"Faster recovery after minimally invasive surgery in total knee arthroplasty"

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Abstract

PURPOSE: The aim of the study was to identify whether less soft tissue and muscle damage during surgery will allow faster recovery after total knee arthroplasty in comparison with the conventional technique. A limited medial parapatellar approach without tibial medial collateral ligament (MCL) desinsertion was compared with the conventional parapatellar approach. METHODS: Three hundred patients were randomized either into the minimally invasive group (MIS group) or into the conventional group (CON group). The evaluation was based on the Knee Society Score, range of motion, blood loss, period of hospitalization and postoperative hemoglobin level. RESULTS: The MIS group showed faster recovery with immediate postoperative full weight-bearing and shorter length of stay (5 vs 10 days). Comparable Knee Society Scores (87.5 vs 88), function scores (90) and alignment (5.5° vs 5.2°) between the CON and MIS group were observed at a follow-up of 24 months. No increase in operative times (52...
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Methods Three hundred patients were randomized either into the minimally invasive group (MIS group) or into the conventional group (CON group). The evaluation was based on the Knee Society Score, range of motion, blood loss, period of hospitalization and postoperative hemoglobin level.

Results The MIS group showed faster recovery with immediate postoperative full weight-bearing and shorter length of stay (5 vs 10 days). Comparable Knee Society Scores (87.5 vs 88), function scores (90) and alignment (5.5° vs 5.2°) between the CON and MIS group were observed at a follow-up of 24 months. No increase in operative times (52 vs 51 min tourniquet time) or no complications were observed. Reduced blood loss was observed in the MIS group (590 vs 989 ml).

Conclusion The MCL sparing limited medial parapatellar approach allows good surgical exposure, easy extension proximally if necessary, contained closure after surgery with less bleeding, faster recovery, full weight-bearing without aid and most importantly no radiological malalignment.

Level of evidence Therapeutic study, Level II.

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

Introduction

In the minimally invasive or 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 no longer violated, the patella is no longer everted, and the tibia is not dislocated anteriorly [1, 7, 20, 27, 31]. 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, 4, 10, 11, 16, 28, 30].

Controversial data are available about minimally invasive surgery (MIS) [2, 5–7, 17]. Some authors observed early failure with malalignment and early revision. However, better short-term recovery leading to early failure is not acceptable for an intervention that has excellent results since many decades [2, 6]. Most of the MIS studies compared different proximal approaches (mini-midvastus, mini-subvastus and the limited parapatellar approach) with conventional techniques [3, 11, 16, 21, 28].

A reduction in the perioperative morbidity by a modification of the surgical approach could be important in these days where more patients have to be treated with less money [14]. A reduction in pain, blood loss and a shorter hospital stay will lead to global cost reduction for total knee arthroplasty [10, 22, 26, 31].

The hypothesis of this study was that previously only subtle differences in outcome in MIS were observed because the proximal part of the approach impacts less the...
recovery of total knee arthroplasty (TKA) patients than the distal part of the arthrotomy [3, 5, 10, 21]. A modification of the limited medial parapatellar approach without release of the medial collateral ligament on the tibial side, by staying within the soft tissue sleeve of the deep medial collateral ligament, was developed. This new approach introduces a MIS version on the tibial side of the arthrotomy.

Materials and methods

We operated 300 patients over a 2-year period from 2005 to 2007. There were 210 female and 90 male patients. A conventional parapatellar approach and a minimally invasive limited parapatellar approach without desinsertion of the medial collateral ligament were used in group one and group two, respectively. The randomization was based on one full surgery day MIS approach and the next day the other approach (CON). The mean age and the BMI were 69 ± 7.2 years (range, 52–84 years) and 29.8 ± 3.8 (26–37) for group one and 68 ± 7.6 years (range, 56–83 years) and 30.4 ± 4.6 (28–36) for group two (Table 1). Inclusion criterion in this prospective randomized study was primary osteoarthritis without limitations in alignment or flexion contracture. Previous trauma or arthrotomy of the knee, neurological problems and infection were exclusion criteria. All procedures were performed by a single surgeon using one of both approaches, implanting a cemented, posterior stabilized implant, with patella resurfacing. Single-shot femoral nerve block combined with general anesthesia was used in all cases. Patients were allowed to weight-bear immediately postsurgery with help of a physiotherapist. When they were able to straight leg raise, they were allowed to walk without aid. Three days postoperation, they were allowed to ascend and descend stairs. We analyzed these patients for Knee Society Score (KSS), visual analogue scale (VAS) for pain, flexion, blood loss, length of stay and alignment. At a minimal follow-up of 24 months (mean, 32 ± 6 months; range, 24–38 months), a final functional outcome and implant survival was analyzed. 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 [8]. 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).

