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Knee Extensor Strength and Gait Characteristics After Minimally Invasive Unicondylar Knee Arthroplasty vs Minimally Invasive Total Knee Arthroplasty: A Nonrandomized Controlled Trial

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ABSTRACT

Background: In light of the existing lack of evidence, it was the aim of this study to compare gait characteristics and knee extensor strength after medial unicondylar knee arthroplasty (MUKA) with those after total knee arthroplasty (TKA), given the same standardized minimally invasive surgery (MIS) approach in both groups.

Methods: Patients scheduled for MIS-MUKA or MIS-TKA as part of clinical routine were invited to participate. A posterior cruciate ligament-retaining total knee design was used for all MIS-TKA. A 3-dimensional gait analysis was performed preoperatively with a VICON system and at 8 weeks postoperative to determine temporospatial parameters, ground reaction forces, joint angles, and joint moments. At the same 2 times, isokinetic tests were performed to obtain peak values of knee extensor torque. A multivariate analysis of variance was conducted and included the main effects time (before and after surgery) and surgical group and the group-by-time interaction effect.

Results: Fifteen MIS-MUKA patients and 17 MIS-TKA patients were eligible for the final analysis. The groups showed no differences regarding age, body mass index, sex, side treated, or stage of osteoarthritis. We determined neither intergroup differences nor time × group interactions for peak knee extensor torque or any gait parameters (temporospatial, ground reaction forces, joint angles, and joint moments).

Conclusion: It is concluded that MUKA is not superior to TKA with regard to knee extensor strength or 3-dimensional gait characteristics at 8 weeks after operation. As gait characteristics and knee extensor strength are only 2 of the various potential outcome parameters (knee scores, activity scores…) and quadriceps strength might take a longer time to recover, our findings should be interpreted with caution.

Previous research rarely compared gait characteristics and knee strength in medial unicondylar knee arthroplasty (MUKA) and total knee arthroplasty (TKA). Komnik et al [1] very recently conducted a systematic review of gait analysis following different types of knee arthroplasty. They reported that only a very small number of the 87 analyzed articles dealt with UKA and recommended that future studies compare UKA and TKA with regard to gait. Of the existing studies dealing with gait characteristics in the context of MUKA [2-7], all but one [6] used either no control group [3,4,7] or compared MUKA with procedures other than TKA [2,5].

In principle, when comparing MUKA and TKA, 2 surgical factors could be assumed to interfere with each other and thus weaken the interpretation of the findings. First, potential differences in outcome between MUKA and TKA might be attributed to the different implant designs and the respective consequences (preservation of both cruciates and the remaining 2 knee compartments). Second, potential differences might be attributed to the fact that MUKA is normally performed via a minimally invasive surgical approach (MIS; mini-arthrotomy, no patella eversion, no tibiofemoral dislocation), whereas in most cases, TKA is performed via conventional anteromedial arthrotomy.

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Because of the previously mentioned lack of evidence, the present study aimed to compare gait characteristics and knee extensor strength after MUKA vs TKA, given the same standardized approach in both groups. It was hypothesized that the groups would show significant differences in terms of knee extensor strength (H1) and typical gait analysis parameters (H2, temporospatial parameters; H3, ground reaction forces; H4, knee kinematics; and H5, knee kinetics).

Materials and Methods

Applying a prospective, comparative study design, consecutive patients on the waiting list for routine MIS-MUKA or MIS-TKA were enrolled. Exclusion criteria for both groups were (1) age younger than 55 years or older than 80 years, (2) neuromuscular or neurodegenerative disease, (3) prior arthrodesis in any joint of the lower limbs (except toes II-V), (4) prior TKA on the contralateral side, (5) prior arthroplasty of the ipsilateral hip or ankle, and (6) constant need for walking aids. For the MIS-MUKA group, further exclusion criteria were (7) failed upper tibial osteotomy, (8) insufficiency of the collateral or anterior cruciate ligaments, (9) fixed varus deformity greater than 15°, (10) flexion deformity greater than 15°, and (11) rheumatoid arthritis. The study protocol was approved by the ethics committee of our medical university and was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. Written informed consent was obtained from all patients before enrollment.

