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Faster quadriceps recovery with the far medial subvastus approach in minimally invasive total knee arthroplasty

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Abstract
Purpose To identify whether less proximal muscle damage during minimally invasive surgery will allow faster recovery after total knee arthroplasty in comparison with a quadriceps incision approach. A limited medial parapatellar approach without tibial medial collateral ligament (MCL) release was compared to a subvastus approach without tibial medial collateral ligament release (far medial subvastus).
Methods One hundred and eighty patients were studied. In the mini-parapatellar group, ninety patients and in the far medial subvastus group, the remaining ninety patients were included. The evaluation was based on the Knee Society Score, VAS, morphine consumption, range of motion, time to straight leg raising, walking without aid, stairs and period of hospitalization. Alignment on full leg radiographs and component position on plain films were measured.
Results The far medial subvastus group showed faster recovery with earlier straight leg raising (1.7 ± 0.5 vs. 2.7 ± 0.4 days), postoperative weight bearing without aid (1.7 ± 0.6 vs. 2 ± 0.8 days) and stair negotiation (3 ± 0.4 vs. 4 ± 0.3 days) resulting in shorter length of stay (4 ± 0.5 vs. 5 ± 1.2 days). Comparable Knee Society Scores (88.5 ± 6.8 vs. 90 ± 10), Function Scores (90 ± 10) and alignment (5.4° ± 2.1° vs. 5.0° ± 2.4°) between the medial parapatellar and far medial subvastus group were observed at a follow-up of 24 months. An increase in operative time for the far medial subvastus was observed (55 ± 10.6 min vs. 67 ± 12 min tourniquet time) but without complications.
Conclusion The MCL sparing far medial subvastus approach allows good surgical exposure, faster straight leg raising, full weight bearing without aid and shorter length of stay with most importantly no radiological malalignment.
Level of evidence Therapeutic study, Level II.

Keywords Total knee replacement · Minimally invasive surgery · Medial parapatellar approach · Subvastus approach · Rehabilitation · Recovery

Introduction

In the minimally invasive (MI) limited medial parapatellar approach, the quadriceps tendon is incised 2–3 cm and the transcapsular incision is extended distally medial from the patella to the tibial tubercle. The suprapatellar pouch is not violated, the patella is no longer everted but shifted laterally, and the tibia is not anteriorly dislocated except once during tibial component implantation [1, 18, 24]. Several studies were able to show earlier recovery in the short term, but most publications failed to demonstrate significant differences among the available surgical approaches [3, 5–7, 13, 16, 25].

Most of the MIS studies that found only subtle differences compared different proximal approaches (mini-mid-vastus, mini-subvastus and the limited parapatellar approach) with conventional techniques [3, 16, 25, 27]. A recent paper showed, however, that the tibial part of the arthrotomy could play an important role in faster recovery [23].

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The aim of this study was to compare two different modified proximal minimally invasive approaches and the hypothesis was that a far medial subvastus approach would allow faster quadriceps recovery with easier straight leg raising, early full weight bearing without aid and a reduced length of stay compared to a limited medial parapatellar approach both with medial collateral ligament conservation.

Materials and methods

One hundred and eighty patients were included over a 2-year period undergoing primary total knee arthroplasty (TKA). There were 130 female and 50 male patients. In group one, a MI limited medial parapatellar approach and in group two, a MI far medial subvastus approach, both without desinsertion of the medial collateral ligament, were used. First 90 medial parapatellar and then 90 far medial subvastus approaches were consecutively performed. The mean age (SD) for group one was 69.2 ± 7.4 years and a BMI of 28.8 ± 4.2, and for group two was 70.4 ± 6.2 years (n.s.) and a BMI of 29.4 ± 4.8 (n.s.).

