Minimally invasive total knee arthroplasty using the contralateral knee as a control group: a case-control study

Peter M. Bonutti · Michael G. Zywił ·
Thorsten M. Seyler · Seung Yong Lee ·
Mike S. McGrath · David R. Marker · Michael A. Mont

Received: 9 February 2009 / Revised: 11 February 2009 / Accepted: 12 February 2009 / Published online: 8 April 2009
© Springer-Verlag 2009

Abstract The primary purpose of this study was to compare clinical and functional results of bilateral total knee arthroplasties in which a conventional total knee replacement was initially performed on one knee and a minimally invasive total knee replacement was later performed on the contralateral side. Operative factors, clinical and radiographic outcomes, and quadriceps muscle strength were evaluated in twenty-five patients (50 total knee arthroplasties). Twenty-one of the 25 patients preferred the minimally invasive approach. Knee society objective scores and range-of-motion were significantly greater in the minimally invasive group. Isokinetic testing demonstrated statistically improved quadriceps muscle strength in the minimally invasive technique group compared to the standard approach at both 12 weeks and one year postoperatively. Radiographic analysis did not reveal differences in alignment variables between the two approaches. The results of this study suggest that minimally invasive total knee

arthroplasty offers superior short-term as well as possible long-term results.

Introduction

Standard total knee arthroplasty has consistently led to both excellent and reproducible results, which have been reported in multiple long-term studies [3, 7, 9, 12, 13, 16]. The medial parapatellar approach is the most common technique used to expose the knee, providing the ability to address all three knee compartments and allowing for reproducible correction of the mechanical alignment. Although standard total knee arthroplasty has proven to be a successful procedure, the recovery period is often long, painful, and difficult. Thus, most orthopaedic surgeons advise patients preoperatively that rehabilitation may take up to one year for full functional recovery. While these issues may not preclude the surgical result from ultimately being successful, these aspects of patient satisfaction need to be addressed. Neither satisfactory postoperative radiographs, nor long-term survivorship of greater than 90% for many studies address patient expectations and satisfaction issues. Patient expectations have been reported to be important independent predictors of improved functional outcomes and satisfaction following total knee arthroplasty [4, 6, 15].

The recent extensive interest in minimally invasive techniques in orthopaedics has been mainly attributed to market- and patient-driven demand. Despite the lack of long-term outcome data to objectively evaluate the role of minimally invasive surgery in orthopaedic surgery, many surgeons believe that these techniques are the wave of the future and will become more prevalent over time. Some

---

P. M. Bonutti
Bonutti Clinic,
1303 Evergreen Avenue,
Effingham, IL 62401, USA

M. G. Zywił · T. M. Seyler · M. S. McGrath · D. R. Marker ·
M. A. Mont (✉)
Center for Joint Preservation and Replacement,
Rubin Institute for Advanced Orthopedics,
Sinai Hospital of Baltimore,
2401 West Belvedere Avenue,
Baltimore, MD 21215, USA
e-mail: mmont@lifebridgehealth.org

S. Y. Lee
Hallym University Medical Center,
445 Kildong, Kangdonggu,
Seoul, Korea

characteristics of minimally invasive surgery are specialised techniques and instrumentation that allow surgeons to proceed without large incisions. Besides a reduction in both hospital costs and length of hospital stay, minimally invasive surgery (MIS) techniques have been reported to offer (1) a smaller incision with less damage to soft tissue and cosmetic benefit to patients, (2) improved muscle strength and increased range of motion in the early rehabilitation process, (3) less postoperative pain, and (4) a more rapid return of full knee function. In addition to the claimed advantages, MIS techniques may provide surgeons with a powerful tool to market their practice and increase patient referrals.

Since 1996, two of the authors have used minimally invasive surgical approaches for total knee arthroplasty in over 3,000 cases. In this study, all patients received a standard total knee arthroplasty with a medial parapatellar approach on one knee and a later minimally invasive total knee arthroplasty using a mini-midvastus approach on the contralateral side. The purpose of this study was to evaluate the short-term functional and radiographic results of this minimally invasive approach compared to a standard parapatellar approach in total knee arthroplasty.

