximal tibia-cutting guide (Zimmer) for standard MIS TKA in front of the proximal portion of the tibia, with anterior dislocation of the tibia.

For both groups, the arthrotomy served as a “mobile window” and could be shifted in position from a medial to lateral and from a superior to inferior position.

The postoperative rehabilitation protocol was the same for both the groups. Physical therapy was initiated on the same day as the surgery; weight bearing using an assistive device, on the first postoperative day; and ROM exercises, on the fourth postoperative day with increase in complexity as per the patients tolerance.

Clinical assessment

Before the start of the operation, all patients underwent an assessment of the ROM and Visual Analog Scale (VAS) score (0 points, no pain and 10, severe pain). At the final follow-up, the clinical outcomes were evaluated with ROM, muscle torques, VAS score, Knee Society Score (KSS), and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). The preoperative and final follow-up values of the VAS score were collected prospectively. At the final follow-up, each patient underwent isokinetic muscle testing of the hamstrings and quadriceps ratios (H/Q ratio) at the rates of 60°/s and 120°/s, by using a dynamometer (Biodex Medical Systems, Inc., Shirley, NY, USA); the highest value of 3 tests was recorded. The number of complications was ascertained on the basis of both the inpatient and outpatient medical records of each enrolled patient. The clinical records were reviewed by the same author (BY), who was not involved in the treatment of the enrolled patients. Only results at the end of the follow-up period were considered because this study focused

primarily on the mid- to long-term outcomes of the two MIS approaches for TKA.

Radiographic assessment

Before the operation and at the final follow-up examination, hip-to-ankle radiographs of both extremities were acquired in the anteroposterior and lateral views, in the standing position. All the measurements were made by the same observer (DM), in accordance with the principles stipulated by the knee society,^[18] by using computer-generated data derived from the digital radiographs. DM did not participate in the surgical procedures, and all the measurements made by the observer were verified by another author (BY). The following parameters were measured: The mechanical axes, coronal femoral component angle (α ; angle between femoral shaft and transcondylar line of the femoral component); coronal tibial component angle (β ; angle between the mechanical axis of the tibia and tibial base plate); sagittal femoral component angle (γ ; angle of femoral component flexion); and sagittal tibial component angle (δ ; posterior slope angle of the tibial component). In addition, the Insall-Salvati index was computed to assess patellar height. An outlier was defined as a deviation in the value of a given parameter (α , β) of $>3^\circ$ from the expected value. The number of outliers for each measured parameter was then determined for each group, and the groups were compared.

Statistical analysis

Statistical analysis was performed using IBM Corp. Release 2011. IBM SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as means \pm standard deviation. Intergroup comparison for age, BMI, ROM, length of follow-up, knee alignment, component alignment, incision length, and WOMAC score were made using the independent *t*-test. The VAS score, KSS, and H/Q ratios in the two groups were compared using the Mann–Whitney *U*-test. Categorical variables and the percentages of the outliers in different components were analyzed by the Chi-square test and Fisher’s exact test. A *P* value of 0.05 or less was considered to be the threshold for significance in all comparisons.

RESULTS

The demographic characteristics of the patients and the study results are summarized in Table 1. The two groups showed no significant differences in terms of sex ($P = 0.26$), age ($P = 0.97$), or BMI ($P = 0.49$). At the final follow-up examination, 10 patients were lost to follow-up: 8 of them could not be contacted, and 2 of them refused to participate (QS group, 4 cases; MMP group, 6 cases). The mean length of follow-up in this study was 69.6 ± 7.1 months and the lengths in the m-QS group and the MMP group were comparable, at 67.1 ± 5.2 months and 70.0 ± 6.8 months, respectively.

Clinical outcomes

The mean length of incision in the m-QS group and the MMP groups was 9.9 ± 1.0 cm and 12.3 ± 1.2 cm, respectively ($P < 0.01$). The mean VAS scores were 6.9 ± 1.2

and 7.0 ± 1.6 before the operation, which improved to 1.6 ± 2.0 ($P < 0.01$) and 0.8 ± 1.5 ($P < 0.01$) at the final follow-up, in m-QS group and MMP group, respectively. The difference between the two groups was not significant both before operation ($P = 0.92$) or at the last follow-up ($P = 0.07$). Similarly, no significant intergroup differences were noted in the KSS and WOMAC score, at the final follow-up. The KSS functional score differed between the two approaches, with a mean of 83.4 for the m-QS group and a mean of 89.6 for the MMP group. However, this difference of approximately 6 points was not considered clinically important [Table 2].