Inclusion criteria in this cohort study were primary osteoarthritis without limitations in alignment or flexion contracture. The surgeon evaluated quadriceps function preoperatively during the clinic. If patients were able to engage stairs, rise from a chair and resist to downward pressure of an extended leg, they were included in the study. Previous trauma or arthrotomy of the knee except for open meniscectomy, neurological problems and infection were exclusion criteria. Also patients who had quadriceps or patellar tendon problems were excluded. A single surgeon using one of the both approaches performed all procedures. A cemented, posterior stabilized implant with patella resurfacing (Vanguard, Biomet, USA) was implanted in all cases. Patients were allowed to weight bear immediately postsurgery with the help of a physiotherapist. When they were able to straight leg raise, they were also allowed to walk without aid. Three days postoperation, they were allowed to ascend and descend stairs. We analysed these patients for Knee Society Score (KSS), visual analogue scale (VAS) for pain, flexion, length of stay and alignment. At a minimal follow-up of 24 months (median 26 ± 6 months, range 24 to 38 months), a final functional outcome and implant survival were analysed. Standing anteroposterior (AP), lateral and long-standing AP radiographs were performed. Osteolytic lines were described, if present, according to the Knee Society Roentgenographic Evaluation system [11]. All patients were evaluated at the same time of day by a physiotherapist, blinded both for the incision and the muscular approach.

The postoperative regimen was the same for all patients. They received multimodal pain control, cryotherapy and nadroparin adapted to their weight, daily for a 10-day period.

This study analysed the results of this MCL sparing far medial subvastus approach to see if it would be as consistent as the MI limited parapatellar approach and more specifically, if it was possible to perform a TKA through this approach without desinserting the medial collateral ligament, if the immediate outcome with regard to pain, function and hospital stay was effective, if the alignment would be influenced with more outliers in the FMS group, and if the clinical results in terms of range of motion and implant survival would be reliable at a follow-up of 24 months.

Surgical technique

In the minimally invasive medial parapatellar approach, the skin incision is performed with the knee at 80° of flexion. The incision is made on the edge of the medial border of the patella. The operation is started at the superior limit of the suprapatellar pouch and moved down to the tibial tuberosity. The length of the incision will be adapted, if necessary during surgery, depending on the width of the femur. At this stage, the arthrotomy can be performed. The knee should be at 70° of flexion and the proximal part of the incision exposed. We incise the quadriceps tendon for 2–3 cm proximally to the superior pole of the patella leaving a little rim of tendon inserted to the vastus medialis muscle. The incision runs in a straight line, but at the proximal pole of the patella, we make a parapatellar angle. The arthrotomy proceeds then distally and medially to the tibial tuberosity. At that stage, we dissect the medial soft tissues of the tibia within the limits of the deep medial collateral ligament (MCL). The medial meniscus is then resected and the MCL remains inserted on the tibia, only working within the soft tissue envelope of the deep MCL.

For the minimally invasive far medial subvastus approach, the medial vastus muscle is elevated from its distal insertion on the medial patellofemoral ligament and medially and proximally released up to Hunter's canal. The subvastus arthrotomy is made far medial allowing the capsular incision to run next to the medial femoral condyle. The distal extension on the tibial side runs just next to the medial collateral ligament. The tibial soft tissues are released towards the patellar tendon in one flap keeping the medial patellotibial ligament intact.

The knee is put in almost full extension to use the mobile windows, and the soft tissues in front of the tibia are released to the lateral border of the tibial plateau. Part of the Hoffa fat pad is usually resected during this part of the procedure. The patella will at no point be everted and

shall only be shifted to the side and remain in the lateral pouch during the entire procedure. Limited anterior dislocation of the tibia is only necessary at the implantation of the tibial component. Good closure of the tibial flap is usually possible. No drains were used in either group.

Intramedullary alignment was used on the femur and extramedullary alignment with an asymmetrical medially based cutting block on the tibial side. A measured resection with a femur first technique was used. Ligament balancing was performed with trial implants in place. All implants were cemented with one batch of cement. Standard closure in flexion was performed layer by layer.

Statistical analysis

Data are represented as mean ± SD. Statistical analysis was performed with Mann–Whitney *U* test for independent samples and the unpaired *t* test for dependent samples. All differences were considered significant at a probability level of 95 % ($P < 0.05$).