Materials and methods

Study design

The study design is a cohort analysis of 25 patients (50 total knee arthroplasties) who underwent MIS total knee arthroplasty (quadriceps muscle sparing, no patellar eversion, small incision length less than 12 cm) through a mini-midvastus approach, and who previously received a total knee arthroplasty through a standard approach of the contralateral knee (medial parapatellar, patellar eversion, incision length greater than 16 cm). All MIS operations were performed between January 1st, 1997 and March 1st, 2004. The authors reviewed medical records, physical therapy reports, as well as preoperative and postoperative radiographs. Institutional review-board approval was obtained prior to review of the clinical and radiographic data for these patients.

Patient demographics

The study cohort included nine men and 16 women who had a mean body mass index of 35 kg/m² (range 18–57 kg/m²). The underlying diagnosis leading to total knee arthroplasty was primary osteoarthritis in all patients. The mean age at the time of MIS surgery was 73 years (range 59–85 years) and the mean follow-up was 48 months (range 30–67 months). The mean size of the MIS incision

in full extension was 8.5 cm (range 6–11 cm). In the standard medial parapatellar group, the mean age at the time of surgery was 67 years (range 51–78 years) and the mean follow-up was 115 months (range 45–213 months). The incision size in full extension was a mean of 18 cm (range 17–26 cm).

Data collection

Preoperative data collection included age, gender, body mass index, diagnosis, and Knee Society objective and functional scores [10] including pain and range of motion. Patients with more than ten degrees of varus or valgus deformity were excluded from the study. All study participants were then carefully screened for various intraoperative parameters such as implant type, incision size in full extension, surgery time, blood loss, and any intraoperative complications. Postoperative clinical data collected until discharge included range of motion (active and passive), Knee Society objective and functional scores [10], visual analog pain scores, and patient response when asked which knee, if any, was more satisfactory.

Standard anteroposterior and lateral radiographs were used preoperatively to template the components and to evaluate the degree of deformity. Intraoperative and postoperative complications were recorded. A Lido Active II dynamometer (Chattanooga Group, Hixson, Texas) was employed to measure the isokinetic peak torque of knee extension at 60°/second. The testing of all knees in the MIS mini-midvastus group was done at 12 weeks and at one year postoperatively, and compared to the knees in the standard parapatellar incision at 12 weeks and at one year postoperatively, respectively. The patients were asked to perform five extensions with maximal effort for each knee, and the mean of these measurements was used to compare the two approaches.

Patients were evaluated radiographically using the Knee Society total knee roentgenographic evaluation and scoring system [8]. Antero-posterior and lateral views were obtained in all patients and component alignment, seating, and sizing, as well as any radiolucencies were documented.

Surgical approaches and instrumentation

The limited approach used was midvastus with the length of the incision no longer than two and half times the length of the patella (proximal to distal). The dissection exposed the superior and inferior aspect of the vastus medialis obliquus muscle and its insertion into the quadriceps tendon and the medial aspect of the patella. The incision is started about 1 cm distal and medial to the patella, releasing all medial articular structures. A cuff of soft tissue was preserved for later repair. When the

superomedial pole of the patella was reached, the dissection was continued by incising the obliquus muscle about 2 cm proximally in line with its fibres. Retracting the patella laterally without eversion, the exposure was completed in an identical manner as the standard medial parapatellar approach. All instruments used for the midvastus approach were approximately half the size of traditional instruments to facilitate the minimally invasive approach to total knee arthroplasty. The limit for the length of the incision in the minimally invasive group was 12 cm or less with the knee in full extension.

For the standard approach group, the medial parapatellar approach was used. A straight anterior midline skin incision extending approximately 8 cm proximal to the superior patellar pole and approximately 2 cm distal to the patellar tendon insertion just distal to the tibial tubercle was made. With this approach, the patella was everted and the tibia dislocated anteriorly. The incisions in the standard group were all greater than 16 cm in full extension.