This study analyzed the results of this MCL sparing limited medial parapatellar approach to see whether it would be as consistent as the classic medial parapatellar approach and, more specifically, whether it was possible to perform a TKA through this approach without desinserting the medial collateral ligament, whether the immediate outcome with regards to pain, function, blood loss and hospital stay was effective, whether the alignment would be influenced with more outliers in the MIS group, and whether 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 (Fig. 1). The length of the incision will be adapted, if necessary during surgery, depending on the width of the femur. The skin length changes about 24 % between extension and flexion of the knee [23]. 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

<table>
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<tr>
<th>Table 1 Demographics of study groups</th>
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<tr>
<td>CON group</td>
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<tr>
<td>Number of patients (N)</td>
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<tr>
<td>Sex (M/F)</td>
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<tr>
<td>Mean age (range)</td>
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<td>BMI (range)</td>
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Fig. 1 Reference points for skin incision: proximal border pouch, medial condyle femur, tuberosity. Mean length of skin incision is 14 cm in extension
2–3 cm proximally to the superior pole of the patella leaving a little rim of tendon inserted to the vastus medialis muscle (Fig. 2). The incision runs in a straight line, but at the proximal pole of the patella, we make a parapatellar angle. The arthrotomy proceeds 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 (Fig. 3).

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 (Fig. 4). Limited anterior dislocation of the tibia is only necessary at the implantation of the tibial component.

Starting with our reference point at the proximal point of the patella, closure is performed at 80° of flexion.

Closure of the arthrotomy is vital because it limits the risk of infection and blood leakage. As the MCL is kept attached and there is no damage to the posterior capsule, the joint remains contained. This is key to hematoma containment and limitation of postoperative blood loss.

Results

Functional outcome

The Knee Score improved significantly from 54 ± 10.5 (33–71) to 87.5 ± 6.8 (72–98) for the classic ($P < 0.05$) and from 56 ± 11.8 (31–69) to 88 ± 7.2 (74–97) points ($P < 0.05$) for the minimally invasive approach. The function score improved from 35 ± 20 (30–60) to 90 ± 10 (70–90) for the classic ($P < 0.05$) and from 30 ± 25 (25–50) to 90 ± 10 (70–90) ($P < 0.05$) for the minimally invasive group (Table 2).

The preoperative flexion was 113° ± 10.6° (87°–134°) in the classic and 112.5° ± 11.3° (85°–132°) in the minimally invasive approach ($P = \text{n.s.}$). The flexion at 6 weeks was 107° ± 10.8° (96°–131°) for the classic and 118.7° ± 12° (104°–128°) ($P < 0.05$) for the minimally invasive approach. Flexion improvement was better at 6 weeks and 2 years for the limited approach (Table 2). The average time to reach 90° of flexion was 4 ± 1.2 (2–7)
days for the classic and 2.3 ± 0.3 (1–3) days (P < 0.05) for the minimally invasive approach. The average time to straight leg rising was 3 ± 1.3 (3–5) days for the classic and 2.7 ± 0.2 (1–3) days (P < 0.05) for the minimally invasive approach.

Hospital stay until return to their own home was 10 ± 2 (4–12) days for the classic incision and 5 ± 1.2 (2–6) days (P < 0.05) for the minimally invasive approach.

