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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

Matthias Braito, MD [a], Johannes M. Giesinger, PhD [b], Stefan Fischler, MSc [a], Arnold Koller, MSc [c], David Niederseer, MD, PhD [d], Michael C. Liebensteiner, MD [a, *]

[a] *Department of Orthopaedic Surgery, Medical University of Innsbruck, Innsbruck, Austria*
[b] *Department of Psychiatry and Psychotherapy, Medical University of Innsbruck, Innsbruck, Austria*
[c] *Institute for Sports Medicine, Alpine Medicine & Health Tourism, Innsbruck, Austria*
[d] *Department of Cardiology, Zurich University Hospital, Zürich, Switzerland*

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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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* Reprint requests: Michael C. Liebensteiner, MD, Department of Orthopaedic Surgery, Medical University of Innsbruck, Anichstrasse 35, A-6020 Innsbruck, Austria.

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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.


[redacted]

Fig. 2. Isokinetic torque measurement with the Contrex dynamometer.

Eight weeks postoperatively, peak extensor torque was 39.60 Nm and 41.13 Nm, respectively. The changes over time were statistically significant ($P = .004$), but statistical significance was not determined for the factor group or for time × group interactions (H1).

The temporospatial parameters were not seen to be influenced by the factors "surgical group" or "time." There were no time × group interactions (H2).

Analysis of the various components of the ground reaction force (vertical, mediolateral, and anteroposterior) did not reveal any influence of the factors "surgical group" or "time," nor were there time × group interactions for any of the 3 components of ground reaction force (H3).

For sagittal knee kinematics, there were no effects of the surgical group, nor were there any time × group interactions. However, sagittal knee kinematics was found to change over time ($P < .001$). Analysis for individual parameters identified postoperatively increased "min knee flexion gait cycle" (walking with less knee extension) in both groups ($P < .001$). Similarly, frontal knee kinematics also showed significant changes over time (no group effects, no time × group interactions). Analysis of individual parameters identified lower "max knee varus angles" and higher "min knee varus angles (= max knee valgus angle)" in both groups from preoperative to postoperative ($P = 0.005$ and $P < .001$, respectively; H4).

Table 1
Participant Characteristics.

	MIS-TKA, n = 17, Mean (SD)	MIS-MUKA, n = 15, Mean (SD)	*P* Values
Age at surgery	66.4 (5.0)	65.7 (6.9)	.773
BMI	29.5 (3.8)	30.8 (2.4)	.265
	n (%)	n (%)	
Female	11 (64.7)	7 (46.7)	.476
Male	6 (35.3)	8 (53.3)	
Left sided	9 (52.9)	7 (46.7)	1.000
Right sided	8 (41.7)	8 (53.3)	
IKDC OA grading			
B	2 (11.8)	5 (33.3)	
C	8 (47.1)	5 (33.3)	.334
D	7 (41.2)	5 (33.3)	

BMI, body mass index; IKDC, International knee documentation committee; OA, osteoarthritis; MIS, minimally invasive surgery; MUKA, medial unicondylar knee arthroplasty; SD, standard deviation; TKA, total knee arthroplasty.

The sagittal knee moments (extensor/flexor moment) were not affected by the surgical group. We also observed no time × group interactions. However, statistical significance was determined for the factor "time" (longitudinal changes; $P = .018$). Analysis of individual parameters found an increase in "maximum knee extensor moment gait cycle" in both groups from preoperative to postoperative duration ($P = .003$). The "minimum knee extensor moment stance" (= maximum flexor moment) decreased in both groups from preoperative to postoperative duration ($P = .015$). The frontal knee moments (valgus/varus moment) were neither affected by the surgical group nor were there time × group interactions. However, statistical significance was determined for the factor "time" ($P < .001$) and showed the "maximum internal knee valgus moment" (= external varus moment) to decrease from preoperative to postoperative duration ($P < .001$; H5; for detailed results, see Tables 2 and 3).

Beyond the hypotheses, we also found no group differences or time × group interactions for joint angles or joint moments of the hip or ankle.