The surgical implant used in the minimally invasive midvastus and the medial parapatellar group was the Stryker Scorpion posterior cruciate retaining total knee design (Stryker Orthopaedics, Mahwah, New Jersey). All patellae were resurfaced and the femoral, tibial, and patellar components were cemented.

Data analysis

The data was compiled and tabulated using a Microsoft Excel spreadsheet. Descriptive statistics were calculated using SigmaStat statistical software, version 3.0 (SPSS Inc., Chicago, Illinois), and a paired *t*-test was used to analyse any differences in the various parameters between the two groups. All *p* values less than 0.05 were considered significant.

Results

There was a marked improvement in mean Knee Society objective and functional scores for both surgical approaches at 12 weeks and at final follow-up, with a significantly higher Knee Society objective score ($p<0.001$) for the MIS group, but no significant difference in functional score ($p=0.216$) at final follow-up. An overview of the preoperative and postoperative Knee scores for both groups can be found in Table 1.

The patients in the MIS mini-midvastus group had a faster improvement in range of motion compared to patients in the medial parapatellar group. The mean flexion at 12 weeks and at final follow-up for the MIS group was 114° (range 105–127°) and 116° (range 105–127°), respectively, compared to 105° (range 85–120°) and 112° (range 100–120°) for the medial parapatellar group. At both 12-week and final follow-up, patients in the MIS group had statistically significant better range of motion ($p<0.001$ and $p=0.034$, respectively).

Isokinetic muscle strength testing at 60° flexion demonstrated statistically higher quadriceps muscle strength in the MIS mini-midvastus group at both 12 weeks ($p=0.033$) and at one year ($p=0.002$) follow-up when compared to testing of the standard incision group at the same follow-up. Eighteen of the 25 patients were able to generate more quadriceps muscle peak torque when compared to the contralateral standard medial parapatellar incision arthroplasty, and three patients showed no difference in measured peak torque between the two knees. The mean peak strength of the quadriceps muscle was 7% (range –26% to 33%) higher in the MIS group compared to the standard incision group. Isokinetic muscle strength testing at one year postoperatively revealed that the mean peak strength of the quadriceps muscle was 8% higher (range –11% to 36%) in the MIS mini-midvastus group when

Table 1 Comparison of preoperative and postoperative Knee scores

Pre- and postoperative evaluations	Mini-midvastus approach		Standard approach		<i>p</i> value
	Mean	Range	Mean	Range	
Preoperative					
Knee Society objective score (points)	53	33 to 65	50	33 to 65	0.399
Knee Society function score (points)	45	0 to 60	49	15 to 60	0.067
12 week follow-up					
Knee Society objective score (points)	96	90 to 100	90	80 to 98	<0.001
Knee Society function score (points)	90	80 to 100	91	80 to 100	0.520
Knee flexion (degrees)	114	105 to 127	105	85 to 120	<0.001
Final follow-up					
Knee Society objective score (points)	96	78 to 100	91	78 to 99	<0.001
Knee Society function score (points)	90	80 to 100	89	80 to 100	0.216
Knee flexion (degrees)	116	105 to 127	112	100 to 120	0.034

compared to the contralateral standard incision knee at one year follow-up. As with the earlier follow-up, 18 patients were able to generate higher quadriceps muscle peak torque with the mini-midvastus knee, and three patients had no measurable difference in peak torque between the two knees.

The surgical time for both groups was comparable. The mean total surgical time (incision to wound closure per knee) was 63 min (range 45–120 min) for the MIS mini-midvastus group and 64 min (range 40–108 min) for the standard incision group. There were four lateral releases necessary in the MIS mini-midvastus group, and there were five lateral releases performed in the standard medial parapatellar group.

Most patients preferred the MIS mini-midvastus approach. Of the 25 patients, 21 patients preferred the MIS approach, two patients had expressed no preference and two patients favoured the standard medial parapatellar approach. However, all patients noticed a cosmetic difference with a significantly shorter incision in the MIS approach knee compared to the standard incision knee.

