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Authors

Tomek, Ivan M
Kantor, Stephen R
Cori, LuAnne A
et al.

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Early Patient Outcomes After Primary Total Knee Arthroplasty with Quadriceps-Sparing Subvastus and Medial Parapatellar Techniques

A Randomized, Double-Blind Clinical Trial

Ivan M. Tomek, MD, FRCS(C), Stephen R. Kantor, MD, LuAnne A. Cori, BA, Jennifer M. Scoville, BS, Margaret R. Grove, MS, Tamara S. Morgan, MA, Ishaan Swarup, MD, Wayne E. Moschetti, MD, MS, and Kevin F. Spratt, PhD

Investigation performed at the Department of Orthopaedics, Dartmouth-Hitchcock Medical Center, Lebanon, New Hampshire

Background: Techniques that reduce injury to the knee extensor mechanism may cause less pain and allow faster recovery of knee function after primary total knee arthroplasty. A quadriceps-sparing (QS) subvastus technique of total knee arthroplasty was compared with medial parapatellar arthrotomy (MPPA) to determine which surgical technique led to better patient-reported function and less postoperative pain and opioid utilization.

Methods: In this prospective, double-blind study, 129 patients undergoing total knee arthroplasty were randomized to the QS or the MPPA group after skin incision. All surgical procedures utilized minimally invasive surgery principles and standardized anesthesia, implants, analgesia, and rehabilitation. The Knee Society Score (KSS) was obtained at baseline and one and three months after surgery. Weekly telephone interviews were used to collect patient-reported outcomes including ambulatory device use, the UCLA (University of California Los Angeles) activity score, performance of daily living activities, and opioid utilization.

Results: No differences between groups were seen in opioid utilization, either during the acute hospitalization or in the eight weeks after surgery. The QS group reported significantly less pain at rest on postoperative day one and with activity on day three ($p = 0.04$ for each). Compared with baseline, both groups showed significant improvements in the KSS at one month (MPPA, $p = 0.0278$; QS, $p = 0.0021$) and three months ($p < 0.0001$ for each) as well as week-to-week gains in walking independence through five weeks after surgery. Independence from ambulatory devices outside the home lagged behind independence indoors by about two weeks in both groups.

Conclusions: When primary total knee arthroplasty was performed with contemporary minimally invasive surgery principles and standardized implants, anesthesia, and postoperative pathways, the QS technique yielded no significant early functional advantages or differences in opioid utilization compared with the MPPA technique. However, the mean pain scores reported by patients in the QS group were slightly lower at rest on postoperative day one and during activity on day three.

Level of Evidence: Therapeutic Level I. See Instructions for Authors for a complete description of levels of evidence.

Peer Review: This article was reviewed by the Editor-in-Chief and one Deputy Editor, and it underwent blinded review by two or more outside experts. It was also reviewed by an expert in methodology and statistics. The Deputy Editor reviewed each revision of the article, and it underwent a final review by the Editor-in-Chief prior to publication. Final corrections and clarifications occurred during one or more exchanges between the author(s) and copyeditors.

Techniques that reduce injury to the knee extensor mechanism may cause less pain and allow faster recovery of knee function after primary total knee arthroplasty[1]. The most common total knee arthroplasty technique, as reported in national joint registries, is medial parapatellar arthrotomy (MPPA)[2], as it provides excellent exposure in both primary

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and revision procedures. Quadriceps-sparing (QS) techniques, such as the subvastus approach, avoid incising the quadriceps muscle or tendon by retracting the knee extensor muscles laterally[3]. However, a QS technique can be more difficult in stiff knees or muscular patients, and there is a learning curve for surgeons new to the technique[1,4].

Systematic reviews have indicated that the quality of published trials is poor and no one technique can be considered superior on the basis of the available evidence[2,5]. Most studies were uncontrolled, retrospective case series with small sample sizes, utilizing a variety of outcome measures that were usually not patient-reported[6]. In the few existing randomized trials, important variables known to influence postoperative function, pain, and duration of hospital stay after total knee arthroplasty were ignored in the study design. Such design flaws include the lack of clearly defined patient selection criteria; nonstandardized anesthesia, analgesia, and rehabilitation protocols; and adherence to minimally invasive surgery (MIS) principles in the treatment group but not the control group[2,4,7,8].

The present randomized, controlled, double-blind study was designed to compare early outcomes after primary total knee arthroplasty performed with an MPPA or a QS technique, eliminating between-group differences in the use of contemporary minimally invasive surgery principles, patient selection, and protocols relating to anesthesia, analgesia, and rehabilitation. The primary outcomes of interest were early postoperative pain, opioid utilization, and functional recovery.

Materials and Methods

This study was approved by our institutional ethics review board and was registered with ClinicalTrials.gov (NCT00633113; the "Minimally Invasive Knee Replacement Outcome Study [MIKRO]").

Enrollment and Randomization

The power and sample size estimation was based on historical data comparing the Knee Society Score (KSS) in patients undergoing total knee arthroplasty with a mini-midvastus technique compared with standard MPPA[6]. Setting the power at 0.80, the type-I error rate at 0.05 with two-tailed testing, and the effect size at 0.50 as suggested by the results of that study, we calculated that a sample size of sixty patients in each group was required. We therefore decided to enroll seventy patients per group to allow for patient attrition.

