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The dependence between clinical condition and value of the maximum force in the quadriceps femoris muscle during MVC test in patients with knee osteoarthritis

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The aim of this study was to check whether there was a correlation between the value of the maximum developed torque of the *quadriceps femoris* muscle and subjective evaluation of a patient's pain which is measured by the VAS. Also evaluated were changes in the muscle torque value and KSS scale over time. For examining patient's condition use was made of a KSS scale (knee score: pain, range of motion, stability of joint and limb axis) before the surgery and in weeks 6 and 12, as well as 6 months after surgery. It was found to be constantly improving in comparison with the condition before the surgery. This is confirmed by a significant statistical value difference of KSS scale. The surgery substantially increases the quality of live and function recurrence.

Key words: *arthroplasty, quadriceps femoris, visual analogue scale, Knee Society Score, maximal voluntary isomertic contraction*

1. Introduction

Osteoarthritis of the musculoskeletal system accounts for less than half of all chronic diseases (after cardiovascular diseases) which significantly reduces the quality of life, and consequently leads to disability in the elderly [4], [5], [16], [22]. For more than a century, the society has been suffering from gonarthrosis, currently defined as knee pain and dysfunction, which is radiologically confirmed to be a degenerative process. As a proof of diagnosis, one considers at least the presence of osteophytes on the articular edge of the tibia and (or) the femoral joint space narrowing, subchondral sclerosis and geods layers of bone [12], [13], [25], [26].

A common predominant symptom is pain felt only initially when moving the affected joint [10]. The causes of pain can be numerous and are often complex. These include changes in the same joint, such as mild inflammation of the synovium, articular surface damage, subluxation, and deformities, osteophytes, and thickening of the capsule [2], [8], [9], [25], [26]. Consequently, gonarthrosis disrupts the pattern of locomotion and the functioning of the musculoskeletal system (weakness of the *quadriceps muscle*, the mechanics of ankle, knee and the position of the pelvis and spine) [14], [21], [26]. The treatment of arthroplasty patients who are being subjected to, is the ultimate form of treatment to give good clinical results. The main objective of treatment is to reduce the patient's pain, increase the range of motion in the knee joint and restore normal gait pattern [2], [15], [17], [19]. Using relevant scales, non-invasive tests can be made for assessing clinical status before and after arthroplasty (evaluation of pain in the affected joint) [11], [18].

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The aim of this study was to check whether there was a dependence between the value of the maximum developed torque of the *quadriceps femoris* muscle and subjective evaluation of a patient's pain which is measured by the VAS and KSS scales.

Also evaluted were changes in muscle torque value and KSS scale over time.

Research questions were the following:

1. Does the intensity of pain has an impact on the value of muscle torque during the Maximal Voluntary Isometric Contraction (MVC)?

2. Does the value of muscle torque and the scale of Knee Society Score (KSS) change over time?

2. Materials and methods

The study was conducted at the Department of Orthopedics and Traumatology, Medical University of Silesia in Katowice. Clinical assessment was performed in the period from February to September 2009 in a group of 18 people (for group characteristics, see table 1) with osteoarthritis of the knee surgery scheduled for arthroplasty (6 with ailments in the left and 12 in the right knee). The study was conducted four times: before surgery, in weeks 6, 12 and 24 after surgery. To assess the pain Visual Analogue Scale was used (VAS), which was conducted right before the surgery. Determining the intensity of pain was to mark the point on the line with a length of 10 cm with only signs of its beginning and end (minimum and maximum pain). This segment is represented as a horizontal line on which the patient marks the point corresponding to the intensity of pain. This result is given in millimeters, where the value 0 is attributed to the complete absence of pain and 10 to the strongest pain you can imagine [25]. Another scale used for clinical evaluation was the Knee Society Score (KSS) modified in 1993, by Dr. Insall, which consisted of clinical and functional subscale. A typical procedure was based on generally accepted ways of assessment [3], [6]. The sum of clinical subscale includes pain (question about when it occurs and what is the level of pain during physiological activities). A goniometer was used in the assessment of: (plane: A/P, M/L) mobility, joint stability, the occurrence of flextion contracture, extension deficit and evaluation of the limb axis. Lack of the above was indicated by 0 points, and occurrence of negative points.

The second part of the scale assesses the patient's functional status, concerning the distance numbers, walking up the stairs and using assistive devices. In each of the scales you can get from 0 to 100 points. Patients are also given negative points for the use of orthopedic equipment, or the lack of active extension, flexion contracture, or the alignment of the limb. Both parts of an overall score of the scale were summed. A questionnaire was filled in during each examination, before surgery, in weeks 6, 12 and 24 after surgery. This method due to its simplicity and universal use is one of the more commonly used tools for measuring the intensity of pain and clinical evaluation of patients with dysfunctions of the musculoskeletal system. The study instruments included an electromyography system (4-channel EMG MyoTrace™400, Noraxon U.S.A., Scottdale, Arizona, USA) synchronized with video camera and dynamometer. Measuring station consisted of a force sensor attached in an adjustable arm chair and applied to the subject's lower leg to measure the force exerted. The sensor was connected to the system MyoTrace ™ 400 (Noraxon USA, Scottdale, Arizona, USA), and for each sample an archived program MyoResearchXP was used. Video records were also performed using a video camera synchronized with the measuring system. Patient was seated with the hip flexed to 90 degrees and the trunk supported against the back of the test chair. Knee was stabilized at 60 degrees. After two sub-maximal contractions lasting 4 to 5 seconds, patient performed maximal voluntary isometric contraction lasting approximately 7 to 8 seconds. Knee extension force was measured with dynamometer. The torque was calculated using the measured val-