Discussion

The most important finding made in this study was that no difference was seen between MIS-MUKA and MIS-TKA at 8 weeks after operation with regard to any of the tested functional outcome parameters (knee extensor torque, temporospatial gait pattern, ground reaction forces, knee kinematics, and knee kinetics). Consequently, none of the hypotheses were deemed confirmed by the findings. By applying the same "quadriceps-friendly" MIS approach (mini-midvastus arthrotomy, no patella eversion, and no joint dislocation) in both groups, such a confounder effect was ruled out. From a variety of functional outcome measurements, it

Table 2
Descriptive Statistics of Temporospatial and Kinematic Gait Parameters.

			Unit	MIS-TKA				MIS-MUKA			
				Before		After		Before		After	
				Mean	SD	Mean	SD	Mean	SD	Mean	SD
Temporospatial parameter											
	Gait velocity		m/s	0.91	0.22	0.93	0.15	1.00	0.19	1.04	0.17
	Stance		% gait cycle	60.75	2.63	60.51	2.14	56.21	15.12	59.74	1.66
	Swing		% gait cycle	39.25	2.63	39.49	2.14	40.04	2.08	40.26	1.66
	Double support		s	0.29	0.11	0.26	0.06	0.24	0.07	0.23	0.06
	Double support		% gait cycle	23.99	6.14	22.09	4.06	21.11	5.03	20.59	4.30
	Stride length		m	1.05	0.17	1.09	0.12	1.12	0.16	1.14	0.15
	Cadence		steps/min	102.69	13.08	102.28	8.02	106.74	12.16	109.24	8.91
	Step width		m	0.14	0.04	0.14	0.03	0.16	0.03	0.16	0.04
	Gait cycle duration		s	1.19	0.16	1.18	0.09	1.14	0.13	1.11	0.10
Kinematics											
Sagittal	Sagittal knee angle	Max knee flexion stance	deg	19.16	7.78	21.53	5.50	20.53	6.98	23.64	4.60
	(+ Values: flexion)	Max knee flexion swing		56.70	10.97	58.66	6.27	59.48	6.07	57.15	6.22
		Min knee flexion gait cycle		12.45	6.81	15.29	4.29	10.87	5.79	16.19	4.46
		Knee flexion at toe off		33.93	7.34	36.56	5.24	35.12	5.34	37.22	5.19
		Knee flexion at foot strike		14.54	6.17	15.86	4.34	13.86	5.15	15.97	4.54
		Total sagittal knee ROM gait cycle		45.07	11.74	44.90	6.76	49.40	5.36	43.62	4.41
	Sagittal hip angle	Max hip flexion gait cycle		32.38	6.46	34.78	5.87	33.35	6.67	34.65	6.69
	(+ Values: flexion)	Min hip flexion gait cycle		−5.36	6.72	−4.01	7.36	−5.81	9.31	−4.60	6.10
		Total sagittal hip ROM gait cycle		37.74	5.23	38.79	4.03	39.17	4.20	39.25	4.12
	Sagittal ankle angle	First minimum gait cycle		−1.66	10.62	−3.25	3.85	−2.95	3.73	−2.80	3.28
	(+ Values: dorsiflexion)	Maximum gait cycle		16.99	10.27	16.27	3.44	15.12	3.15	15.43	3.02
		Second minimum gait cycle		−4.56	12.06	−6.04	6.63	−5.10	5.11	−5.58	5.86
		Total sagittal ankle ROM gait cycle		23.32	5.01	23.04	3.85	21.32	2.95	22.54	4.16
Frontal	Frontal pelvis angle	Maximum gait cycle		1.68	2.70	1.40	2.67	1.72	1.65	1.46	1.88
	(Pelvic obliquity)	Minimum gait cycle		−2.79	2.42	−2.62	2.07	−1.79	2.27	−2.24	1.86
	(+ Values: up)	Total frontal pelvis ROM gait cycle		4.47	2.04	4.02	2.20	3.51	1.86	3.69	1.72
	Frontal hip angle	Maximum gait cycle		6.49	5.70	9.69	3.82	5.46	4.26	7.28	4.36
	(+ Values: abduction)	Minimum gait cycle		−0.77	6.09	2.61	4.28	−1.99	3.88	−0.78	4.11
		Total frontal hip ROM gait cycle		7.26	3.51	7.08	3.37	7.45	3.05	8.06	2.57
	Frontal knee angle	Maximum stance		8.46	5.82	5.04	5.02	7.22	6.02	5.01	4.16
	(+ Values: varus)	Minimum stance		−2.56	5.15	−6.29	3.98	−2.14	5.74	−4.16	5.16
		Total frontal knee ROM stance		11.01	4.56	11.32	4.98	9.35	4.15	9.16	3.77

