

Effects of a Less-invasive Surgical Technique on Cement Mantle Quality in Total Knee Arthroplasty

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abstract

Full article available online at Healio.com/Orthopedics. Search: 20120822-17

The purpose of this study was to assess the effects of a less-invasive midvastus exposure during total knee arthroplasty (TKA) on cement mantle grade compared with a standard parapatellar arthrotomy and standard TKA. Fifty consecutive cemented minimally invasive TKAs using a midvastus approach, patellar subluxation without eversion, and less-invasive instrumentation were compared radiographically with a control cohort of 50 consecutive cemented standard TKAs. To eliminate patient selection bias, the standard cohort included consecutive surgeries completed before 2004, prior to the advent of minimally invasive techniques in TKA. Analog supine anteroposterior and lateral radiographs were evaluated using Ewald's criteria. Lucent lines, cement voids, and cement debris were recorded for each group.

Radiographic analysis revealed compromised femoral component cement mantle grades in the minimally invasive group. The number of anterior femoral cement voids (zone 1) was significantly higher in the minimally invasive group, and peripatellar and tibial cement debris was also more common in the minimally invasive group. Based on these findings, the midvastus approach compromises the surgeon's ability to duplicate a consistent femoral cement mantle obtained using a standard exposure.

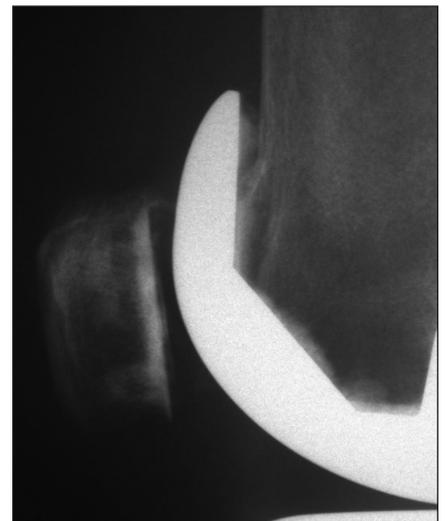


Figure: Postoperative lateral radiograph of the distal femur after minimally invasive total knee arthroplasty showing anterior femoral cement voids in zone 1.

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doi: 10.3928/01477447-20120822-17

Recently, literature has been published supporting the use of less-invasive or minimally invasive techniques for total knee arthroplasty (TKA).¹ Although less-invasive techniques offer the opportunity to improve the method by which TKAs are performed, the indications, potential benefits, and possible detriments of minimally invasive surgery remain in question. It has been reported that improvements in outcomes of patients who undergo minimally invasive surgery do not remain beyond the early postoperative period; however, significant benefits, such as earlier return to function and better subjective recovery, have been reported in properly selected patients.¹ In addition, several pitfalls, including a steep learning curve, component malposition, and infrapatellar tendon injury, have also been identified.^{2,3} Many of these potential pitfalls involve decreased visualization as a result of limited exposure.

The purpose of this study was to assess radiographically whether a minimally invasive exposure would affect the quality of cement in TKA.

MATERIALS AND METHODS

Fifty consecutive cemented minimally invasive TKAs were evaluated clinically and radiographically, and the results were compared with those of a control cohort of 50 consecutive cemented standard TKAs. To eliminate patient selection bias, the standard TKA cohort included consecutive surgeries completed before 2004, prior to the advent of minimally invasive techniques.

Patients were evaluated pre-and postoperatively using the Knee Society Clinical Rating System. Analog supine anteroposterior and lateral radiographs were evaluated using the Knee Society Total Knee Arthroplasty Roentgenographic Evaluation and Scoring System as described by Ewald.⁴ Lucent lines, cement voids, and cement debris were recorded for each group.