Table 1. Description of the study group

	Patients (n = 18)		Female (n = 16)		Male (n = 2)	
	X	SD	X	SD	X	SD
Height [m]	1.61	0.046	1.60	0.037	1.69	0.014
Weight [kg]	80.00	12.010	79.56	12.231	83.50	13.435
BMI [kg/m²]	30.95	4.614	31.17	4.741	29.20	4.215
Age [years]	69.5	5.66	69.9	5.89	66.5	2.12

BMI – Body Mass Index,
X – mean,
SD – standard deviation.

ues of the force and the lever arm of the knee joint. This value of torque in the MVC static conditions is equal to the peak torque [1], [8]. Taking into consideration the body mass of the patients, relative torque was also calculated using the known formula.

$$\tau_{rel} = \frac{\tau_{max}}{m} \left[\frac{Nm}{kg}\right]$$

were:

τ_{rel} – relative torque,
τ_{max} – maximal torque,
m – body mass.

For assessment purposes, a statistical test was used according to package Statistica (license AWF, Katowice).

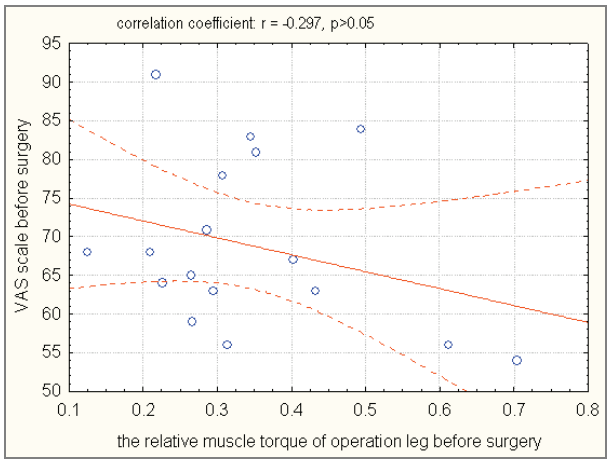

Fig. 1. Correlation VAS test with the relative muscle torque before surgery

3. Results

The assessment of pain sensation using VAS was performed only before surgery and was correlated with the torque (relative and absolute). No statistically significant correlation between the parameters was obtained ($p < 0.05$), one could only observe a trend indicating that the larger the value of VAS in the test, the smaller the torque (figure 1). KSS test results were correlated with torque for all examinations. Also in this comparison, there was not obtained any statistically significant correlation, while the coefficient r indicated some trends before the surgery and 6 weeks after the study, namely, the larger the KSS test results the greater the moment of absolute muscle strength. A similar trend is observed only for testing before surgery and 6 weeks after surgery until the relative value of muscle strength (table 2).

Table 2. The correlation between relative muscle torque of operated leg and value of KSS score

	before surgery	6 weeks after surgery	12 weeks after surgery	24 weeks after surgery
r	0.24	0.18	0.03	–0.05
p	0.470	0.606	0.935	0.879

r – correlation coefficient,
p – level of significance.

KSS test values during the period of time before surgery to 6 months after surgery increase (from 48 pts. to 88 pts.) and these changes are statistically significant between all measurements (table 3). The values of torque of both relative and absolute terms do not undergo significant changes throughout the period of considering separately the values obtained for the operated limb and non-operated one. However, significant differences between legs when tested before surgery, as well as six and twelve weeks after surgery. In

Table 3. Test T of KSS test

Examination	X	SD	Examination	X	SD	p value of T test
KSS before surgery	48.61	11.687	KSS 6 weeks after surgery	66.00	6.444	$p < 0.001$
KSS before surgery	48.61	11.687	KSS 12 weeks after surgery	71.11	5.120	$p < 0.001$
KSS before surgery	48.61	11.687	KSS 24 weeks after surgery	88.33	8.581	$p < 0.001$
KSS 6 weeks after surgery	66.00	6.444	KSS 12 weeks after surgery	71.11	5.120	$p < 0.001$
KSS 6 weeks after surgery	66.00	6.444	KSS 24 weeks after surgery	88.33	8.581	$p < 0.001$
KSS 12 weeks after surgery	71.11	5.120	KSS 24 weeks after surgery	88.33	8.581	$p < 0.001$

KSS – Knee Society Score test (points).

a recent study 24 weeks after surgery the average values continue to indicate higher torques for a healthy limb, however, the differences between the limbs are not statistically significant (table 4). The analysis indicates torques to reduce the torque values on the healthy side, and if a stable level on the side of a patient, resulting in 6 months after surgery no statistically significant differences between limbs in the torque generated (figure 2).