max, maximum; min, minimum; MIS, minimally invasive surgery; MUKA, medial unicondylar knee arthroplasty; SD, standard deviation; TKA, total knee arthroplasty.

appears that MUKA is not superior to TKA (when using a PCL-retaining TKA design) at 8 weeks after operation.

An attempt to integrate our results in the findings made in previous research revealed that gait analysis and knee strength were rarely investigated and compared between MUKA and TKA. Komnik et al [1] very recently conducted a systematic review of the issue of gait analysis after 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 that previous research dealing with gait characteristics in the context of MUKA [2-7], all studies but one [6] used either no control group [3,4,7] or compared UKA with procedures other than TKA [2,5]. The one study that compared MUKA to TKA with regard to gait data [6] reported no differences and is therefore in good agreement with the findings of our study. However, the authors (1) determined only ground reaction forces and (2) included only 5 patients in the MUKA group. Of the remaining 5 studies without an appropriate control group [2-5,7], Chassin et al [3] performed gait analysis in 10 MUKA patients. They reported that MUKA patients are likely to exhibit a gait that is closer to normative values than TKA patients usually do. This was attributed to the preservation of both cruciate ligaments. However, no direct control group was used in that study. Others investigated 17 cases of UKA and found no gait differences as compared to patients with bi-UKA (combined medial and lateral UKA) [5]. However, it is believed that that study suffered from relevant limitations as (1) the UKA group was composed of medial *and lateral* compartment UKA and (2) only 6 gait parameters were determined. In addition, Börjesson et al [2] measured gait pattern in MUKA patients and found results superior to those in patients who underwent high tibial osteotomy (3 months after operation). However, only temporospatial gait parameters were assessed. Fu et al [4] reported on 17 MUKA cases and found no interlimb differences (gait asymmetry). The authors concluded that MUKA provides satisfactory gait symmetry, which supports the clinical use of MUKA. However, the study did not provide ground reaction forces, joint moments, or a control group. Webster et al [7] investigated the preoperative to postoperative course of gait characteristics in a case series of MUKA patients (no control group) and determined improved walking speed and increased knee flexion at 1 year after operation. The previously mentioned specific limitations (or distinct questions) of the studies severely restrict their comparability with our findings.

Others investigated the even more distinct issue of gait pattern after bicompartmental knee arthroplasty [11,12]. Fuchs et al [11] investigated gait in 15 subjects with combined medial and lateral UKA and found no differences as compared to TKA. Leffler et al measured the gait pattern of 10 patients with bicompartmental arthroplasty (medial and patellofemoral) and compared it with the contralateral uninvolved side and a historic data set of healthy controls. From their findings, it was concluded that normal gait pattern was replicated with that specific prosthesis [12]. Although the authors were dealing with a similar issue (a kind of knee arthroplasty with preservation of the anterior cruciate ligament), it is believed that comparability with the findings of the present study is very limited.

Regarding gait pattern in TKA, several reports have demonstrated improvements in gait during the first 2 years after TKA, but

Table 3
Descriptive Statistics of Kinetic Gait Parameters (Joint Moments) and Ground Reaction Forces.