### Analgesia requirement

The average VAS during the first 3 days was 6.11 ± 1.1 (4.8–8.3) for the classic and 2.97 ± 1.3 (1.6–6.0) (P < 0.05) for the minimally invasive approach. The total equianalgesic dose of morphine used during the first 48 h was 64.8 ± 10 mg (48–82) for the classic and 32.2 ± 12 mg (14–59) (P < 0.05) for the minimally invasive approach.

### Radiographic findings

The mean preoperative lower extremity alignment measured on a standing full leg radiograph was 6.2° ± 9° varus (15° varus to 12° valgus) in the classic and 6.7° ± 10.4° varus (16° varus to 14° valgus) in the minimally invasive approach (P = n.s.). Postoperatively on a standing full leg X-ray, the tibial alignment was deemed to be 0.5° ± 2° varus (3.4° varus to 1.8° valgus) for the classic and 0.7° varus ± 2° (2.8° varus to 2.4° valgus) for the minimally invasive approach (P = n.s.). The overall alignment was 5.5° in the classic and 5.2° in the minimally invasive approach (P = n.s.).

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

### Blood loss

The mean time a tourniquet was used was 52 ± 11.6 min (46–58) in the classic and 51 ± 12 min (49–57) in the minimally invasive approach (P = n.s.). The estimated total blood loss was 989 ± 125 ml (780–1087 ml) for the classic and 590 ± 113 ml (489–693 ml) (P < 0.05) for the minimally invasive approach. The mean hemoglobin level at 5 days postoperative was 8.2 ± 1.8 gr/dL (6.8–10.4) in the classic and 10.6 ± 2.1 gr/dL (9.8–13.4) (P < 0.05) in the minimally invasive approach. The mean drop in hemoglobin was 5.8 ± 1.6 gr/dL (8.1–4.2 gr/dL) in the classic and 3.9 ± 2.3 gr/dL (6.4–2.6 gr/dL) (P < 0.05) in the minimally invasive approach.

### Complications

No complications were observed in either approach.

### 24 months follow-up

There were an extension of −1° ± 4.1° (−5° to 3°) in the classic and 0° ± 4.8° (−4° to 2°) in the minimally invasive approach (P = n.s.) and a mean flexion of 125° ± 8° (95°–132°) in the classic and 132° ± 6.8° (118°–142°) (P < 0.05) in the minimally invasive 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 limited parapatellar approach with MCL conservation allows fast recovery in the early postoperative phase, with less pain, less bleeding, better flexion and shorter length of stay and this without malalignment or complications, after TKA with a minimal follow-up of 2 years.

Many papers have focused on the smaller skin incision and the proximal arthrotomy comparing the different proximal soft tissue approaches, often observing only a difference in short-term results for patients [4, 9–11, 20, 21, 25]. This early clinical advantage seems to fade over time in most studies [7, 10, 21, 30]. No significant difference in length of stay or analgesia intake was observed when comparing these different muscular approaches [19].

### Table 2 Functional scores of both groups

<table>
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<th></th>
<th>Preoperative</th>
<th>6 weeks Postop</th>
<th>P value</th>
<th>24 m Postop</th>
<th>P value</th>
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<tbody>
<tr>
<td><strong>Conventional group</strong></td>
<td></td>
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<tr>
<td>Knee score</td>
<td>54 ± 7.5 (33–71)</td>
<td>60 ± 5.3 (55–74)</td>
<td>&lt;0.05</td>
<td>87.5 ± 6.8 (72–98)</td>
<td>&lt;0.05</td>
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<tr>
<td>Function score</td>
<td>35 ± 10 (30–60)</td>
<td>50 ± 20 (45–70)</td>
<td>&lt;0.05</td>
<td>90 ± 20 (70–90)</td>
<td>&lt;0.05</td>
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<tr>
<td>Flexion</td>
<td>113° ± 10.6° (87°–134°)</td>
<td>107° ± 10.8° (96°–131°)</td>
<td>&lt;0.05</td>
<td>125° ± 8° (95°–132°)</td>
<td>&lt;0.05</td>
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<tr>
<td><strong>MIS group</strong></td>
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<tr>
<td>Knee score</td>
<td>56 ± 8 (31–69)</td>
<td>82 ± 20 (65–80)</td>
<td>&lt;0.05</td>
<td>88 ± 7.2 (74–97)</td>
<td>&lt;0.05</td>
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<tr>
<td>Function score</td>
<td>30 ± 10 (25–50)</td>
<td>80 ± 10 (70–90)</td>
<td>&lt;0.05</td>
<td>90 ± 10 (70–90)</td>
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<tr>
<td>Flexion</td>
<td>112.5° ± 11.3° (85°–132°)</td>
<td>122° ± 8° (98°–126°)</td>
<td>&lt;0.05</td>
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Many of these studies were focusing on the mini-midvastus approach [3, 10, 16, 21]. Maybe this transmuscular approach is not so innocent as sometimes inferior quadriceps function [29], or higher muscle enzymes were observed in mini-midvastus and mini-subvastus approaches through stretching or cutting of the muscle [22, 29].

