ISOKINETIC EVALUATION OF PATIENTS SUBMITTED TO TOTAL KNEE ARTHROPLASTY

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ABSTRACT

Objective: In total knee arthroplasty, the minimally-invasive approach has been claimed to enable earlier rehabilitation because it spares the femoral quadriceps muscle. To check the influence of preserving the extensor apparatus during surgery, the strength of knee extension and flexion muscles was evaluated in patients submitted to total knee arthroplasty with different approaches. Materials and Methods: The values of maximum torque and total work obtained by isokinetic dynamometry six months after surgery were compared for the Minimally invasive surgery group constituted of 12 individuals submitted to total knee arthroplasty by the minimally invasive surgical approach and the Control group, constituted of eight patients submitted to total knee arthroplasty by the transquadricipital approach, between January 2005 and July 2006. Results: Statistical analysis of the absolute values for maximum torque and total work adjusted for body weights did not show differences between both groups. Conclusion: There was no difference in the extension and flexion strength of the knee muscles six months after surgery.

Keywords: *Arthroplasty replacement knee. Knee prosthesis. Minimally-invasive surgical procedures. Muscle strength.*

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INTRODUCTION

The knee can be affected by degenerative processes, changing its function. The incidence of knee osteoarthrosis is increasing as population's life expectation and physical activities practiced by individuals at older age groups increase.[1]

Total knee arthroplasty (TKA) is an efficient therapeutic method for functional recovery and for pain relief. With the increased prevalence of symptomatic osteoarthrosis, TKA surgery has become more frequent.[1] Between 1996 and 1997, TKA accounted for 56% of joint replacement surgeries performed in the United States (USA).[2] According to the U.S. National Center of Health Statistics, 299,000 total knee arthroplasties were performed in 2000, and the American Association of Orthopaedic Surgeons (AAOS) estimates that 475,000 total knee arthroplasties will be performed in 2030.

Different access ports for TKA surgery have been studies. The transquadricipital access port is the most used one.[3] Also, the access port with vastus medialis muscle dissection[4] and the access port below vastus lateralis muscle have been described.[5] More recently, the access port sparing the femoral quadriceps muscle, named as minimally-invasive access port, has been described.[6]

Isokinetic dynamometry is currently one of the most accurate methods for muscle assessment. [7]

The objective of the present study is to compare, by means of an isokinetic dynamometer, muscle strength of the knee of patients submitted to total arthroplasty surgery by a minimally-invasive access port and by transquadricipital access port after six months of surgery, using as parameters, the maximum torque, total work, and the ratio between maximum torque of extensor and flexor knee muscles.

MATERIALS AND METHODS

This paper reflects an interventive, prospective, almost randomized study involving patients with degenerative knee conditions indicated to surgical treatment by total knee arthroplasty. selection criteria included: female gender, age group between 55 and 75 years; presence of moderate orteoarthrosis; no improvement of pain even with non-operative therapy; absence of varus or valgus knee deformities above 10 degrees; absence of contraction at flexion above 15 degrees; presence of knee range of motion above 100 degrees; ability to understand and follow medical and physiotherapeutic guidelines; no history of previous surgery on the affected knee; anesthetic risk corresponding to ASA I or II (usually healthy or with mild systemic disease) [8]; no contraindication to regional blockage anesthesia; absence of rheumatic conditions; absence of serious hypertrophic arthritis; absence of serious osteoporosis.

The exclusion criteria were the following: inability to perform test with the isokinetic dynamometer; contraindication to the proposed rehabilitation protocol due to postoperative complications.

Twenty-six patients were selected and submitted to TKA via transquadricipital access port (control group) or via minimally-invasive access port (MIS group) according to surgery schedule sequence and dependant on the routine of the service. Each technique was employed on thirteen patients by knee surgeons of the same hospital. The transquadricipital access port was performed as described by Insall[3] and Scuderi[9], and the minimally-invasive access port was performed as described by Tria[6] and by Bonutti et al.[10]

All study subjects were made aware of the procedures to which they would be submitted, having signed a free and informed con-

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sent term. The Committee of Ethics for Research Projects Analysis approved the protocol and the consent term.
The "Hospital of Special Surgery" questionnaire was applied at the preoperative phase, then at the completion of the rehabilitation program and six months postoperatively to all patients.
Patients groups were submitted to the same anesthesia protocol, with analgesia and clinical control, considering each patient's clinical status, and customizing modifications when necessary. All patients were submitted to the same rehabilitation protocol for twelve weeks. The objectives of the physical therapy were: relieve pain; strengthen musculature; mobilize joints, particularly on the operated knee; teach exercises for maintaining range of motion and muscle strength, as well as to minimize postoperative complications.
Of the patients included on MIS group, one could not continue in the study because she presented with a lateral patellar dislocation on the second postoperative month. In the control group, some patients (five) lost isokinetic dynamometry follow-up on the sixth postoperative month. Thus, this case series is composed by 20 subjects, 12 of which were submitted to total knee arthroplasty through a minimally-invasive access port, and eight patients submitted to total knee arthroplasty through transquadricipital access port.
The anthropometric measures of studied patients are listed on table 1. Mean surgery times and the use of tourniquet are described on table 2.