Results

Functional outcome

Knee Pain and Functional scores and mean arc of flexion improved significantly for both groups after surgery, as given in Table 1. The average time to reach 90° of flexion was 2.4 ± 1.2 days for the medial parapatellar and 2.1 ± 1.3 days for the far medial subvastus approach (n.s.).

The average time to straight leg rising was 2.7 ± 0.4 days for the medial parapatellar and 1.7 ± 0.5 days ($P < 0.05$) for the far medial subvastus approach. Walking without aid was possible at 2 ± 0.8 days for the medial parapatellar and 1.7 ± 0.6 for the far medial subvastus ($P < 0.05$). Stairs up and down were done at 4 ± 0.3 days for the medial parapatellar group and at 3 ± 0.4 days for the far medial subvastus group ($P < 0.05$).

Hospital Stay until return to their own home was 5 ± 1.2 days for the medial parapatellar and 4 ± 0.5 days for the far medial subvastus approach ($P < 0.05$).

Analgesia requirement

The average VAS at movement during the first 2 days was 5.11 ± 1.1 for the medial parapatellar and 4.97 ± 1.3 (n.s.) for the far medial subvastus approach. The total equianalgesic dose of morphine used during the first 48 h was 34.8 ± 11 mg for the medial parapatellar and 33.2 ± 14 mg (n.s.) for the far medial subvastus approach.

Radiographic findings

The mean preoperative lower extremity alignment measured on a standing full leg radiograph was 8.2° ± 7° varus in the medial parapatellar and 8.7° ± 8.4° varus in the far medial subvastus approach (n.s.). Postoperatively on a standing full leg radiograph, the tibial alignment was deemed to be 0.4° ± 1° varus for the medial parapatellar and 0.2° varus ± 1° for the far medial subvastus approach (n.s.) and 89° ± 2° for the femoral component in the medial parapatellar and 88.8° ± 2° for the far medial subvastus group (n.s.). The overall alignment was 5.4° ± 2.1° in the medial parapatellar and 5.0° ± 2.4° in the far medial subvastus approach (n.s.). There were no significant outliers out of 3° in either group.

No osteolytic lines were observed in either of groups at 24 months follow-up.

Blood loss

The mean time a tourniquet was used for was 55 ± 10.6 min in the medial parapatellar and 67 ± 12 min in the far medial subvastus approach ($P < 0.05$). The mean haemoglobin level at 5 days postoperative was 10.6 ± 2.1 gr/dl (9.8–13.4) in the medial parapatellar and 10.8 ± 1.8 gr/dl (8.8–12.4) (n.s.) in the far medial subvastus approach. The mean drop in haemoglobin was 3.9 ± 2.3 gr/dL

Table 1 Functional score of both groups

	Preoperative	6 weeks postop	*P* value	24 months postop	*P* value
Medial parapatellar group					
Knee score	47.1 ± 3.5	75 ± 10	<0.05	88.5 ± 6.8	<0.05
Function score	50 ± 20	70 ± 10	<0.05	90 ± 10	<0.05
Flexion	124° ± 11.6	117° ± 8.8	<0.05	135° ± 6.8	<0.05
Far medial subvastus group					
Knee score	45.9 ± 3.8	76 ± 8	<0.05	90 ± 7.2	<0.05
Function score	50 ± 25	75 ± 15	<0.05	90 ± 10	<0.05
Flexion	125° ± 12.3	119° ± 9	<0.05	134° ± 8	<0.05

(6.4–2.6 gr/dL) in the medial parapatellar and 3.8 ± 1.8 gr/dL (6.1–2.2 gr/dL) in the far medial subvastus approach (n.s.).

Complications

No complications were observed in either approach.

24 months follow-up

There was an extension of 0° ± 2.8° (−4° to 3°) in the medial parapatellar and −1° ± 2.6° (−5° to 4°) in the far medial subvastus approach (n.s.) and a mean flexion of 135° ± 6.8° (98° to 148°) in the medial parapatellar and 134° ± 8° (95° to 142°) (n.s.) in the far medial subvastus approach. There was no septic or aseptic loosening observed at a follow-up of 24 months in either approach.