The mean ROM did not show any significant difference between the m-QS and MMP groups, both before the operation (105.0 ± 14.2 vs. 105.0 ± 13.8 ; $P = 0.99$) and at the final follow-up examination (118.9 ± 11.7 vs. 120.0 ± 13.9 ; $P = 0.73$). Similarly, the peak torques for H/Q ratios at $60^\circ/s$ and at $120^\circ/s$ showed no intergroup differences, at the final follow-up [Table 2].

Radiographic data

The postoperative radiological data are summarized in Table 3. The postoperative hip-knee-ankle angle measured in the coronal plane was -2.4 ± 4.5 and -1.7 ± 3.9 in the m-QS group and MMP group, respectively. The differences in the femoral and tibial alignment angles, measured in the sagittal plane, showed no significant intergroup differences. Outliers in the m-QS and MMP group were found to be 4 (12.9%) and 4 (11.1%) for the femoral component and 9 (29.0%) and 8 (22.2%) for the tibial component, respectively. The intergroup differences in these variables were not significant. The Insall-Salvati index at the final follow-up examination was similar in the two groups [Table 3]. Radiolucent lines around the tibial component were observed in one knee in MMP group, but the patient was asymptomatic and required no intervention [Figure 2].

Complications

Three and two complications were noted in the m-QS group and MMP group, respectively, indicating no significant intergroup difference ($P = 0.65$). The complications noted in the QS group were temporary peroneal nerve palsy, which resolved at 6 postoperative months; knee stiffness, which required a manipulation under anesthesia; and lateral collateral ligament relax, not requiring surgery. The complications in the MMP group were temporary peroneal nerve palsy and knee stiffness.

DISCUSSION

Minimally invasive surgery techniques of TKA have become increasingly popular worldwide in the management of advanced arthritis of the knee.^[19] Tenholder *et al.*^[6] reported that TKA performed using the MMP approach was associated with the lesser need for blood transfusion and better flexion in the perioperative period, as compared to TKA with the traditional approach. On the other hand, Tria and Coon^[8] reported that considering its favorable early outcomes, the m-QS technique for TKA appears to be promising. More

Table 1: Demographic and clinical data of patients

Variables	QS group	MMP group	P
Number of patients (male/female)	2/25	6/25	0.26
Number of knees	31	36	–
Age (year)	69.6 ± 7.8	69.5 ± 6.7	0.97
BMI (kg/m ²)	26.9 ± 3.2	27.6 ± 3.4	0.49
ROM (°)	105.0 ± 14.2	105.0 ± 13.8	0.99
VAS score	6.9 ± 1.2	7.0 ± 1.6	0.71
HKA (°)	-7.9 ± 6.9	-8.8 ± 6.1	0.57
Follow-up (months)	67.1 ± 5.2	70.0 ± 6.8	0.09

QS: Quadriceps-sparing approach; MMP: Mini-medial parapatellar approach; BMI: Body mass index, calculated as the ratio of weight to squared height (kg/m²); VAS: Visual analogue scale; HKA: Hip-knee-ankle angle, ROM: Range of motion.

Table 2: Comparison of the clinical outcomes at the final follow-up after TKA with the m-QS approach or MMP approach

Variables	QS (n = 31)	MMP (n = 36)	P
Incision length (cm)	9.9 ± 1.0	12.3 ± 1.2	0.00
ROM (°)	118.9 ± 11.7	120.0 ± 13.9	0.73
H/Q ratios (60°/s)	0.4 ± 0.1	0.4 ± 0.1	0.09
H/Q ratios (120°/s)	0.4 ± 0.1	0.4 ± 0.1	0.12
VAS score	1.6 ± 2.0	0.8 ± 1.5	0.07
KSS knee score	90.0 ± 13.0	93.2 ± 9.6	0.49
KSS functional score	83.4 ± 13.1	89.6 ± 14.9	0.03
WOMAC score	9.9 ± 9.0	6.4 ± 6.7	0.07
Complication (n)	3	2	0.65

QS: Quadriceps-sparing approach; MMP: Mini-medial parapatellar approach; ROM: Range of motion; H/Q ratios: Peak torques of hamstring-quadriceps ratio; VAS: Visual analog scale; KSS: Knee society score; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; TKA: Total knee arthroplasty; m-QS: Modified quadriceps-sparing.