Patients who met the inclusion and exclusion criteria (see Appendix) reviewed a one-page pictorial decision aid describing the two total knee arthroplasty techniques. Patients who agreed to participate signed the study consent form in the presence of a research staff member. Randomization of patients to the treatment groups was stratified by surgeon, with equal numbers in each treatment arm randomly ordered in blocks of four and six, with the ordering of these blocks randomized. A total of 100 treatment assignments were created for each surgeon; each was printed on paper and placed in a numbered, opaque envelope. After the skin incision, the circulating nurse opened the envelope to reveal the surgical technique.

Surgical Techniques

Preemptive multimodal analgesia and anti-nausea protocols consisted of 200 mg of celecoxib, 1000 mg of acetaminophen, and 10 mg of sustained-release oxycodone on the morning of surgery. Intraoperatively, patients received 12.5 mg of dolasetron intravenously, which was continued during the hospitalization according to the protocol. A standardized spinal anesthetic, 2 mL of 0.75% bupivacaine with dextrose, was offered to all patients. A single-shot femoral nerve block with 30 mL of 0.5% bupivacaine, 2.5 μg/mL of epinephrine, and 50 μg of clonidine was administered preoperatively utilizing ultrasonographic guidance. A general endotracheal anesthetic was utilized for patients who declined the spinal anesthetic or in whom the spinal anesthetic did not function adequately. Patients who declined the femoral nerve block or spinal anesthetic were not withdrawn from the study, but all deviations from the standard protocols were recorded and were reported to the Data Safety and Monitoring Board.

TABLE I Contemporary Minimally Invasive Total Knee Arthroplasty Principles*

Smaller incision (≤15 cm, measured in knee extension)
Patella subluxated laterally rather than everted
Tibial and femoral cuts made in situ or with knee subluxation, not dislocation
Use of low-profile minimally invasive total knee arthroplasty instrumentation

*These principles were adhered to for both treatment groups in the study.

Minimally invasive surgery principles were adhered to during all arthroplasty procedures (Table I). Incisions were measured and were limited to ≤15 cm in full knee extension, but the surgeon had discretion to enlarge or alter the surgical exposure as necessary. In the MPPA group, the quadriceps tendon was incised longitudinally along its medial edge sufficiently to allow lateral patellar subluxation, leaving a cuff of approximately 5 mm that allowed tendon-to-tendon repair. In the QS group, a subvastus approach was used; the vastus medialis was mobilized and was bluntly separated from the intermuscular septum, allowing its retraction laterally.

The Legacy Posterior Stabilized (LPS) total knee arthroplasty system (Zimmer, Warsaw, Indiana), tobramycin-containing Simplex polymethylmethacrylate cement (Stryker Orthopaedics, Mahwah, New Jersey), and small-profile instrumentation were used in all procedures. An MIS tibial component was used, augmented with a modular stem in cases of poor bone quality. The LPS-Flex Femur and Flex polyethylene insert were used. The LPS Sex Specific femur was used when the femoral trial revealed implant overhang at the medial or lateral edges of the femoral condyle.

Postoperative Care

Warfarin was used for thromboprophylaxis except when individual patient characteristics warranted alternative agents. A patient-controlled analgesia pump delivering hydromorphone or morphine on demand, with no background infusion, was started in the post-anesthesia care unit and was discontinued on the morning of the first postoperative day. Thereafter, a short-acting oral analgesic (oxycodone or hydromorphone) as well as a sustained-release oral analgesic (oxycodone or morphine) were used. Each morning during the hospitalization, a research staff member blinded to the surgical randomization visited patients and asked them to rate their pain level at rest and with activity on a 0-to-10 numerical scale.

Pain medication usage for each patient was determined from the patient-controlled anesthesia record and the medication nursing record. Although some minor variations exist among published conversion formulas, all opioid doses in the present study were converted to oral morphine equivalents as indicated in the Appendix[9,10]. For intravenous and intramuscular administration of codeine, hydromorphone, meperidine, and fentanyl, doses were first converted to the parenteral form of morphine with use of the appropriate conversion factor before being multiplied by a factor of three to convert to oral morphine equivalents.

A continuous passive motion machine and sequential compressive devices were utilized during the acute hospitalization. A standardized physical therapy protocol began on postoperative day one, and patients were encouraged to walk three times daily with supervision from nursing staff or their family. Patients were discharged from the hospital, according to standardized discharge

TABLE II Patient Characteristics at Baseline

Characteristic	QS Group, N = 62	MPPA Group, N = 65	P Value*
Age† *(yr)*	63.7 (9.7)	64.8 (9.3)	0.572
Female sex *(%)*	62.3	67.7	0.525
White race *(%)*	96.4	100	0.335
Living alone *(%)*	21.9	21.2	0.939
Post-high school education *(%)*	81.5	72.9	0.278
Never smoked *(%)*	34.6	51.7	0.066
Body mass index† *(kg/m²)*	30.7 (6.4)	30.3 (6.5)	0.759

*The Student t test was used for comparisons involving mean values, and the chi-square test was used for comparisons involving percentages. The p values have not been adjusted to account for testing of multiple hypotheses (which increases the probability of a type-I error), as not correcting for multiplicity is a more conservative approach in this case because retention of the null hypothesis was considered evidence for successful randomization. †The values are given as the mean, with the standard deviation in parentheses. ‡The values are given as the mean, with the standard error in parentheses.

criteria relating to mobility and safety, either to home or to an acute rehabilitation hospital, skilled nursing facility, or nursing home.

Functional Outcome Assessments

The KSS was obtained preoperatively for all patients, and a clinician blinded to the treatment assignment obtained the KSS again after examining each patient during clinic visits at one and three months postoperatively. In addition, research staff blinded to the treatment assignment conducted weekly telephone interviews during the first eight weeks after surgery, collecting data in a patient diary developed for the study. Such a methodology, which has been used in other musculoskeletal clinical trials, allows earlier and more frequent collection of patient-reported data after a surgical intervention[11].