Table 1

Patient Characteristics for Standard and Minimally Invasive TKA Cohorts		
Characteristic	Standard (n=49)	Minimally Invasive (n=47)
Mean age (range), y	68.4 (48-85)	71.8 (54-89)
Male sex, No. (%)	24 (49)	16 (43)
Mean BMI (kg/m ²)	<40	<35
Preoperative diagnosis	Osteoarthritis Posttraumatic arthritis Inflammatory arthritis Charcot arthropathy	Osteoarthritis Posttraumatic arthritis
Exclusion criteria	BMI >40	BMI >35 Previous open surgical scars Rheumatoid arthritis Flexion contracture >5° Varus or valgus deformity >10°

Abbreviations: BMI, body mass index; TKA, total knee arthroplasty.

Minimally Invasive TKA Group

The minimally invasive cohort included 50 consecutive minimally invasive cemented TKAs in 47 patients (16 men and 31 women) (Table 1). To avoid the well-established learning curve associated with less-invasive techniques for TKA,⁵ patients in the minimally invasive cohort were identified prospectively after minimally invasive techniques had been fully integrated into the senior surgeon's (F.R.D.) practice. Patients who underwent minimally invasive TKA met the appropriate indications, which included non-morbidly obese patients (body mass index [BMI] <35) without extreme preoperative deformity. Patients with inflammatory arthritis and large muscular quadriceps were excluded.

All procedures were performed using the Natural-Knee II System (Zimmer, Warsaw, Indiana) by the same surgeon (F.R.D.) in 2005. All patients were available for clinical and radiographic evaluations at a minimum of 24 months. Mean patient age was 71.8 years (range, 54-89 years), and mean BMI was less than 35 kg/m².

Preoperative diagnoses included osteoarthritis and posttraumatic arthritis. Exclusion criteria for the minimally invasive group were previous open surgical scars, rheumatoid arthritis, BMI less than 35 kg/m², flexion contracture more than 5°, and varus or valgus deformity less than 10°.

Standard TKA Group

The standard TKA cohort included 50 consecutive standard cemented TKAs in 49 patients (24 men and 25 women) (Table 1). All procedures were completed using the Natural-Knee II System by the same surgeon in 2004, prior to the incorporation of the minimally invasive technique. All patients were available for clinical and radiographic evaluations at a minimum of 24 months. Mean patient age was 68.4 years (range, 48-85 years), and mean BMI was less than 40 kg/m².

Preoperative diagnoses included osteoarthritis, posttraumatic arthritis, inflammatory arthritis, and Charcot arthropathy. Because exclusion criteria were less stringent, the standard group included patients with previous open sur-

gical scars, BMI 35 to 40 kg/m², flexion contracture more than 5°, and varus or valgus deformity more than 10°.

SURGICAL TECHNIQUE

Patients in the standard cohort underwent TKA using a traditional surgical technique with a midline incision and an underlying standard medial parapatellar arthrotomy.⁶ The incision varied by patient size but was based on an incision from 4 finger-breadths above the superior pole of the patella to a point 2 finger-breadths below the tibial tubercle. Patients in the minimally invasive cohort underwent a less-invasive approach using a short midline incision (less than 15 cm) from the palpable superior pole of the patella to a point just medial to the tibial tubercle. An underlying midvastus arthrotomy without patellar eversion was used for exposure.⁷

The standard surgeries were completed with the traditional Natural-Knee II instrumentation, whereas the minimally invasive surgeries were performed with newly designed minimally invasive instrumentation. All surgeries used a standard femoral component design matched with ultracongruent posterior-stabilized, highly cross-linked Durasul polyethylene tibial inserts (Zimmer) and a cobalt chrome, cemented Natural-Knee II tibial baseplate (Zimmer). Highly cross-linked Durasul polyethylene patellar components also were used. All surgeries were completed with Palacos cement (Zimmer).

All patients received 1 g of cefazolin preoperatively and 1 g every 8 hours for 24 hours postoperatively. Clindamycin was used in patients with a suspected allergy to cefazolin. All patients received oral therapeutic warfarin or subcutaneous Factor Xa inhibitor (Arixtra; GlaxoSmithKline, Research Triangle Park, North Carolina) postoperatively for deep venous thrombosis prophylaxis.

