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FACULTY OF PHYSICAL EDUCATION AND SPORT,
DEPARTMENT OF ANATOMY AND BIOMECHANICS

CHANGES OF RHEOLOGICAL PROPERTIES DURING VARIOUS DEGREES OF KNEE FLEXION AFTER MENISCECTOMY

ANETA VRÁNOVÁ, MONIKA ŠORFOVÁ, PETR KUBOVÝ

ABSTRACT

Aim of this article is to find out if there is any difference in rheological properties in various degrees of flexion in the knee with meniscal tear and compare the results with measurement after physical activity. Experimental measurements were done by using the method of biorheometry which detects the passive resistance of the knee in movement from flexion to extension. We found changes of rheological properties in higher degrees of knee flexion with typical rising followed by fall of biorheogram around flexion of 80°. They were more remarkable after physical activity. Changes of rheological properties were more expressive in patients who have undergone meniscectomy a few years ago than changes in patients with recent meniscectomy.

Keywords: meniscus; knee joint; biorheometry; rheology; meniscectomy

INTRODUCTION

The meniscus is an important multifunctional component of the knee joint and is considered to be a complex biomechanical system. It has a role in load transmission, shock absorption, proprioception, improvement of stability and lubrication (Bartoníček, 2004; Vedi et al., 1999). Menisci also transmit between 30% and 70% of the load applied across the joint (Guerrero, 2008).

Biorheometer is a measuring equipment which has been constructed in “hidden for review purposes”. It is focused on determination of rheological properties of the knee joint. In our study we were going to find out if there is any difference in rheological response during various sequences of knee flexion in patients who have undergone meniscectomy and compare these results after physical activity (50 squads).

PURPOSE

Meniscal tear is one of the most common knee joint injuries. The purpose of this study is to find out if there is any difference in rheological properties in various degrees of flexion in the knee with meniscal tear and compare the results with measurement after physical activity. Then we wanted to compare changes of the rheological properties of patients who have experienced meniscectomy a few years ago to patients with recent meniscectomy.

METHODS

Biorheometer

Biorheometer measures *in vivo* the overall mechanical impedance of the knee-joint. The mechanical impedance is the ratio of complex stress to complex strain. This is measured by the biorheometer at fixed frequency and the corresponding hysteresis-curve is obtained. The hysteresis-curve gives some insight in the viscoelastic properties of the knee-joint. This hysteresis-curve is called a **biorheogram** (Riha, 2012).

It measures the resistance to passive flexion and extension of a leg which is fixed by a socket to the drifter arm above the subject's ankle (Figure 1).

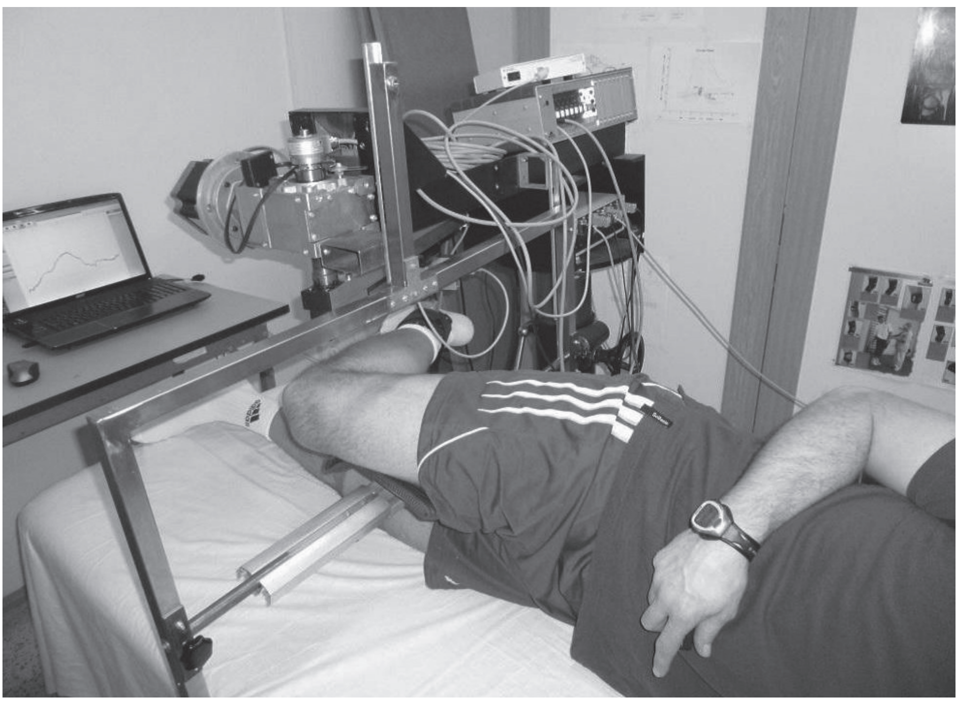

Figure 1. Biorheometry measuring in Department of Anatomy and Biomechanics, Faculty of Physical Education and Sport, Prague

Measuring

We recruited 6 subjects with meniscal tear, all were treated surgically. Subjects with meniscal tear together with ACL lesion were excluded. All subjects suffered from several discomforts while doing sports or activities of daily living. All subjects were injured on their medial meniscus, and were competitive sportsmen, aged 24–45.

All volunteers experienced case history questionnaire and completed WOMET (Western Ontario Meniscal Evaluation Tool). It is a disease specific quality of life measurement tool for patients with meniscal lesions. It consists of three sections: physical symptoms, sports/recreation/work/lifestyle and emotions.