Minimally invasive approaches result in less soft tissue invasion with less pain and early higher knee scores [4, 9, 12, 27]. Not needing to evert the patella leads to better flexion and more quadriceps force after TKA [1, 20, 25, 26, 31]. In this study, we observed significant differences for range of motion in favor of the minimally invasive group both at 6 weeks (11°) and 2 years (7°) intervals, probably explained by less soft tissue damage at the tibial side.

Minimally invasive TKA was previously thought to provide early clinical advantages but result in malalignment of the component [6, 10, 15]. A higher prevalence of revision within 24 months has been observed in minimally invasive TKR [2]. Several recent papers reported that good alignment can be obtained through the minimally invasive approach [4, 9, 10, 17, 19, 26, 30] and emphasize the importance of good exposure and visualization of the classic anatomical reference points [5, 6, 18], especially exposure of the femoral side will be crucial [24]. In this study, correct alignment through the MCL sparing minimally invasive approach was confirmed because proximal exposure allowing good visualization of femur and tibia was possible within the soft tissue envelope.

We also observed like other authors less pain, faster straight leg raising, shorter hospital stay and better knee and function scores at 6 weeks in the minimally invasive approach [1, 12, 20, 27, 30, 31]. Similar to other studies, no longer tourniquet times were observed in the MIS group [25, 30]. Longer tourniquet times could of course eliminate some of the potential benefits of minimally invasive surgery [4, 12, 26].

The minimally invasive technique has been refined to our 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. This keeps the posterior capsule and the collaterals intact and makes containment of postoperative hematoma possible. No drains are used. We observed in this series less bleeding and a higher postoperative hemoglobin level in the MIS group as other authors did [12].

Minimally invasive TKR requires a learning curve of up to 50 cases for a high volume arthroplasty surgeon [13, 17]. In our experience, the minimally invasive medial parapatellar approach may be the easiest approach to convert from the classic approach [16].

The subtle clinical differences that were observed by other authors in between different minimally invasive approaches suggest that the proximal part of the arthrotomy may not be the main factor determining the recovery and pain after TKA. The distal part of the approach and especially the surgical release of the medial collateral ligament possibly play a role in pain, stiffness and recovery. The observations of this study seem to emphasize this. The clinical impact of tibial MCL lesions is known in athletes with swelling, pain and limited range of motion. Surgical release of the MCL in the approach can be compared to these lesions.

The limitation of this study is that we have not compared an MCL sparing approach with another proximal approach like the MCL sparing midvastus or subvastus. We will set up a new study to determine these results comparing subvastus and limited parapatellar approach with MCL conservation.

Conclusion

Minimally invasive TKA can be performed safely through a limited medial parapatellar approach with attachment of the medial collateral ligament without evertting the patella, with a minimal quadriceps tendon incision and without anterior tibia dislocation. This MCL sparing approach allows reduced recovery time, fast weight-bearing without aid and a good range of motion without compromising the long-term results. At 2 years of follow-up, better end flexion was observed. With good capsular containment, blood loss and hematoma are reduced. Radiological alignment is comparable to the classic approach.

References