The Independence from Ambulatory Devices Score (IADS) was developed for this study as a means of quantifying patient-reported daily use of ambulatory devices (see Appendix). The IADS instrument generates a score that can range from 0 to 10, with higher values reflected greater independence from assistive devices. Separate scores reflecting walking within the home and outside the home were calculated on the basis of each patient's self-reported use of ambulatory devices (see Appendix). The daily ratings of device use for each setting were then aggregated within each week.

Leisure activity after the primary total knee arthroplasty was assessed with use of the patient-reported UCLA (University of California Los Angeles) activity score[12,13] (see Appendix); although this instrument was designed for use by patients who had undergone hip resurfacing, it has been used extensively in assessing arthroplasty outcomes. Patients self-rated their participation in leisure activities every day of the week, and a mean weekly score was calculated as long as scores were reported on at least four days).

Activities of daily living were assessed with use of seven patient-reported questions regarding the ability to bathe, cook, dress, drive, take stairs, and get in and out of a bed and chair (see Appendix). Each activity was scored on a 6-point Likert difficulty scale. Patients rated their performance of activities of daily living each day during the eight weeks after surgery. A mean daily score was calculated as long as at least four activities were scored. When divided by five (the highest possible score) and then multiplied by 100, the possible range of the daily score was from 0 to 100, with higher scores reflecting greater proficiency in performing the activities.

Adverse Events

Adverse events that occurred intraoperatively and in the eight weeks after surgery were recorded by research staff and were classified with use of currently accepted guidance on reporting risks[14]. The events were first categorized according to relatedness to the study intervention as "unrelated," "possibly related," or "probably related." They were also categorized according to whether they were "serious" or "not serious" and whether they were "expected" or "unexpected." All events were reported to the Data Safety and Monitoring Board, which met biannually. Serious and unexpected adverse events related to treatment were reported to the institutional review board.

Statistical Analysis

Patient demographics were summarized with use of means, standard deviations, and counts (for continuous outcomes) or with use of frequencies (for categorical outcomes). Baseline differences between the two treatment groups were evaluated with use of a general linear model (for continuous variables) or with use of the chi-square test (for categorical variables). The reliability of the three outcome measures was evaluated on the basis of the internal consistency of the responses from weeks five to eight by calculating appropriate intraclass correlation coefficients (ICCs) according to generalizability theory methods summarized by Shrout and Fleiss[15].

Longitudinal mixed-model regression was used to evaluate changes across the first eight weeks in opioid utilization, the KSS, and the patient-reported IADS, UCLA activity score, and activities of daily living score. If a baseline difference between treatment groups was observed, that factor was included in the model as a covariate. The primary objective was exploring the treatment-by-time interaction between the two treatment groups. The models were evaluated with use of the SAS (SAS Institute, Cary, North Carolina) GLIMMIX procedure.

Source of Funding

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Results

Patient Characteristics, Randomization, and Compliance with Protocols

The study included 129 patients randomized to undergo primary total knee arthroplasty with use of one of the two techniques from January 2008 to August 2010. Table II summarizes patient baseline demographics by treatment group. Perioperative data on 128 patients and outcomes data on 127 patients were available, as one patient was withdrawn when daily opioid use was discovered and a second patient was withdrawn postoperatively because of hearing problems (Fig. 1).