The initial physical therapy protocol included 100% full weight bearing on the first postoperative day.

Cement Technique

All cementing was performed with the tourniquet inflated to 325 mm Hg. Pulse lavage irrigation with saline was used to prepare all resected surfaces of bone. Two bags of Palacos R bone cement were prepared under vacuum using the Zimmer Compact Mixer for 30 seconds. A manual pressurization technique was used prior to implantation of the tibial, femoral, and all-polyethylene patellar components.

Clinical Evaluation

The Knee Society Clinical Rating System scores and anteroposterior and lateral radiographs were obtained preoperatively and at all postoperative assessments. Postoperative assessments were completed at the initial postoperative visit, at 3 months, and annually thereafter. The eClinical Outcomes Program (Zimmer Holdings, Warsaw, Indiana) was used to monitor clinical progression and outcomes.

Radiographic Evaluation

Preoperatively, anteroposterior, lateral, and Bell-Thompson standing radiographs were obtained. Postoperatively, supine anteroposterior and lateral radiographs were obtained at all visits. All anteroposterior and lateral radiographs were reviewed by a fellowship-trained musculoskeletal radiologist for the purpose of reporting. Radiolucencies around the implant–cement–bone interfaces were assessed according to Ewald's zones.⁴ Radiographic signs of cement voids (absence of cement) and cement debris were recorded on both radiographic views.

RESULTS

Clinical Results

Mean preoperative Knee Society Clinical Rating System scores were similar for the standard and minimally invasive groups with no statistically significant differences. All femoral, tibial, and patellar components were clinically successful.

No femoral, tibial, or patellar components were revised for loosening, instability, thigh pain, or osteolysis in either group. No acute postoperative infections were observed in either group.

Radiographic Results

All radiographs demonstrated signs of radiographic stability at latest follow-up (mean, 3.3 and 2.1 years for the standard and minimally invasive groups, respectively). No cases were observed of excessive varus or valgus alignment (range, 3°–8°); no evidence was found of component migration or subsidence. No gross polyethylene wear or osteolysis was recorded at latest follow-up in either cohort. Although alignment, migration, and wear were all similar in the 2 groups, statistically significant differences were noted with regard to lucent lines at the bone–cement interface, cement voids, and the presence of cement debris on postoperative radiographs.

Compared with the standard cohort, the minimally invasive cohort demonstrated a significant increase in the presence of cement voids, which were primarily located in zones 1 and 4 as described by Ewald,⁴ representing the anterior flange and the posterior condyles (Figure 1). The minimally invasive cohort also had a higher incidence of cement debris retained after surgery, typically located in the peripatellar (Figure 2) and along the lateral side of the tibia (Figure 3). The radiographic results for both groups are summarized in Table 2.

DISCUSSION

The benefits of minimally or less-invasive techniques used in TKA remain unproven. Questions regarding whether limitations in exposure may lead to component malalignment have been studied,^{1,8} but objective evaluation of whether cement fixation is compromised has not been examined in the literature. In the current study, the cement technique results obtained by a single surgeon using

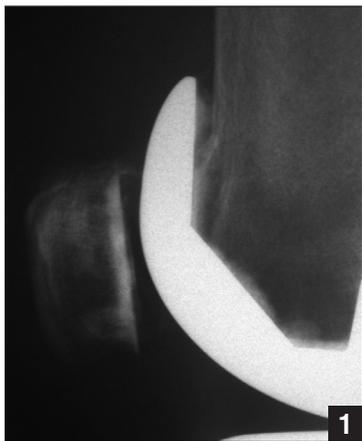


Figure 1: Postoperative lateral radiograph of the distal femur after minimally invasive total knee arthroplasty showing anterior femoral cement voids in zone 1.

