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Minimally Invasive Total Knee Arthroplasty Improves Early Knee Strength But Not Functional Performance

A Randomized Controlled Trial

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Abstract: A prospective, randomized investigation compared early clinical outcomes of total knee arthroplasty (TKA) using conventional or minimally invasive surgical (MIS) approaches (n = 44). Outcome measures included isometric quadriceps and hamstrings strength, quadriceps activation, functional performance, knee pain, active knee range of motion, muscle mass, the Short Form-36, and Western Ontario and McMaster University Osteoarthritis Index, assessed preoperatively and 4 and 12 weeks after TKA. Four weeks after TKA, the MIS group had greater hamstring strength (P = .02) and quadriceps strength (P = .07), which did not translate to differences in other outcomes. At 12 weeks, there were no clinically meaningful differences between groups on any measure. Although MIS may lead to faster recovery of strength in patients undergoing TKA, there was no benefit on longer-term recovery of strength or functional performance. **Keywords:** total knee arthroplasty, joint arthroplasty, quadriceps, muscle strength, minimally invasive surgery.

Almost 700 000 total knee arthroplasties (TKAs) are performed each year in the United States to alleviate pain and disability associated with knee osteoarthritis (OA) [1]. Future projections suggest that by the year 2030, 3.48 million TKAs will be performed annually [2]. Although TKA reliably reduces pain in patients with knee OA, quadriceps strength and function often lag behind healthy, age-matched adults many years after surgery [3]. Reductions of about 20% in walking speed and 50% in stair-climbing speed compared with age-matched groups without knee pathology have been reported a year after surgery and have been largely attributed to quadriceps weakness [3].

Quadriceps muscle weakness is most pronounced within the first month after surgery and declines 50% to 60% from preoperative values [4-6]. This early quadriceps weakness is largely explained by muscle activation failure, presumably secondary to extensive trauma to the quadriceps muscle during surgery [4,5,7]. This trauma is largely a combined result of patellar eversion, extreme knee flexion, and cutting of the quadriceps muscle and tendon to improve visualization. The eversion of the patella required for conventional TKA (often >1 hour) stretches the quadriceps by more than 16% compared with retraction of the patella, which stretches the quadriceps by only 8% [8]. In addition to patellar eversion, conventional TKA requires extreme knee flexion that further stretches the quadriceps mechanism and requires partial dissection of the quadriceps muscle or tendon. The substantial tension and trauma to the quadriceps muscle during conventional TKA may

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contribute to permanent quadriceps dysfunction, as evidenced by long-term postoperative weakness and activation failure [3,9,10].

Traditionally, successful outcomes with TKA have been measured by long-term implant performance and low revision rates, rather than a rapid recovery of function [11]. As a result, conventional TKA surgical approaches have been designed to allow for good visualization to achieve predictable primary fixation, restore alignment, optimize range of motion (ROM), and maintain ligament balance [11]. However, good visualization requires compromise of the quadriceps muscle and tendon by splitting or detaching portions of each to allow for eversion of the patella [8,10,12]. Recently, minimally invasive surgical (MIS) techniques for TKA have been introduced as promising alternatives to conventional TKA and have been purported to improve function more quickly, decrease the length of hospital stays, and reduce pain [10,11,13-19]. Compared with conventional TKA, MIS techniques use smaller skin incisions, smaller instrumentation, and avoid patellar eversion and joint dislocation [8,10,20-22]. Most importantly, these techniques avoid disruption of the extensor mechanism and suprapatellar pouch and minimize extreme knee flexion during surgery [8,10,13,20,21]. The combined effects of these modifications may diminish damage to the quadriceps muscle [4,5,7] and, therefore, decrease postoperative muscle weakness and activation failure, but there is little evidence to support these expectations.

Early retrospective cohort comparisons indicated that MIS TKA reduced hospital stays, decreased postoperative pain, and enabled patients to return to functional activities more quickly than conventional TKA [8,10,13,23-25]. More recently, small-scale randomized trials were not as universally supportive of whether the benefits of MIS TKA outweigh the risks of decreased visualization during surgery and increased length of operating time [14,17,24-26]. However, many of these studies focused on self-report and surgical outcomes without including functional performance measures or specific measures of quadriceps strength and activation. Patient self-report measures such as the Western Ontario and McMaster University Osteoarthritis Index (WOMAC) [27] or the Knee Injury and Osteoarthritis Outcome Score (KOOS) [28] do not reflect the magnitude of performance deficits present postoperatively, especially within the first 2 months after TKA [29,30]. In large part, this is because self-reported outcomes closely parallel pain relief after surgery. Therefore, investigations of TKA outcomes should include a more comprehensive combination of performance measures (including muscle strength) and self-report to more completely evaluate intervention effectiveness. Furthermore, few studies have involved blinding of both patients and evaluators (ie, because incision lengths are different between MIS and conventional TKA), and very few studies have standardized rehabilitation.

The purpose of this investigation was to evaluate the efficacy of MIS TKA in a blinded, prospective, randomized controlled trial (RCT). We hypothesized that MIS TKA would decrease quadriceps strength loss (primary outcome) and hamstrings strength loss, attenuate quadriceps activation deficits, improve functional performance, increase knee ROM, decrease postoperative knee pain, and attenuate muscle mass loss (confirmatory measures) when compared with conventional TKA surgery.

Materials and Methods

Design Overview

This was a randomized, controlled trial to evaluate potential benefits of MIS TKA. Eligible patients were randomized with concealed allocation to a MIS or conventional (CONTROL) TKA group. Randomization included stratification for sex and decade of age. Patients were assessed 1 to 2 weeks before surgery and 4 and 12 weeks after TKA at the Clinical and Translational Research Center at the University of Colorado. The study was approved by the Colorado Multiple Institutional Review Board. Informed consent was obtained from all participants.

Setting and Participants

Patients anticipating a primary, unilateral knee arthroplasty for OA aged 50 to 85 years who met the following inclusion criteria were recruited by a single surgeon between December 2006 and June 2010: (1) no significant neurologic impairments, (2) no uncontrolled hypertension, (3) minimal contralateral knee OA (as defined by pain <5/10 with activity), and (4) no other unstable lower-extremity orthopedic conditions. In addition, although only half of the patients were randomized for MIS, all patients met the additional criteria for MIS eligibility: (1) a minimum of 80° of active knee flexion; (2) no greater than 15° knee varus, 15° valgus; and (3) a body mass index (BMI) of 40 kg/m^2 or less.

Randomization and Interventions

Blocked randomization was used to assure balanced assignment of subjects to the 2 intervention groups by sex and decade of age, with random block sizes of 4, 6, or 8. Group assignment occurred after enrollment criteria were met and after the preoperative testing session. Except for the surgeon performing the TKA, patients, investigators, and treating physical therapists were all blinded to group assignment because identical skin incision lengths were used for both groups.

Surgical Approach

Both conventional and MIS TKA approaches were performed through an anterior midline incision using a medial parapatellar approach. In the CONTROL group, the incision extended from the level of the distal tibial