All surgical procedures were performed under general or spinal anesthesia under tourniquet control and after standard antibiotic prophylaxis. In the MIS-TKA group, a midline skin incision was followed by a medial mini-midvastus arthrotomy (1-2 cm) [8]. The patella was subluxated instead of being everted. Special downsized retractors and cutting jigs were used in accordance with the operation manual for the Scorpio MIS procedure, as provided by the manufacturer [8,9]. A posterior cruciate ligament (PCL)-retaining total knee design (Scorpio CR; Stryker Corp, Kalamazoo, MI) was applied using intramedullary referencing in the femur and extramedullary referencing in the tibia. In keeping with the clinical routine at our institution, the patella was left unresurfaced. In the MIS-MUKA group, patients received the “Oxford 3” implant (Biomet Inc., Warsaw, IN). The surgical technique was as recommended in the manufacturer's surgical manual, including an anteromedial skin incision and the same mini-midvastus arthrotomy as in the MIS-TKA group. Both procedures were performed with cement fixation. All patients underwent the same standardized rehabilitation program. Patients were mobilized from the second postoperative day under supervision of our physiotherapists. Exercises included continuous passive motion, assisted and unassisted knee extension, walking and stair climbing with 2 crutches, and progression as tolerated.

Three-dimensional (3D) gait analysis was performed preoperatively and at 8 weeks postoperative with a 3D motion analysis system (VICON, Oxford, UK and AMTI, Watertown, MA), using a 4-segment lower-body marker model (Fig. 1). During level walking at self-selected speed temporospatial parameters, joint angles (kinematics), external joint moments (kinetics), and ground reaction forces were determined with the software packages provided by the manufacturer of the motion analysis system (Workstation V4.6 and Polygon Authoring Tool V3.1; VICON, Oxford, UK). The accuracy of our measuring system was previously tested [10]. This study shows that with dynamic calibration, overall accuracy was 63 ± 5 μm.

Extensor torque measurements were also performed preoperatively and at 8 weeks postoperative by always the same investigator. This was done in a standardized manner using an isokinetic dynamometer (Con-Trex MJ; CMV AG, Zurich, Switzerland). Patients were seated on the dynamometer with their hip flexed to approximately 90° and their trunk secured with dual-crossover straps and a waist strap. The range of motion (ROM) at the knee was set at 110° and was modified according to available passive motion and the subject's tolerance. The angle was 0° when the leg was fully extended at the knee and 110° when it was fully flexed. A thigh strap on the test leg was used to restrict any lateral movement at the knee, allowing only flexion and extension (Fig. 2). The testing protocol consisted of concentric quadriceps contractions after familiarization with the equipment (2 minutes; submaximal trials at an angular velocity of 60°/second). The patients performed 4 repetitions at an angular velocity of 60°/second. Peak extensor torque was recorded for the surgically treated leg and used for further analysis.

Fig. 1. The lower-body marker model as part of the 3-dimensional gait analysis procedure.

Sample characteristics are given as means, standard deviations, and frequencies. A multivariate analysis of variance was applied including the main effects time (before and after surgery) and surgical group and the group-by-time interaction effect. The peak extensor torque and the gait parameters (ie, the dependent variables) were grouped according to hypotheses H1-H5 and analyzed separately. To determine the significance of the multivariate tests, we used the Hotelling–Spur statistics. All analyses were performed with SPSS 20.0 (IBM Corporation, Armonk, NY).

Results

Participant characteristics were comparable between the groups with regard to age, body mass index, side of surgery, sex, and osteoarthritis grading (Table 1).

Preoperative peak extensor torque of the operated leg was 52.75 Nm and 56.46 Nm for MIS-TKA and MIS-MUKA, respectively.