			Unit	MIS-TKA				MIS-MUKA			
				Before		After		Before		After	
				Mean	SD	Mean	SD	Mean	SD	Mean	SD
Ground reaction forces											
GRF vertical (Fz) (+ values: up)		Fz1: first maximum	N/kg	9.58	0.45	9.59	0.23	9.73	0.53	9.73	0.72
		Fz2: first minimum	N/kg	8.64	0.59	8.65	0.41	8.50	0.47	8.32	0.35
		Fz3: second maximum	N/kg	9.85	0.61	9.89	0.44	9.82	0.55	9.87	0.51
		Fz1-time: time to Fz1	% stance	31.10	7.37	30.26	5.07	30.88	5.28	27.81	5.40
		Fz2-time: time to Fz2	% stance	48.66	6.64	49.42	5.85	50.49	5.87	47.99	5.50
		Fz3-time: time to Fz3	% stance	70.49	8.42	74.17	4.97	74.41	4.69	74.59	3.29
GRF ap shear (Fx) (+ values: anterior)		Fx1: minimum	N/kg	−0.84	0.24	−0.96	0.19	−0.96	0.30	−1.11	0.24
		Fx2: maximum	N/kg	1.08	0.41	1.30	0.35	1.27	0.38	1.40	0.42
		Fx1-time: time to Fx1	% stance	16.79	5.47	16.68	6.94	15.59	4.66	15.62	2.45
		Fx2-time: time to Fx2	% stance	86.07	4.53	89.11	1.94	88.59	3.53	88.45	3.33
GRF ml shear (Fy) (+ values: lateral)		Fy1: first minimum	N/kg	−0.36	0.15	−0.40	0.12	−0.46	0.11	−0.50	0.13
		Fy1-time: time to Fy1	% stance	31.20	6.61	33.03	4.89	32.28	3.67	31.83	6.43
Kinetics (internal joint moments)											
Sagittal	Sagittal hip moment (+ values: extensor)	Maximum gait cycle	Nm/kg	0.74	0.24	0.79	0.23	0.80	0.23	0.73	0.22
		Minimum stance		−0.32	0.18	−0.29	0.16	−0.41	0.22	−0.42	0.13
		Minimum swing		−0.24	0.08	−0.30	0.08	−0.31	0.13	−0.34	0.09
	Sagittal knee moment (+ values: extensor)	Maximum gait cycle		0.20	0.11	0.25	0.11	0.26	0.19	0.39	0.16
		Minimum stance		−0.26	0.12	−0.23	0.10	−0.25	0.13	−0.15	0.10
		Minimum swing		−0.19	0.07	−0.20	0.07	−0.21	0.07	−0.21	0.04
	Sagittal ankle moment (+ values: plantar flexion)	Maximum gait cycle		1.28	0.27	1.33	0.20	1.31	0.18	1.34	0.28
Frontal	Frontal hip moment (+ values: abduction)	Maximum stance		0.93	0.24	1.02	0.15	0.90	0.22	0.94	0.14
	Frontal knee moment (+ values: abduction)	Maximum stance		0.47	0.20	0.35	0.15	0.52	0.13	0.40	0.12
		Minimum stance		−0.05	0.03	−0.05	0.03	−0.05	0.05	−0.06	0.03

GRF, ground reaction force; MIS, minimally invasive surgery; MUKA, medial unicondylar knee arthroplasty; SD, standard deviation; TKA, total knee arthroplasty.

even patients with good clinical scores demonstrate postoperative gait abnormalities [13-15]. In normal gait, the stance phase is characterized by a biphasic pattern of initial knee flexion followed by knee extension. A loss of this knee flexion–extension pattern during stance with little or no change in knee flexion angle throughout stance is notable in patients after TKA [13,16,17]. Andriacchi et al [18] showed that after TKA, about 75% of patients demonstrated either a predominantly flexional or extensional moment pattern. An abnormal extensional moment pattern (reduction in the net quadriceps load during gait) has been attributed to the absence of the anterior cruciate ligament (ACL), leading to a pathologic femoral rollback mechanism [19]. This so-called "quadriceps avoidance gait" in patients with ACL-deficient knees is further characterized by a shorter stride length and a reduction in knee flexion angle during stance. Clinical data suggest a functional advantage of UKA over TKA because of retention of the ACL in the UKA population [20], but there is little literature on gait analysis to support that finding. Although 70% of the UKA patients exhibited a normal biphasic pattern of flexion/extension moments, only 23% of TKA patients have normal flexion/extension moment patterns [3]. It might not be possible to generalize these findings for all TKA, as Dorr et al [21] found better results with cruciate-retaining designs.