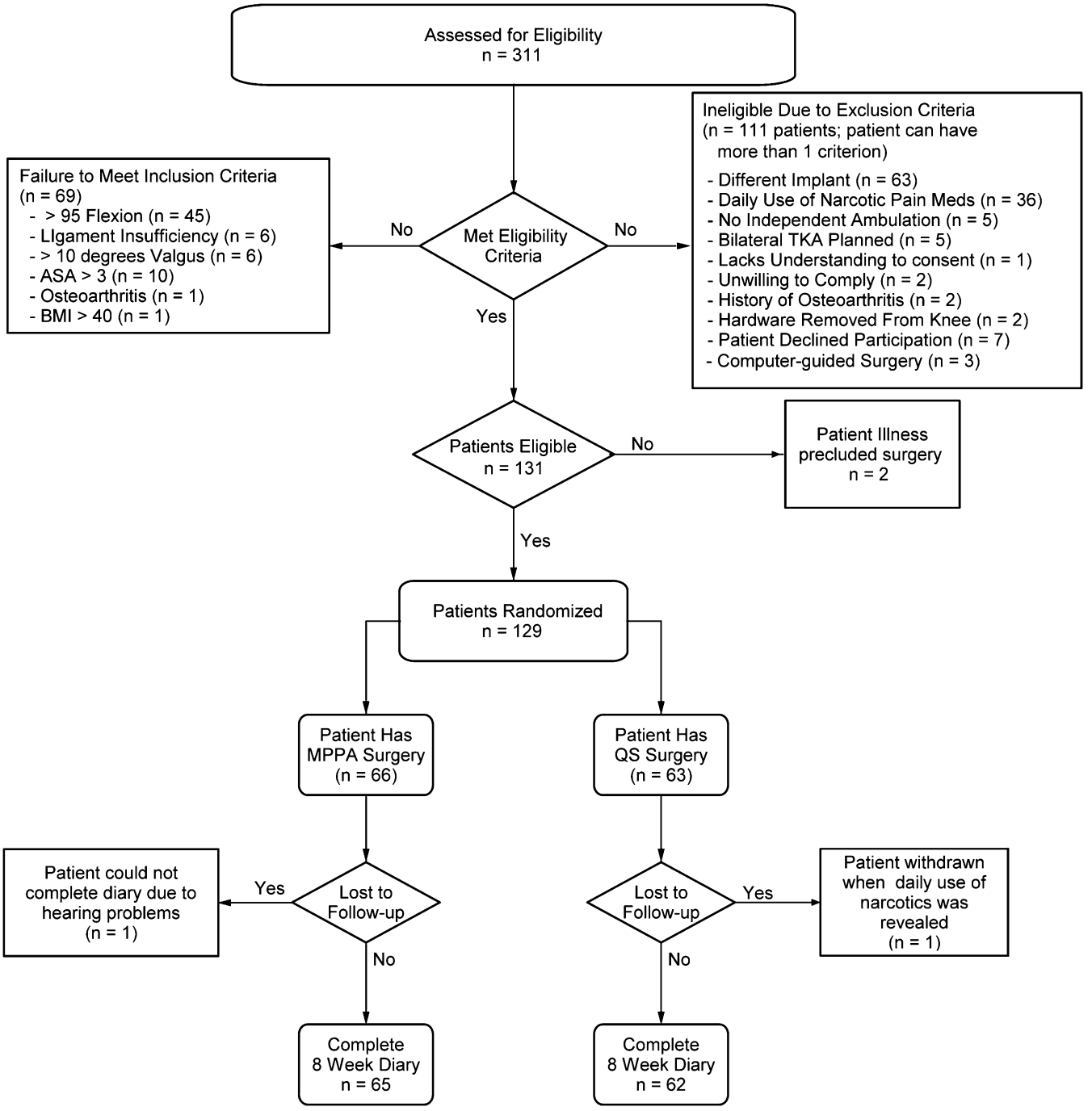

Fig. 1

CONSORT (Consolidated Standards of Reporting Trials) flow diagram for the MIKRO study. ASA = American Society of Anesthesiologists, BMI = body mass index, and TKA = total knee arthroplasty.

Most patients in the MPPA group (72%, forty-seven of sixty-five) and the QS group (77%, forty-eight of sixty-two) adhered to the study anesthesia protocols and had both a standard spinal and a standard femoral nerve block with no additional anesthesia ($p = 0.51$). Overall, general anesthesia was used in 23% (fifteen) of the patients in the MPPA group compared with 23% (fourteen) of the patients in the QS group ($p = 0.95$). There was no significant difference in anesthetic protocol adherence between the two groups.

Deviation from the randomized surgical technique occurred during one procedure; a male patient required a conversion from a QS to an MPPA technique to achieve adequate surgical exposure. Consistent with the intent-to-treat philosophy, this patient was analyzed in the QS group to which he had

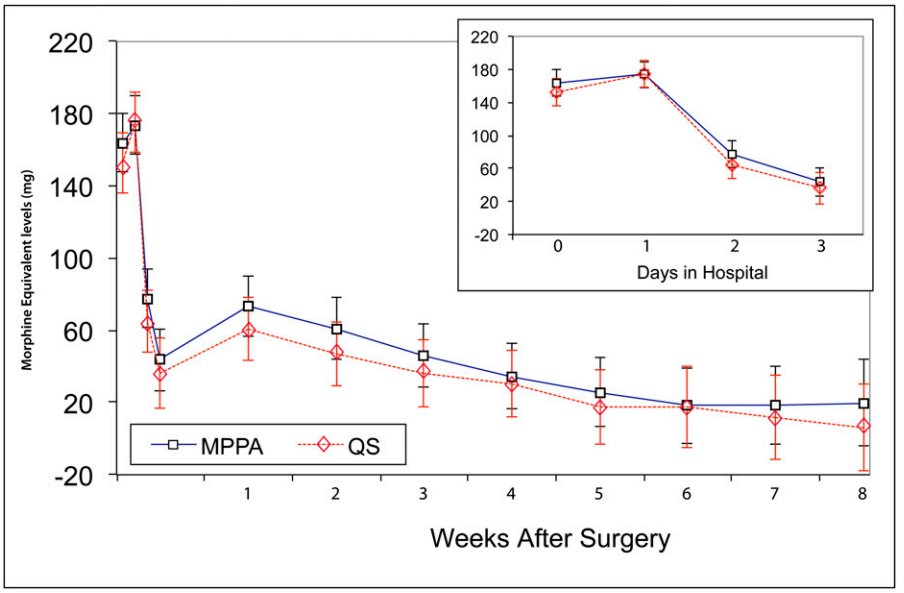

Fig. 2
Oral morphine equivalents administered in the first three days (inset) and the first eight weeks after surgery in the QS and MPPA groups. The error bars indicate the standard deviation.

been randomized. A post hoc analysis indicated no change in the inferences drawn from the results when that patient's treatment classification was changed to MPPA in an as-treated analysis.

Pain Scores and Analgesia Requirements

Pain scores at rest were significantly lower in the QS group on postoperative day one ($p = 0.04$) but not on days two or three. Pain scores with activity were significantly lower in the QS group on postoperative day three ($p = 0.04$) but not on days one or two (Table III).

Opioid medications in the first three postoperative days showed the highest requirements on the day after surgery, with no significant differences between the two approaches (Fig. 2). The pattern of opioid utilization was similar in the two treatment groups and demonstrated a significant decrease in use during each of the first five weeks after surgery ($p < 0.0001$). None of the pairwise differences in the daily mean analgesic requirement were significant at any of the eight time intervals.