Table 1 – *Mean values, standard deviation (SD), median, minimum and maximum for variables weight, age, height, and body mass index (BMI) found on patients of MIS and control groups*

Variable	Group	Mean	SD	Median	Minimum	Maximum
Weight[1]	MIS	73.4	6.2	73.0	63.0	80.0
	Control	79.9	11.2	81.5	62.0	94.0
Age[2]	MIS	63.0	5.0	63.5	55.0	73.0
	Control	67.9	4.1	68.0	62.0	73.0
Height[3]	MIS	1.59	0.07	1.60	1.46	1.68
	Control	1.60	0.07	1.61	1.50	1.70
BMI[4]	MIS	29.07	3.19	29.69	23.38	32.87
	Control	31.23	5.03	32.01	24.22	37.80

NOTE: Number of cases per group: MIS = 12 , Control = 8.
(1) Weight as kilograms (2)
(3) Age as years
(4) Height as meters
(4) Body mass index as kg/m^2

Table 2 – *Mean values, standard deviation (SD), median, minimum and maximum for variables surgery time and tourniquet use time found for patients of MIS and Control groups*

Variable	Group	Mean	SD	Median	Minimum	Maximum
Surgery time[1]	MIS	134.0	30.7	131.0	99.0	210.0
	Control	102.5	16.9	100.0	85.0	135.0
Tourniquet use time[2]	MIS	137.8	18.9	139.0	109.0	170.0
	Control	64.5	34.2	45.0	37.0	120.0

NOTE: Number of cases per group: MIS = 12 , Control = 8.
(1) Surgery time as minutes
(2) Tourniquet use time as minutes

All patients were submitted to computed isokinetic dynamometry on flexor and extensor knee musculature six months after surgery with a dynamometer Byodex System 3 Pro. Flexion and extension tests were performed with an angular speed of 60 °/s. Each test was performed with the patient in sedestation and with belts fastened around thorax, abdomen, thigh root and on the region above the knee to be examined intending to limit patient's movements. A built-in device on the dynamometer concomitantly corrected gravidity effect.
Absolute values for maximum torque and total work, as well as the adjusted values for body weight, were measured on both groups. All values correspond to concentric contractions.
The average values for anthropometric variables, for the scores of HSS scale evaluations, for surgery time and tourniquet use time parameters, and for the scores of isokinetic evaluation tests for Control group and MIS group were compared by means of the Student's t test.
Variance premises and distributions were assessed for applying mean values comparison test. In addition, the Mann-Whitney non-parametric test was applied for comparing distributions. A significance level of 5% was adopted for all comparisons (p=0.05).
We conducted the Sperman's and the Pearson's tests to assess the existence or not of statistical correlation between parameters such as age, surgery time, tourniquet use time, and total work values.

RESULTS

The results are shown on tables 3, 4, 5, 6 and 7.
The anthropometric measures show similar distributions, except for age variable, which, by the Mann-Whitney test, indicated a statistical difference with p=0.04. MIS group shows lower mean ages as compared to control group with a statistical difference. Mean values for surgery time and tourniquet use time are different, being higher in the MIS group. However, total work values adjusted by body weight in extension and flexion do not show

Table 3 – *Results of the statistical analysis comparing mean values for variables weight, age, height, body mass index (BMI), surgery time and tourniquet use time according to MIS and Control groups*

Variable	Group	Mean	P value
Weight[1]	MIS	73.4	0.114
	Control	79.9	
Age[2]	MIS	63.0	0.035
	Control	67.9	
Height[3]	MIS	1.59	0.744
	Control	1.60	
BMI[4]	MIS	29.07	0.252
	Control	31.23	
Surgery time[1]	MIS	134.0	0.017
	Control	102.5	
Tourniquet use time[2]	MIS	137.8	<0.001[a]
	Control	64.5	