Discussion

The most important finding of this study was that the minimally invasive far medial subvastus approach with MCL conservation allows faster recovery in the early postoperative phase, with quick ambulation, fast straight leg raising and stair negotiation resulting in a shorter length of stay and this without malalignment or complications, after TKA with a minimal follow-up of 2 years.

Most studies on MIS have focused on the smaller skin incision and the arthrotomy comparing the different proximal soft tissue approaches with conventional surgery, often observing only a difference in short-term results for patients [5–7, 12, 13, 18, 19]. In most studies, this early clinical advantage seems to fade over time [10, 13, 20].

Minimally invasive approaches result in less soft tissue damage with less pain and early higher knee scores [7, 12, 14, 24]. Not everting the patella leads to better flexion and more quadriceps force after TKA [1, 5, 15, 17, 18, 20, 26]. Although the absolute quadriceps force in this study was not measured, the time to functional recovery of this important muscle was well evaluated. Earlier straight leg raising was observed for the subvastus group as published by other authors [4, 5, 10, 15, 17, 21]. Time to full weight bearing without aid and stair negotiation ability was also quicker in the far medial subvastus group [24]. Since most of the patients go to their own home, this earlier functional recovery resulted in a shorter length of stay.

In this study, no significant differences for range of motion at 6-week interval or at 2-year intervals were observed, and the minimally invasive aspect of both approaches can probably explain this finding.

Like in other studies, no differences in pain or Knee and Function Scores at 6 weeks or 2 years were observed for either approach [4, 16]. This, despite a longer tourniquet time in the far medial subvastus group, has also been observed for the classic subvastus by other authors [2, 5, 14]. The dissection and the respect for the proximal soft tissues clearly takes more surgical time but results in better functional results [4, 10].

Minimal invasive TKA was previously thought to provide early clinical advantages but to result in malalignment of the components [9, 13]. Several recent papers reported that good alignment can be obtained through the minimally invasive approach [5, 8, 12, 13] and emphasize the importance of good exposure and visualization of the classic anatomical reference points [8, 9, 23]. Especially, exposure on the femoral side will be crucial [22, 23]. In this study, correct alignment through both of the MCL sparing minimally invasive approaches was confirmed because proximal exposure allowing good visualization of femur and tibia was possible within the soft tissue envelope.

The minimally invasive technique has been refined to this current technique where the MCL is not released in the approach and where all cuts are made in situ without dislocation of the tibiofemoral or patellofemoral joint [23]. The arthrotomy is made on the far medial edge to reduce soft tissue tension during mobilization. This keeps the patellotibial ligament intact and makes closure of the distal part of the arthrotomy easier.

The subtle clinical differences that were observed by other authors in between different minimally invasive and conventional approaches suggest that the proximal part of the arthrotomy is maybe not the main factor determining recovery and pain after TKA. The distal part of the arthrotomy and especially the surgical release of the medial collateral ligament during the approach possibly play a role in pain, stiffness and recovery [23]. However, faster straight leg raising and stair negotiation resulting in shorter length of stay are observed when the soft tissue damage is limited on the proximal side of the arthrotomy like in this minimally invasive far medial subvastus approach.

The limitation of this study is that the quadriceps force was not objectively measured with a tool like a Cybex test or similar device. However, these results can be questioned after surgery depending on the residual pain or apprehension of the patient.

The clinical relevance of this study lies in the observation that faster quadriceps recovery is possible with a subvastus approach. This initial faster recovery can result in a shorter hospital stay leading to a lower cost for the same surgery.

Conclusion

Minimally invasive TKA can be performed safely through a far medial subvastus approach with attachment of the

medial collateral ligament without everting the patella and with minimal anterior tibia dislocation during component implantation. This MCL sparing approach allows reduced recovery time, fast weight bearing without aid, easier straight leg raising and stair climbing without compromise of the long-term results.

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