KSS

Differences in the KSS between treatment groups were significant ($p = 0.014$) at baseline but not at one and three months postoperatively. Each treatment group showed significant gains from baseline in the KSS at one and three months (Fig. 3).

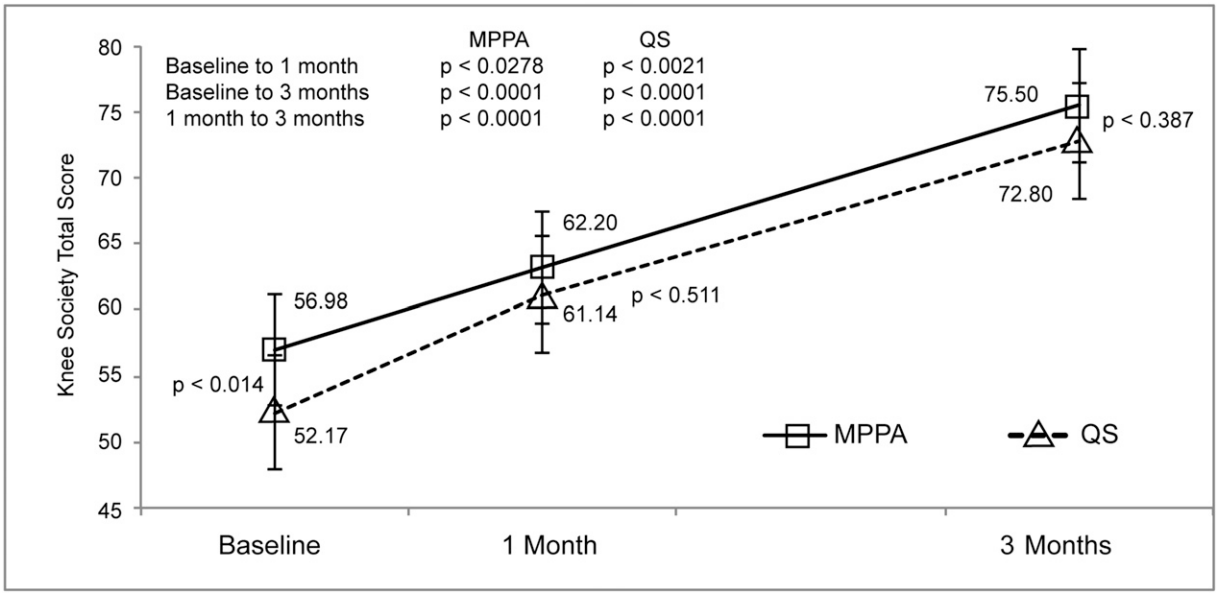

Fig. 3
Patient-reported KSS at baseline and one and three months after surgery in the QS and MPPA groups. The error bars indicate the standard deviation.

TABLE III Patient-Reported Pain Scores on Postoperative Days One, Two, and Three*

	Pain at Rest					Pain with Movement				
	MPPA Group, N = 66		QS Group, N = 62			MPPA Group, N = 66		QS Group, N = 62		
Day	Mean†	P Value	Mean†	P Value	P Value‡	Mean†	P Value	Mean†	P Value	P Value‡
1	3.64 (0.279)		2.79 (0.288)		0.0358	6.18 (0.308)		5.35 (0.318)		0.0623
2	2.77 (0.279)		2.50 (0.288)		0.4969	5.83 (0.308)		5.29 (0.318)		0.2215
3	2.16 (0.289)		2.14 (0.310)		0.9516	5.10 (0.318)		4.15 (0.341)		0.0424
1 vs. 2		0.0043		0.3485			0.2389		0.8324	
1 vs. 3		0.0000		0.0483			0.0005		0.0003	
2 vs. 3		0.0490		0.2703			0.0169		0.0006	

*Although one patient was not able to complete the diary, resulting in n = 65 for the outcomes following hospital discharge in the MPPA group, in-hospital data were available for all patients. †The values are given as the mean, with the standard error in parentheses. ‡For the difference between treatment groups.

Other Outcomes

None of the pairwise differences between treatment groups were significant for the IADS in or outside the home at any of the eight weekly time intervals (Fig. 4). The general and often significant improvement in these scores over time was considered important evidence for the validity of the IADS instrument, as was the clear discrimination between the scores in and outside the home. The IADS reported inside the home was significantly higher than the score reported outside the home ($p = 0.0001$). The score outside the home initially lagged behind the in-home score by approximately two weeks, but this gap narrowed to less than a one-week difference at eight weeks. Walking ability in both settings, as measured with the IADS, improved significantly ($p < 0.001$) during the first five weeks after surgery and for both treatment groups; the improvement in each treatment group then slowed, and additional week-to-week gains were not significant.

The UCLA leisure activity score and the activities of daily living score demonstrated significant improvement across the first eight weeks after surgery ($p < 0.0001$) but no significant differences between the two treatment groups (see Appendix). The differences between the two treatment groups at the weekly assessments were quite small and were always smaller than the measurement error associated with the instrument.

The reliability estimates for the IADS, UCLA activity, and activities of daily living outcomes, as assessed with the ICC, were adequate and were similar across these four outcomes (see Appendix). Reliability estimates were markedly lower in the first four weeks after surgery compared with the following four weeks, as the earlier functional scores tended to be more heterogeneous.

There were no significant differences between the treatment groups with respect to the rates of adverse events during the first eight weeks after surgery (Table IV).

Of the 127 patients, 14% (nine of sixty-five) in the MPPA group and 15% (nine of sixty-two) in the QS group were discharged to institutional care (rehabilitation hospital, skilled nursing facility, or nursing home) ($p = 0.92$); all others were discharged to their home.