Radiographic analysis did not reveal any differences in postoperative alignment. The overall postoperative tibiofemoral angles averaged 5.1° valgus (range 3° valgus to 7° valgus) in the MIS mini-midvastus knees and 4.9° valgus (range 0° valgus to 9° valgus) in the standard medial parapatellar knees. No differences in patella alignment between MIS midvastus and the parapatellar group were noted with two small medial patella tilts observed in the parapatellar group.

The overall complication rate for both surgical approaches was low with no fractures, extensor mechanism injuries, neurovascular complications, wound healing problems, and no deep infections noted in either group. There was one painful knee secondary to a haemarthrosis in the MIS group that resolved after four weeks. In the standard incision group, there were two knees with stiffness (less than 90° flexion) that required manipulation under anaesthesia. This led to an excellent outcome with the knees returning to normal function and an arc of motion of 0° to 110° and 0° to 105°, respectively, at final follow-up.

Discussion

To date, over 3,000 total knee arthroplasties have been performed by the authors using MIS techniques [1, 2]. Reproducibly excellent clinical results, minimal complications, and maintenance of radiographic alignment have been obtained [2]. It was the purpose of this study to evaluate any differences in outcomes in comparison to a standard medial parapatellar approach for total knee arthroplasty when performed in the same patient. With a

growing interest in applying MIS techniques to total knee arthroplasty surgery, it is critical for both surgeon and patient to understand the specific differences in outcomes with this technique as compared to standard approaches. At 12 weeks, one year, and at a mean final follow-up of 48 months, the MIS knees demonstrated improved range of motion, peak extensor muscle torque, and cosmesis, without sacrificing radiographic positioning of the implants.

The midvastus approach has been shown by several authors to be associated with less pain and improved strength in the early postoperative period [5, 11, 14, 17]. In this study, the authors modified the classic midvastus approach following minimally invasive principles, which may have led to less stretching and less twisting of the patella tendon and quadriceps muscle mechanism, less spreading of the vastus medialis muscle, and less trauma to the joint capsule. These techniques may have contributed to the superior clinical outcomes with the MIS approach knees and have been emphasised in an earlier study with patients who had MIS total knee arthroplasties [1].

In this study, we found that peak extensor muscle strength was significantly higher in the MIS group, and that most patients preferred the knee treated with the MIS approach. In addition, various other parameters were superior in the MIS approach including range of motion and Knee Society objective scores. Interestingly, there was no significant difference in Knee Society function scores, and it is possible that this measure is not sufficiently sensitive to capture the improved outcomes achieved with the MIS surgical approach, but detected by more focussed metrics such as isokinetic muscle strength testing. We believe that even though this is relatively short-term data, the consistency of our findings suggest the possibility of lasting benefits for the reported MIS approach, and deserve attention given the tremendous demand from patients for these MIS approaches. Even if the results of MIS surgery were comparable to standard approaches, many patients would prefer smaller incisions from a cosmetic point of view. It remains to be seen if long-term follow-up or the analysis of certain demographic parameters will impact long-term results of these MIS procedures.

One limitation of the study is that the implantation through either the MIS approach or the standard approach was not done at the same time. All patients had a standard approach before the MIS approach which is a possible bias of the study. The ideal design of this study would include performing these two procedures at the same time. However, this would be difficult to construct in a prospective manner as most patients and institutional review boards would not agree to a study proposal with these two different approaches.

Although this is a short-term follow-up report, the authors believe that this demonstrates superior outcomes

in patients who had a total knee arthroplasty with a MIS approach compared to a standard medial parapatellar approach. The authors await more long-term follow-up, but believe that these preliminary results are encouraging for the use of safe MIS techniques in total knee arthroplasty.

Acknowledgements The authors wish to thank Lindsay Rudert, Gina Zerrusen, and Colleen Kazmarek for their assistance in the preparation of this paper.