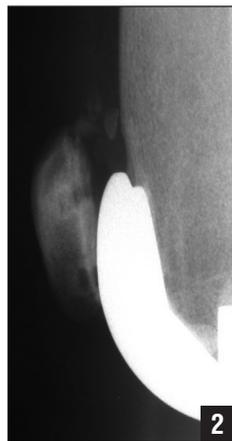


Figure 2: Postoperative lateral radiograph of the patella after minimally invasive total knee arthroplasty showing peripatellar cement debris.

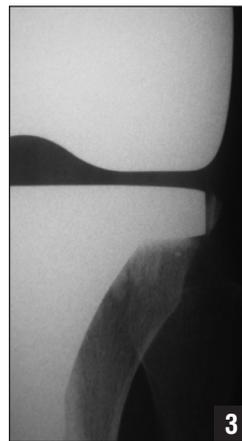


Figure 3: Postoperative anteroposterior radiograph of the knee after total knee arthroplasty in the minimally invasive group showing lateral tibial cement debris.

body polyethylene wear.¹³ In addition, the current study’s results suggest that this decreased exposure can result in cement voids around the femoral component anterior flange and posterior condyles, which may result in premature femoral component loosening. Based on their surgical experience, the current authors would have predicted anterior femoral cement voids in the minimally invasive cohort due to the limited proximal exposure from the smaller incision, intact quadriceps tendon/ extensor mechanism, and no intraoperative patellar eversion.

This study had several limitations. First, no predetermined sample size was defined by a power analysis. Fifty patients were chosen as a convenience sample that seemed to provide enough patients to ensure proper sampling. Also, the midvastus approach may not represent the most common minimally invasive approach because recent studies have used the subvastus approach.^{14,15} In this study, the midvastus approach was chosen because the senior author was already using it as part of a larger ongoing study. With regard to sample selection, although the patients in both groups shared similar demographic characteristics, the standard group included more complex patients. Although this could introduce bias in regard to clinical and long-term outcomes, the varying exclusion criteria would be unlikely to bias radiographic results.¹⁶

Strengths of this study included the prospective nature of the experimental group and its comparison with a historic control to avoid selection bias. Also, the use of a blinded, musculoskeletal fellowship-trained radiologist decreased bias associated with reading the postoperative radiographs.

CONCLUSION

Although this study presents possible pitfalls to less-invasive surgical techniques, the authors are not advocating the abandonment of such techniques. This study was conducted to guide further investiga-

bone cement in its intraoperative application has not significantly changed since Harris’ description of third-generation cement technique.¹⁰ A proper cement technique is thought to lead to decreased incidence of component loosening and increased longevity of the prosthesis.¹¹ The importance of cement technique to the success of TKA is highlighted by the fact that the Knee Society has put forth an approved method for the evaluation of the cement technique as described by Ewald.⁴

Less-invasive techniques may offer a potential opportunity for accelerated patient recovery, but at what risk?¹² The current study suggests that decreased visualization at the time of minimally invasive TKA may affect the resulting cement mantle. Moreover, the findings in the minimally invasive cohort, namely an increase in cement voids and retained cement debris, may lead to increased osteolysis and increased third-

Table 2

Radiographic Results for Standard and Minimally Invasive TKA Techniques

Radiographic Finding	Standard	Minimally Invasive
Femur		
Cement debris	4	0
Lucent lines	0	3
Cement voids	4	24
Tibia		
Cement debris	7	9
Lucent lines	2	7
Cement voids	0	0
Patella		
Cement debris	0	4
Lucent lines	0	0
Cement voids	0	0

Abbreviations: TKA, total knee arthroplasty.

a less-invasive midvastus approach and a standard medial parapatellar approach were compared radiographically.

Cement remains the gold standard for fixation in TKA.⁹ Despite revolutionary changes in joint replacement technology for the treatment of hip and knee arthritis, the use of polymethylmethacrylate

tions into how this selected technique can be improved in the appropriately selected patients. Long-term studies are needed to elucidate the clinical relevance of our radiographic findings. In addition, technological development of new instrumentation and new cement techniques may assist in avoiding the drawbacks of less-invasive surgical techniques highlighted by this study. 

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