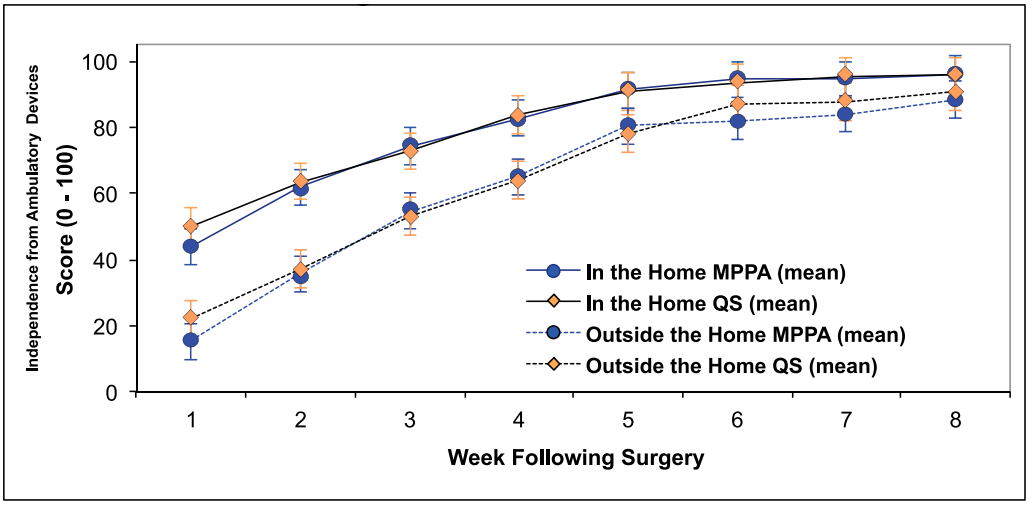

Fig. 4

Patient-reported IADS, inside and outside the home, in the first eight weeks after surgery in the QS and MPPA groups. The error bars indicate the standard deviation.

TABLE IV Adverse Events (Including Surgical Complications) in the First Eight Weeks After Surgery*

Event†	No.	QS Group, N = 62 (%)	MPPA Group, N = 65 (%)	RR for QS Relative to MPPA†	95% CI
Intraoperative event					
Changed surgical technique	1	1.61	0.00		
Patellar tendon laceration	3	1.61	3.08	0.524	0.049 to 5.636
Femoral IM guide stuck in femur	2	1.61	1.54	1.048	0.067 to 16.398
Hematuria with Foley insertion	1	1.61	0.00		
Patellar button had to be reglued	1	0.00	1.54		
Knee drain inadvertently pulled out	1	0.00	1.54		
TEP adverse event‡					
Acute myocardial infarction	0	0.00	0.00		
Pneumonia	2	1.61	1.54	1.048	0.067 to 16.398
Sepsis/septicemia	0	0.00	0.00		
Death	0	0.00	0.00		
Surgical site bleeding	5	4.84	3.08	1.573	0.272 to 9.095
Wound infection (cellulitis)	2	3.23	0.00		
Pulmonary embolism	0	0.00	0.00		
Mechanical complication	0	0.00	0.00		
Periprosthetic joint infection	0	0.00	0.00		
Readmission for any cause	6	3.23	6.15	0.524	0.100 to 2.761
Other event					
To OR for knee manipulation	10	6.45	9.23	0.699	0.207 to 2.359
Transfusion	6	4.84	4.62	1.048	0.220 to 4.999
ICU admission	1	1.61	0.00		
Urinary tract infection	2	1.61	1.54	1.048	0.067 to 16.398
Deep venous thrombosis	1	0.00	1.54		
Stroke (CVA)	1	0.00	1.54		
Depression	3	1.61	3.08	0.524	0.049 to 5.636
Bleeding (other than at surgical site)	4	3.23	3.08	1.048	0.152 to 7.215
Ileus	2	0.00	3.08		
Renal insufficiency	4	3.23	3.08	1.048	0.152 to 7.215

*RR = relative risk, CI = confidence interval, IM = intramedullary, TEP = Technical Expert Panel, OR = operating room, ICU = intensive care unit, and CVA = cerebrovascular accident. †Since the 95% CIs around the RR all include 1.00, this indicates that none of the RRs for the comparisons between the treatment groups was significant (with type-I error set at 0.05). ‡TEP events are postoperative adverse events defined by the Technical Expert Panel, Yale University, for the Centers for Medicare & Medicaid Services in 2010. The ten indicated event types are intended to represent quality-of-care indicators for primary total knee and hip arthroplasty (https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/MMS/downloads/MMSHipArthroplastyTotalKneeArthroplastyTEP.pdf).

Discussion

It has been suggested that use of a QS technique in primary total knee arthroplasty results in faster postoperative recovery and less pain compared with a technique that incises the quadriceps tendon or muscle[16,17]. Our study demonstrated no significant difference between the two techniques with respect to postoperative opioid utilization in the first eight weeks after surgery and the KSS at one and three months. There were no significant differences in the eight weekly assessments of patient-reported functional outcomes, including the use of ambulatory devices, participation in recreational activity, and the ability to carry out activities of daily living. Previous studies have indicated variable results, with some suggesting better early KSS results in patients who had undergone a minimally invasive or quadriceps-sparing technique[6,7]. However, these studies were typically retrospective and nonrandomized.