Table 4 – *Mean values, standard deviation (SD), median, minimum, maximum and comparison of mean scores by HSS functional score at preoperative period, at the end of rehabilitation program and at six months postoperatively in patients of MIS and Control groups*

Variable	Group	Mean	SD	Median	Minimum	Maximum	Comparison of mean values [4]
HSS Pre[1]	MIS	54.6	9.2	55.0	37.0	70.0	p=0.36
	Control	50.1	11.9	46.5	32.0	70.0	
HSS After 3 months[2]	MIS	90.8	3.7	92.0	85.0	95.0	p=0.02
	Control	83.6	9.1	87.5	68.0	92.0	
HSS After 6 months[3]	MIS	91.0	3.33	92.0	85.0	95.0	p=0.74
	Control	90.5	2.98	91.5	84.0	93.0	

NOTE: Number of cases per group: MIS = 12 , Control = 8.
(1) Preoperative values
(2) Values achieved at the end of rehabilitation program after 12 weeks of surgery
(3) Values achieved at isokinetic test six months after surgery
(4) P value according to Student's t test

Table 5 – *Mean values, standard deviation (SD), median, minimum, maximum and comparison of mean values for maximum torque in absolute and body weight-adjusted values for MIS and Control groups*

Maximum Torque	Group	Mean	SD	Median	Minimum	Maximum	Comparison of mean values[5]
Extension[1]	MIS	48.1	12.2	52.8	28.2	62.3	p=0.680
	Control	52.3	26.1	46.0	19.2	88.3	
Flexion[2]	MIS	31.8	11.6	31.9	15.7	52.9	p=0.354
	Control	37.0	12.4	36.5	21.6	60.0	
Extension CPC[3]	MIS	67.3	18.8	72.4	38.2	96.7	p=0.624
	Control	72.9	32.0	82.2	25.3	116.5	
Flexion CPC[4]	MIS	44.8	18.5	42.7	22.7	85.6	p=0.412
	Control	51.2	13.0	52.0	30.8	67.2	

NOTE: Number of cases per group: MIS = 12, Control = 8.
(1) Absolute value for maximum torque in extension as Nxm
(2) Absolute value for maximum torque in flexion as Nxm
(3) Value of maximum torque in extension adjusted by body weight
(4) Value of maximum torque in flexion adjusted by body weight
(5) P value achieved with the Student's t test(6)

Table 6 – *Mean values, standard deviation (SD), median, minimum, maximum and comparison of mean values for total work in absolute and body weight-adjusted values for MIS and Control groups*

Total work	Group	Mean	SD	Median	Minimum	Maximum	Comparison of mean values[5]
Extension	MIS	44.1	15.8	47.6	18.7	63.4	p=0.470
	Control	52.7	30.0	47.7	17.4	99.5	
Flexão[2]	MIS	27.2	12.5	23.0	11.3	50.8	p=0.278
	Control	33.5	12.2	33.2	16.7	58.3	
Extension CPC[3]	MIS	62.0	23.8	66.6	25.3	96.3	P=0.403
	Control	73.6	37.2	84.0	22.9	131.3	
Flexion CPC[4]	MIS	37.6	19.4	31.2	15.0	76.6	p=0.281
	Control	46.5	14.1	45.3	27.1	67.3	

NOTE: Number of cases per group: MIS = 12 , Control = 8.
(1) Absolute value for total work in extension as Joules (2)
(3) Absolute value for total work in flexion as Joules
(4) Value of total work in extension adjusted by body weight (5) (6)
(7) Value of total work in flexion adjusted by body weight
(8) P value achieved with the Student's t test(9)

Table 7 – *Mean values, standard deviation (SD), median, minimum, maximum and comparison of mean values of the correlation between knee flexor and extensor musculature torque for MIS and control groups*

Group	Mean	SD	Median	Minimum	Maximum	Comparison of mean values
MIS	69.6	27.2	66.9	27.9	119.7	p=0.411
Control	80.8	31.9	68.7	43.0	137.1	

NOTE: Number of cases per group: MIS = 12 , Control = 8.
P value achieved with the Student's t test(1)

statistical correlation with the values for surgery time, garrote times or patients' ages.

The values for isokinetic dynamometry did not show difference between groups.

Hospital of Special Surgery questionnaire scores did not show differences preoperatively and six months postoperatively. There was a difference at the end of the 12-week rehabilitation program, with MIS group showing a higher mean value.