Table 3: Comparison between the QS and MMP approaches in the radiological findings at the final follow-up

Planes	Variables	QS (n = 31)	MMP (n = 36)	P
Coronal plane	HKA (°)	-2.4 ± 4.5	-1.7 ± 3.9	0.53
	α (°)	95.7 ± 2.4	95.7 ± 2.6	1.00
	Number of outliers	4	4	1.00
	β (°)	87.7 ± 2.7	88.2 ± 3.2	0.53
Sagittal plane	Number of outliers	9	8	0.58
	γ (°)	4.3 ± 3.5	4.2 ± 2.3	0.88
	δ (°)	83.8 ± 3.0	82.4 ± 3.7	0.11
	Insall-Salvati index	0.9 ± 0.3	0.8 ± 0.2	0.16

QS: Quadriceps-sparing approach; MMP: Mini-medial parapatellar approach; HKA: Hip-knee-ankle angle; α : Angle between femoral shaft and transcondylar line of the femoral component; β : Angle between mechanical axis of the tibia and tibial base plate; γ : Angle of femoral component flexion; δ : Posterior slope angle of the tibial component.

recently, a randomized controlled study revealed that patients undergoing TKA with the MIS approach showed early recovery of strength.^[20] However, although several studies have been conducted over the years on the outcomes of



Figure 2: Radiograph (anteroposterior view) obtained at the final follow-up shows radiolucent lines in zone 1 (arrow). The patient was asymptomatic and required no intervention.

MIS for TKA, most of them have spanned over only up to 2 years of follow-up. Mid- and long-term follow-up studies are necessary to establish firmly the benefits of MIS for TKA. To the best of our knowledge, this is the first study to compare the outcomes of two common MIS techniques over a mid-term follow-up period. A follow-up of a minimum of 5 years revealed that both the MMP and the m-QS approaches afforded gratifying results, at least with respect to the clinical and radiographic parameters, in the light of the previous reports on standard TKA.^[21,22]

The QS approach is considered the least invasive MIS procedure. Several analyses have shown that the QS approach helps minimize intraoperative blood loss and postoperative pain; enables early recovery of quadriceps strength; and facilitates the achievement of good ROM. Chen *et al.*^[19] have shown that patients managed with the QS approach reported less perioperative pain and improved the degree of flexion at all the postoperative visits. Similarly, Huang *et al.*^[23] showed that the QS approach was associated with significantly quicker recovery of quadriceps strength and knee flexion and less pain during the early postoperative period. Both these studies compared the QS approach with the traditional TKA surgery. Further, when compared to other mini-approaches of MIS for TKA, the QS technique continued to show some advantages in perioperative evaluations.^[17,24] The present study failed to detect any significant difference between the m-QS and MMP approaches at the end of a minimum of 5 years of follow-up, in terms of the ROM, peak torques of H/Q ratios, VAS score, KSS knee score, and WOMAC score ($P > 0.05$). Only a minimal difference was noted in the case of the KSS functional score ($P = 0.03$; 6 points), which did not seem to be clinically significant. Nevertheless, in this study, the clinical functional scores in the m-QS group were inferior to those in the MMP group for all the relevant parameters evaluated (P value for VAS score and WOMAC score, 0.07). Our results need to be interpreted with caution. We admit that the present study did not have sufficient power to elicit

small differences between the groups. For instance, it was calculated that 176 patients in each group were required to detect a significant 3-point difference in the KSS. However, our findings provide a basis on which more longitudinal and large-scale investigations could be undertaken to validate the clinical significance of our findings.