Our finding that the surgical technique had no significant effect on early recovery of knee function after total knee arthroplasty is contrary to that of Bridgman et al., who performed a Level-I clinical trial utilizing multiple clinical outcome measures to evaluate the same two techniques over a one-year period after surgery[1]. The subvastus patient group in that study had significantly better function at one week, six weeks, and one year postoperatively. However, certain methodological considerations in that study may reduce the weight of the study conclusions. Unlike the present study, the anesthesia, analgesia, and rehabilitation protocols were not standardized and were left to the discretion of the individual surgeons, each of whom adhered to

their "standard care pathway and practice." Patients were not blinded to the surgical technique, and the authors did not indicate whether the seven participating surgeons employed minimally invasive surgery principles[1].

We are aware of no prospective study comparing functional results of total knee arthroplasty involving a QS subvastus approach compared with an MPPA technique that was standardized with respect to use of minimally invasive surgery principles. Several studies have been performed to compare "conventional" total knee arthroplasty using an MPPA technique with total knee arthroplasty using minimally invasive surgery principles and a QS subvastus or midvastus technique. These have suggested that a "minimally invasive" subvastus and/or midvastus technique has an early advantage compared with a "conventional" MPPA technique with respect to early walking, function, and a diminished need for ambulatory devices[4,7,8]. For instance, a relatively small prospective study compared minimally invasive surgery involving a QS subvastus technique with conventional MPPA, in a mixed group of patients undergoing unilateral and bilateral total knee arthroplasty[17], and noted approximately 12° more knee flexion at ten days in the subvastus group (87.3° compared with 99.2°, $p = 0.004$). There was no significant difference between the groups when flexion was compared at six weeks, and there were no other significant functional differences. The results of another prospective but nonrandomized study[16] also suggested that avoiding incision of the quadriceps tendon may be beneficial. In a group of patients treated with QS total knee arthroplasty, those with a smaller incision of the quadriceps tendon fared better with respect to early walking compared with patients with a longer incision (≥3 cm). However, other studies have indicated no significant difference[18]. The comparison between groups differing with respect to two independent variables—the total knee arthroplasty technique and the use of minimally invasive surgery principles—makes the conclusions of such studies somewhat unclear. Therefore, one may question whether the observed effect is due to the minimally invasive surgery principles or the surgical technique.

Postoperative pain management is important to the success of knee arthroplasty, and pain is an important outcome measure[19]. The authors of several studies have claimed that a subvastus approach results in less pain and narcotic consumption in the immediate postoperative period[20-23]. However, these studies did not adhere to stringent documentation of pain medication consumption over an extended time period, extrapolated pain scores from patient-reported data, and did not adhere to minimally invasive surgery principles. In a prospective randomized trial reporting the WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) pain score, SF-36 (Short Form-36) physical function, and EQ-5D (EuroQol-5D) utility and pain scores, there were no significant differences in pain or analgesic utilization over the first seven days of hospitalization[1]. The present study generally corroborates these findings.

The strengths of the present study include its rigor (utilizing a prospective, randomized, double-blind, controlled design) and its reliance on standardized protocols (for enrollment, perioperative care, and postoperative surveillance). There was little patient dropout or attrition. The KSS, the primary outcome measure in this study, was completed by a clinician blinded to treatment assignment rather than by the surgeon, likely giving a more accurate representation of the actual outcomes than in studies in which outcome measures were surgeon-reported. The secondary outcome measures were all patient-reported. A post hoc analysis of the IADS was performed and suggested that the sample size was sufficient to demonstrate significance. The standard deviations associated with the outcomes were large, likely reflecting patient-to-patient variation in regaining independent walking in the first few weeks after total knee arthroplasty.

The two treatment groups showed equivalently low rates of infection, deep venous thrombosis, and readmission to the hospital. The rate of manipulation under anesthesia was high in both groups, likely because the surgeons involved in the study typically performed manipulation if a patient treated with total knee arthroplasty had not attained 90° of active flexion at the normal six-week follow-up visit. Since patients in the present study were seen at four rather than six weeks, it is possible that this threshold to perform manipulation was applied too early and that some of the patients would have ultimately achieved good knee motion with their own sustained physical therapy efforts.

A limitation of this study involves the number of patients in each treatment group, which was still relatively small. In addition, the race of nearly all enrolled patients was white and most patients were well educated, so the generalizability of our results may be of concern.

On the basis of the findings of the present study, we believe that there is no reason to preferentially recommend either the QS or the MPPA technique for primary total knee arthroplasty, as the two treatment groups showed essentially identical improvements in opioid utilization, postoperative knee function, walking independence, ability to perform activities of daily living, and leisure activity participation. There was a small but significant decrease in postoperative pain at rest in the QS group on postoperative day one and during activity on postoperative day three.

Appendix

(eA) Tables showing the inclusion and exclusion criteria, opiate conversion factors, reliability estimates for various outcome measures, patient diary entries used to calculate the IADS, sample IADS calculations, UCLA activity scale, and patient diary entries used to rate activities of daily living as well as figures showing the UCLA activity score and activities of daily living score over time are available with the online version of this article as a data supplement at jbjs.org. ■

Ivan M. Tomek, MD, FRCS(C)
Stephen R. Kantor, MD
LuAnne A. Cori, BA

Jennifer M. Scoville, BS
Margaret R. Grove, MS
Tamara S. Morgan, MA
Ishaan Swarup, MD
Wayne E. Moschetti, MD, MS

Kevin F. Spratt, PhD
Geisel School of Medicine at Dartmouth,
1 Rope Ferry Road,
Hanover, NH 03755.
E-mail address for T.S. Morgan: tamara.s.morgan@dartmouth.edu

References

1. Bridgman SA, Walley G, MacKenzie G, Clement D, Griffiths D, Maffulli N. Subvastus approach is more effective than a medial parapatellar approach in primary total knee arthroplasty: a randomized controlled trial. Knee. 2009 Jun;16(3):216-22. Epub 2009 Jan 09.