References

1. Bonutti PM, Mont MA, Kester MA (2004) Minimally invasive total knee arthroplasty: a 10-feature evolutionary approach. *Orthop Clin North Am* 35(2):217–226. doi:[10.1016/j.ocl.2004.02.001](https://doi.org/10.1016/j.ocl.2004.02.001)
2. Bonutti PM, Mont MA, McMahon M et al (2004) Minimally invasive total knee arthroplasty. *J Bone Jt Surg Am* 86-A(Suppl 2): 26–32
3. Buechel FF Sr (2002) Long-term followup after mobile-bearing total knee replacement. *Clin Orthop Relat Res* 404:40–50. doi:[10.1097/01.blo.0000036529.46246.88](https://doi.org/10.1097/01.blo.0000036529.46246.88)
4. Bullens PH, van Loon CJ, de Waal Malefijt MC et al (2001) Patient satisfaction after total knee arthroplasty: a comparison between subjective and objective outcome assessments. *J Arthroplasty* 16(6):740–747. doi:[10.1054/arth.2001.23922](https://doi.org/10.1054/arth.2001.23922)
5. Dalury DF, Jiranek WA (1999) A comparison of the midvastus and paramedian approaches for total knee arthroplasty. *J Arthroplasty* 14(1):33–37. doi:[10.1016/S0883-5403\(99\)90199-7](https://doi.org/10.1016/S0883-5403(99)90199-7)
6. Dickstein R, Hefes Y, Shabtai EI et al (1998) Total knee arthroplasty in the elderly: patients' self-appraisal 6 and 12 months postoperatively. *Gerontology* 44(4):204–210. doi:[10.1159/000022011](https://doi.org/10.1159/000022011)
7. Dixon MC, Brown RR, Parsch D et al (2005) Modular fixed-bearing total knee arthroplasty with retention of the posterior cruciate ligament. A study of patients followed for a minimum of fifteen years. *J Bone Joint Surg Am* 87(3):598–603. doi:[10.2106/JBJS.C.00591](https://doi.org/10.2106/JBJS.C.00591)
8. Ewald FC (1989) The Knee Society total knee arthroplasty roentgenographic evaluation and scoring system. *Clin Orthop Relat Res* 248:9–12
9. Font-Rodriguez DE, Scuderi GR, Insall JN (1997) Survivorship of cemented total knee arthroplasty. *Clin Orthop Relat Res* 345:79–86
10. Insall JN, Dorr LD, Scott RD et al (1989) Rationale of the Knee Society clinical rating system. *Clin Orthop Relat Res* 248:13–14
11. Keating EM, Faris PM, Meding JB et al (1999) Comparison of the midvastus muscle-splitting approach with the median parapatellar approach in total knee arthroplasty. *J Arthroplasty* 14(1):29–32. doi:[10.1016/S0883-5403\(99\)90198-5](https://doi.org/10.1016/S0883-5403(99)90198-5)
12. Keating EM, Meding JB, Faris PM et al (2002) Long-term followup of nonmodular total knee replacements. *Clin Orthop Relat Res* 404:34–39. doi:[10.1097/01.blo.0000030485.77561.57](https://doi.org/10.1097/01.blo.0000030485.77561.57)
13. Kelly MA, Clarke HD (2002) Long-term results of posterior cruciate-substituting total knee arthroplasty. *Clin Orthop Relat Res* 404:51–57. doi:[10.1097/01.blo.0000030486.77561.8c](https://doi.org/10.1097/01.blo.0000030486.77561.8c)
14. Maestro A, Suarez MA, Rodriguez L et al (2000) The midvastus surgical approach in total knee arthroplasty. *Int Orthop* 24(2):104–107. doi:[10.1007/s002640000116](https://doi.org/10.1007/s002640000116)
15. Mahomed NN, Liang MH, Cook EF et al (2002) The importance of patient expectations in predicting functional outcomes after total joint arthroplasty. *J Rheumatol* 29(6):1273–1279
16. Pavone V, Boettner F, Fickert S et al (2001) Total condylar knee arthroplasty: a long-term followup. *Clin Orthop Relat Res* 388: 18–25
17. White RE Jr, Allman JK, Trauger JA et al (1999) Clinical comparison of the midvastus and medial parapatellar surgical approaches. *Clin Orthop Relat Res* 367:117–122