An important concern regarding MIS for TKA is the reduced visual access, which leads to poor visualization of landmarks and possible malpositioning of the implant. Lin *et al.*^[13] found that even when performed by an experienced surgeon, the QS approach afforded inferior radiological results compared to the MMP approach and did not recommend the QS approaches a routine procedure, even under computer-assisted navigation. However, the follow-up period in that study was also 2 years. Since malpositioning of the implant can jeopardize the long-term outcomes of TKA, more longitudinal follow-up trials are required to assess the durability of TKA. In the present study, we found that there were no significant differences between the two approaches in terms of the positions of the femoral and tibial components. The rates of component outliers were 12.9% and 11.1% for the femoral component and 29.0% and 22.2% for the tibial component in the m-QS group and the MMP group, respectively. These rates are higher than those previously reported.^[16,19] This may be because the criteria for defining radiological outliers were different in their study and ours. In the previous study, outliers were defined by a deviation of $>4^\circ$ in knee alignment from the target axis; in this study, a deviation of $>3^\circ$ was used to define outliers. The hip-knee-ankle angle measured on the final follow-up radiograph was similar in the two groups. However, in the coronal plane, the angle of the postoperative tibial component was lesser in the m-QS group than in the MMP group. Thus, the final hip-knee-ankle angle showed more varus in the QS group than in the MMP group. A similar phenomenon was observed by Lin *et al.*^[16] This may be related to the side-cutting technique used in the m-QS group. When cutting the distal portion of the femur and the proximal portion of the tibia using the side-cutting instrument, the lateral compartments are usually resected by a free-hand technique because it is not feasible to use cutting blocks for this purpose. It is possible that the deflection of the saw blade may cause a decrease in the valgus of the distal position of femur and an increase in the varus of the proximal tibia.^[16]

Perioperative complications were found more frequent in the case of MIS for TKA (QS approach; 13% of 16 procedures) than the traditional TKA surgery (6% of 7 procedures) in a prospective randomized study.^[11] This difference has been attributed to the limited visualization, greater tension on wound edges, and increased duration of surgery associated with MIS. However, these findings were contrary to those of Schroer *et al.*^[25] whose systematic review of 600 cases of MIS for TKA failed to reveal any increase in the rate of complications of MIS for TKA compared with that noted for traditional TKA. Recent studies have shown that the complication rates with MIS for TKA were significantly

higher than those with standard TKA.^[14,26] In this study, there were 3 instances of complications in the m-QS group and only 2 in the MMP group, which indicates that the difference between the two groups is not significant. None of the patients experienced any major complications. An important determinant of this reduced rate of complications may be that all the operations in this study were performed by a high-volume surgeon, who was already beyond his learning curve. Studies have shown that the volume of the case load and the extent of surgical experience are critical to improving the surgical outcomes.^[15] It is necessary that the surgeon be keenly aware of the possibility of surgery-related complications that could lead to serious problems after primary TKA.

This study has a few limitations. One is the retrospective nature of the study, whereby the results may be influenced by recall bias. To minimize this bias, the same independent researcher was involved in the retrieval and analysis of the data. Second, the QS approach of TKA used in this study was not exactly the same as that described by Tria and Coon. Pagnano *et al.*,^[27] have shown that the inferior edge of the vastus medialis obliquus inserts at the mid-pole of the patella in most cases; thus, the m-QS approach inevitably leads to injury of this insertion. The term “QS” cannot be applied to the surgical approach used in this study because the capsular incision made in the study extends to a distance more cranial to the mid-pole of the patella, unlike the traditional QS approach. Therefore, we have added the word “modified” to describe the technique used in the present study. Nevertheless, the current study does provide some insight into the mid- to long-term outcomes of the m-QS and MMP approaches, which will be useful for surgeons.

In conclusion, in this study with a limited number of cases, we failed to demonstrate any significant differences between the m-QS and MMP approaches of TKA in terms of the clinical and radiographic variables monitored over a mid-term period of minimum 5 years. Preservation of the quadriceps tendon and extensor mechanism in the m-QS approach could not ensure any improvement in the clinical outcomes during the mid-term follow-up duration. In addition, randomized controlled trials and large-scale, long-term, prospective cohort studies are necessary to conclusively establish the superiority of one approach over the other.

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