Table 4. Comparison of relative muscle torque [Nm/kg] between operated and non-operated leg

Time of examination	Operated leg		Non-operated leg		p value of T test
	X	SD	X	SD	
before operation	0.34	0.148	0.47	0.136	$p < 0.05$
6 weeks after surgery	0.33	0.090	0.45	0.124	$p < 0.05$
12 weeks after surgery	0.31	0.084	0.43	0.116	$p < 0.05$
24 weeks after surgery	0.32	0.096	0.40	0.157	$p > 0.05$

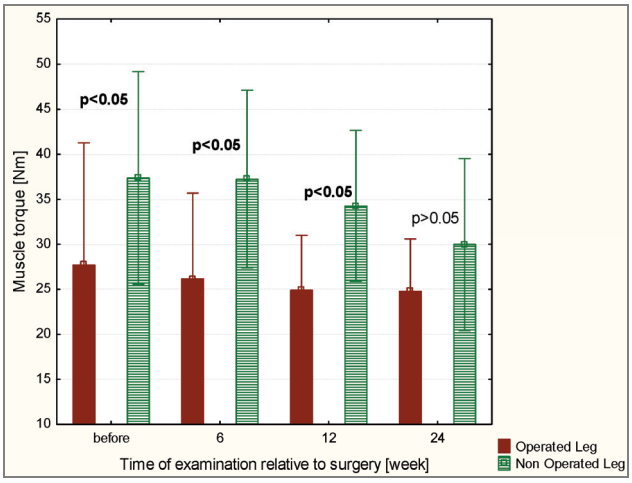

Fig. 2. The absolute value of knee extensors torque in the coming weeks before and after surgery. The significant differences (T test, $p < 0.05$) between operated and non-operated leg have been pointed in the figure

4. Discussion

The essence of MVC is to perform the test of maximum voluntary isometric contraction of muscles trying to produce the maximum possible torque of muscle strength.

In the case of people with various ailments within the musculoskeletal system, it becomes likely that when you feel pain you shall not seek to engage more in order not to expose themselves to the discomfort associated with the emergence of pain or increase its intensity. The effect of those parameter values derived may differ from actual strength abilities of the person examined. The disadvantage of MVC test lies in that one is not sure that the patient tries to test 100% of their current capabilities to perform an isometric contraction. The value of the subjective sensation of pain intensity measured before surgery using the VAS scale may affect the value of the drop-down torque, which is likely to confirm the increased size of the group. The only trend observed was that the higher the VAS scale (higher intensity of pain), the smaller the torque.

As the time passed after arthroplasty KSS scale values increased. Similar observations were made by WALZ and SCHLADITZ [23], who performed examination using a Staffelstein-Score scale in 371 patients after the total knee replacement surgery, with the average score obtained in the early post-hospital rehabilitation amounting to 72 points and 97 points at the end. The improvement was 25 points [24]. The decrease in muscle strength on the affected side, dealt with in the work of ZIMMERMAN-GÓRSKA [25], was confirmed by the results of the study performed before surgery. This state is also observed 6 weeks after surgery. In week 12, reduction of the torque on the non-operated side can attest a reduction in overload, resulting in a compensated work of the muscles of both limbs. This trend is maintained as confirmed by a recent study, where further reduction of the torque on the non-operated side leads to their alignment (no significant statistical differences between the limbs). Judd, Eckhoff, Stevens-Lapsley studied muscle strength loss in the lower limb after total knee arthroplasty. The results showed that knee extensors were 42% weaker compared to preoperative levels, and knee flexors were 34% weaker, whereas the ankle plantarflexors were 17% weaker, and the dorsiflexors were 18% weaker. Three and six months after surgery, strength in all muscle groups was similar to preoperative levels ($p > 0.05$ for all muscle groups). Patient function followed a similar trend, with patients walking slower 1 month postoperatively ($p < 0.001$) and recovering to preoperative levels by 3 and 6 months after surgery ($p > 0.05$) [7].

5. Conclusions

Based on the results the following conclusions were drawn:

1. No statistical relationship between the KSS and torque value has been observed, but the trend is such that the higher the value of KSS scale, the bigger the torque generated.

2. Patient's subjective feeling of the pain (VAS scale) affects the value of the torque generated muscle force, which does not confirm a statistically significant correlation between the results, but the trend between these parameters.

3. The patient's state assessed using KSS test in clinical subscale (pain, mobility and joint stability) is being improved during the six-month observation performed in relation to the state before the surgery, as evidenced by statistically significant differences in the KSS scale.

4. 24 weeks after arthroplasty no differences were observed between the operated side and non-operated one. A decrease of the torque until week 12 after surgery on the non-operated side may be associated with a reduction in excessive weight down on the limb as a result of the ongoing healing process of the operated side.

5. Measurement of the torque allowed an objective assessment of the patient, freeing the result obtained from the subjective assessment of a person performing the tests.

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