Similar to gait characteristics, knee extensor strength was also rarely dealt with in the context of MUKA [22-25]. Munk et al [23] and Barker et al [24] performed longitudinal investigations of leg extension power in MUKA patients (preoperative and postoperative, no control groups). Both research groups reported good outcome of MUKA with regard to leg extension power, but did not compare their findings with TKA patients. Fuchs et al [25] analyzed knee extensor torque in 17 UKA patients at 21.5 months postoperative. A 30% deficit in knee extensor torque was found in comparison to healthy controls, but no comparisons were made with patients after TKA. Chung and Min [22] compared knee extensor torque in patients with bicompartment knee arthroplasty with that of TKA patients. No differences were identified at 6 or 12 months after operation, which means good congruence with our findings. In summary, as no previous studies have compared knee extensor strength in MUKA and TKA patients, the findings of the present study are believed to provide new scientific evidence on this particular issue.

Knee extensor strength was reported as an important determinant of physical function and gait after arthroplasty. After TKA, more than half of the preoperative quadriceps strength is lost in the first postoperative month [26]. Knee extensor strength then gradually increases at 1-3 months after TKA and regains the preoperative level of strength at 6-12 months after surgery [27]. In contrast, as compared to healthy controls, quadriceps strength at 2 years after the procedure was reported to be reduced by 40% after TKA and by 30% after UKA [28-30]. Others reported that the extent of quadriceps injury inflicted while performing knee arthroplasty correlates with postoperative knee extensor strength in the early postoperative course after knee arthoplasty [31-33]. Therefore, an MIS may be advantageous although no benefit for longer term recovery has been seen [34,35].

The presence of competent cruciate ligaments may also play a role in knee muscle strength after arthroplasty procedures because of better proprioception and stability of the knee joint. ACL-deficient knees show significantly less isokinetic quadriceps muscle strength than do normal knees [36,37]. The role of the posterior cruciate ligament for proprioception and stability after TKA remains less clear, as studies comparing PCL-sacrificing and PCL-retaining TKA designs have yielded conflicting results [38-41]. However, from that evidence UKA would appear favorable over TKA in terms of increased proprioception (by sparing both anterior cruciate and posterior cruciate ligaments), which might also contribute to higher extensor strength.

The following limitations of the study are acknowledged. First, we performed gait analyses on only 2 occasions. Additional postoperative measurement would have provided more information on the course of gait recovery, as extensor strength was reported to further increase at 6-12 months postoperatively. Second, it would have been interesting to also test at different walking speeds and inclinations (eg, treadmill) and to perform further tests in the early postoperative period (eg, after 4 weeks). Third, we did not succeed in collecting sufficient knee score data sets along with the other measurements to see further subtle differences between the groups. Fourth, it would have been an advantage to include only patients appropriate for MUKA in the study, and then to randomize the surgical group. This would have prevented patient selection from acting as a confounder. However, as there was no preoperative between-group difference in the stage of osteoarthritis, that confounder might have had only a minor effect. Fifth, as a PCL-retaining TKA design was used for all TKAs, our results might not be applicable for TKA designs with posterior stabilization.

The study at hand is the first to report on an investigation of all aspects of 3D gait analysis (temporospatial, kinematic, and kinetic) and of knee extensor strength after MUKA vs TKA. Therefore, we believe it substantially contributes to the current scientific knowledge. Moreover, as MIS techniques were applied in both groups, it is also the first study to control for potential bias of the surgical approach. The strengths of the study also lie in its prospective, comparative design (level of evidence: 2).

Conclusions

It is concluded that MUKA is not superior to TKA (when using a PCL-retaining TKA design) with regard to knee extensor strength or 3D 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 longer to recover, our findings should be interpreted with caution.

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