DISCUSSION

The use of inclusion criteria similar to the ones suggested by Tria[6] and Berger et al.[7] aimed to provide a more homogeneous group of patients to be studied. Only patients with osteoarthrosis were included, because patients with other knee joint degeneration etiologies, such as rheumatoid arthritis, may present a different postoperative evolution of motor strength.[11] The choice for female patients is also a result of the difference on maximum torque between men and women.[12]

Patients' age was limited, because comparing patients older than 75 years and younger than 55 years could show a significant strength difference due to age.[13,14] In the study by Tria and Coon[15] patients' age ranged from 51 to 84 years (mean: 67 years), and, in the study by Berger et al.[12] age ranged from 50 to 79 years (mean: 68 years). In our study, a difference was found in the mean values for age, but the statistical analysis showed no correlation between isokinetic dynamometry parameters and age. The youngest patient in this study (55 years old), belonging to the MIS group, achieved strength values below average.

As we studied aged women not practicing sports and with knee osteoarthrosis, we chose not to assess dominant and non-dominant sides.[13,14]

The kind of anesthesia and pain relief was standardized in order to enable patients to start rehabilitation protocol with the same status.

Concerning surgery time and tourniquet use time, despite of finding differences between the averages for both studied groups, we didn't find correlation between these parameters and isokinetic dynamometry values. As our study was conducted at six months postoperatively, we believe that this variation between both studied groups does not cause bias to the results.

the preoperative evaluation with the scores of the Hospital of Special Surgery questionnaire has shown that the study started with two groups functionally equivalent. At six months postoperatively, patients operated by both access ports also showed to be equivalent from a functional point of view. Perhaps there is a functional difference at early postoperative period, up to 12 weeks after surgery.

For us, performing the test at six months postoperatively seemed to be appropriate because this would be a moment in which the patient could theoretically perform usual activities with no restrictions, but still under the influence of surgery.[16]

We didn't find equivalent studies in literature, and the existent studies assess different access ports. According to Chang et al.[17], the access under vastus medialis muscle shows a stronger femoral quadriceps force than the transquadricipital access at six months postoperatively. Concerning methodology, the study by Chang et al.[17] is different from this one, because it compares operated knees with "normal" sides of the same individual. We don't think this method is appropriate, because the "normal" side of an aged individual with knee osteoarthrosis usually presents some degree of compromise reducing muscular strength.[16]

Faure et al.[18] and Keating et al.[19], when compare the transquadricipital access port and the access port under vastus medialis muscle in patients submitted to TKA in both knees, did not find difference for strength. From a methodological point of view, the use of bilaterally operated patients is interesting, because it standardizes patient as case and control. It is worthy to mention that this method can, on the other hand, show bias on the side operated later as having stronger muscular strength due to a longer physical therapy time required. We highlight that these studies compare to accesses hurting femoral quadriceps muscle.

Cila et al.[20] found a difference for strength between the access port under vastus medialis muscle and the transquadricipital access port with six weeks of surgery, but they did not find difference at three and six months. In our study, the functional scale score showed difference between groups at the end of rehabilitation program, which was not repeated when performing isokinetic evaluation at six months postoperatively. On the other hand, performing isokinetic dynamometry at six weeks of surgery may be too early, not allowing patients to apply maximum force during the test. Anyway, in a retrospective analysis, we consider that performing isokinetic dynamometry at different moments after surgery would be interesting.

Although this is not the object of this study, we found superiority on patients submitted to surgery via minimally-invasive access port at the end of a 12-week rehabilitation period for range of motion and for functional scores, similarly to the results found by Chen et al.[21] Oppositely, Kim et al.[22] and Kolisek et al.[23] didn't find statistical differences on functional scores using the Knee Society scale, but reported that the group operated through the minimally-invasive access port shows a higher average.

Some authors such as Tria and Coon[15] and Berger et al.[12] have demonstrated the benefits of minimally invasive surgery in knee arthroplasty, such as smaller surgical incision, shorter hospitalization time, less postoperative pain and earlier ambulation without requiring orthosis. Still concerning the preservation of extensor apparatus in knee arthroplasty, Silva et al.[24] say that a stronger quadriceps strength is associated to better scores in functional assessments. Despite not presenting a learning curve and lower surgical exposure, less invasive and aggressive surgeries are a medical and orthopaedic trend in the 21st century. Perhaps, the association of techniques such as computer-guided surgery, which enables good outcomes in implants alignment[25] with the minimally invasive access port come to be used more frequently in knee arthroplasties.

CONCLUSION

The comparison of muscular strength by means of an isokinetic dynamometer allowed us to conclude that there is no difference in knee extensor and flexor musculature strength and at six months postoperatively among patients submitted to total knee arthroplasty using a minimally invasive access port and a transquadricipital access port.

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