2. Bourke MG, Buttrum PJ, Fitzpatrick PL, Dalton PA, Jull GA, Russell TG. Systematic review of medial parapatellar and subvastus approaches in total knee arthroplasty. J Arthroplasty. 2010 Aug;25(5):728-34. Epub 2009 Aug 18.

3. Pagnano MW, Meneghini RM. Minimally invasive total knee arthroplasty with an optimized subvastus approach. J Arthroplasty. 2006 Jun;21(4)(Suppl 1):22-6.

4. King J, Stamper DL, Schaad DC, Leopold SS. Minimally invasive total knee arthroplasty compared with traditional total knee arthroplasty. Assessment of the learning curve and the postoperative recuperative period. J Bone Joint Surg Am. 2007 Jul;89(7):1497-503.

5. Khan RJK, Keogh A, Fick DP, Wood DJ. Surgical approaches in total knee arthroplasty (protocol). Cochrane Database Syst Rev. 2009;1:CD005329.

6. Laskin RS, Beksac B, Phongjunakorn A, Pittors K, Davis J, Shim JC, Pavlov H, Petersen M. Minimally invasive total knee replacement through a mini-midvastus incision: an outcome study. Clin Orthop Relat Res. 2004 Nov;428:74-81.

7. Karpman RR, Smith HL. Comparison of the early results of minimally invasive vs standard approaches to total knee arthroplasty: a prospective, randomized study. J Arthroplasty. 2009 Aug;24(5):681-8. Epub 2008 Jun 06.

8. Kim JG, Lee SW, Ha JK, Choi HJ, Yang SJ, Lee MY. The effectiveness of minimally invasive total knee arthroplasty to preserve quadriceps strength: a randomized controlled trial. Knee. 2011 Dec;18(6):443-7. Epub 2010 Sep 15.

9. Anderson R, Saiers JH, Abram S, Schlicht C. Accuracy in equianalgesic dosing. Conversion dilemmas. J Pain Symptom Manage. 2001 May;21(5):397-406.

10. Foley KM. The treatment of cancer pain. N Engl J Med. 1985 Jul 11;313(2):84-95.

11. Tosteson AN, Skinner JS, Tosteson TD, Lurie JD, Andersson GB, Berven S, Grove MR, Hanscom B, Blood EA, Weinstein JN. The cost effectiveness of surgical versus nonoperative treatment for lumbar disc herniation over two years: evidence from the Spine Patient Outcomes Research Trial (SPORT). Spine (Phila Pa 1976). 2008 Sep 1;33(19):2108-15.

12. Dahm DL, Barnes SA, Harrington JR, Sayeed SA, Berry DJ. Patient-reported activity level after total knee arthroplasty. J Arthroplasty. 2008 Apr;23(3):401-7.

13. Zahiri CA, Schmalzried TP, Szuszczewicz ES, Amstutz HC. Assessing activity in joint replacement patients. J Arthroplasty. 1998 Dec;13(8):890-5.

14. Office for Human Research Protections. Guidance on reviewing and reporting unanticipated problems involving risks to subjects or others and adverse events. 2007 Jan 15. http://www.hhs.gov/ohrp/policy/advevntguid.html#Q8. Accessed 2013 Dec 16.

15. Shrout PE, Fleiss JL. Intraclass correlations: uses in assessing rater reliability. Psychol Bull. 1979 Mar;86(2):420-8.

16. Tanavalee A, Thiengwittayaporn S, Itiravivong P. Progressive quadriceps incision during minimally invasive surgery for total knee arthroplasty: the effect on early postoperative ambulation. J Arthroplasty. 2007 Oct;22(7):1013-8.

17. Jung YB, Lee YS, Lee EY, Jung HJ, Nam CH. Comparison of the modified subvastus and medial parapatellar approaches in total knee arthroplasty. Int Orthop. 2009 Apr;33(2):419-23. Epub 2008 Jan 15.

18. Hernandez-Vaquero D, Noriega-Fernandez A, Suarez-Vazquez A. Total knee arthroplasties performed with a mini-incision or a standard incision. Similar results at six months follow-up. BMC Musculoskelet Disord. 2010;11:27. Epub 2010 Feb 06.

19. Vendittoli PA, Makinen P, Drolet P, Lavigne M, Fallaha M, Guertin MC, Varin F. A multimodal analgesia protocol for total knee arthroplasty. A randomized, controlled study. J Bone Joint Surg Am. 2006 Feb;88(2):282-9.

20. Fauré BT, Benjamin JB, Lindsey B, Volz RG, Schutte D. Comparison of the subvastus and paramedian surgical approaches in bilateral knee arthroplasty. J Arthroplasty. 1993 Oct;8(5):511-6.

21. Hofmann AA, Plaster RL, Murdock LE. Subvastus (Southern) approach for primary total knee arthroplasty. Clin Orthop Relat Res. 1991 Aug;269:70-7.

22. Matsueda M, Gustilo RB. Subvastus and medial parapatellar approaches in total knee arthroplasty. Clin Orthop Relat Res. 2000 Feb;371:161-8.

23. Roysam GS, Oakley MJ. Subvastus approach for total knee arthroplasty: a prospective, randomized, and observer-blinded trial. J Arthroplasty. 2001 Jun;16(4):454-7.