Measuring was done at first on injured limb. Initially, we measured first cycle with angular amplitude of 90 degrees (20 to 100 degrees exactly). Then we used two shorter distances with angular amplitude of 40 degrees (20 to 60 and 60 to 100 degrees). The same was repeated on subject's healthy lower limb. After that subjects had to undergo the physical activity, which consisted of 50 squads. Then we gave them some time (around 10 minutes) to relax and the measurement proceeded again from the beginning with both injured and healthy limbs.

From hysteresis-curve we counted several specific parameters which helped us to determine viscoelastic properties of the knee joint. In our study we were interested in these parameters: stiffness, dissipation energy and local maximums and minimums of the curve.

RESULTS

Results of the WOMET questionnaire in 4 patients showed that the quality of life with their limb after meniscectomy is worse than with the other healthy limb. Only in 2 patients the results were worse in their healthy limb. This may be caused by a pain which could be connected with unrecognized soft tissue injury in their healthy knee (Figure 2).

We divided results of the biorheometry into four sections: we focused on comparison of hysteresis-curves depending on physical activity, healthy and injures lower limb, various degrees of knee flexion (shorter distances 20 to 60 degrees and 60 to 100 degrees) and the year of meniscal injury.

Knees with meniscal tear in history have worse viscoelastic properties than healthy knees. These phenomenons could be caused by the hamstring hyperactivity or structural changes of the knee cartilage.

Results after physical activity vary in specific parameters. This can be caused due to various severity of each meniscal tear.

In short distances from 20 to 60 degrees the changes were less obvious and there were nearly no differences between injured and healthy knees (Figure 3 and 4).

Patients were divided into two groups – first group were volunteers with meniscal tear older than five years, second group were patients with recent meniscal tear (1 year after meniscectomy). We found typical biorheogram rising in angle around 70 degrees in all patients with older meniscal tear. This rising is followed by biorheogram fall which is more obvious after physical activity.

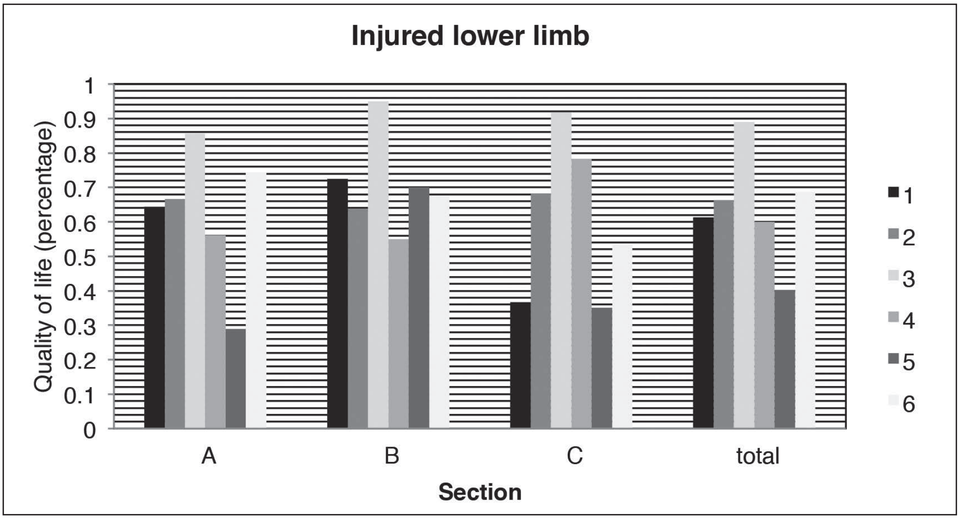

Figure 2. WOMET questionnaire results of injured lower limb. Numbers 1–6, as seen on the right side of graph, are numbers of patients. A – section concerning physical symptoms, B – section concerning sports/recreation/work/lifestyle and C – section concerning emotions. The last part explains total score of each patient's injured lower limb.

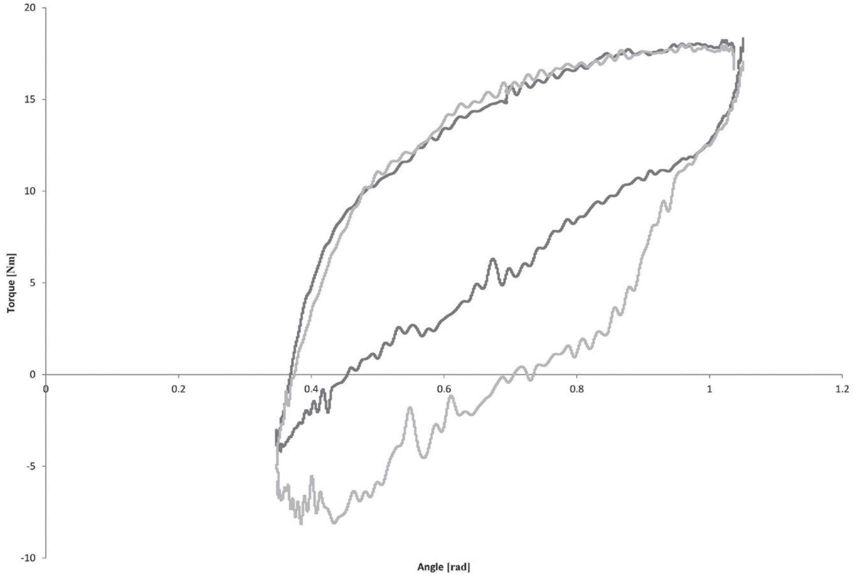

Figure 3. Example of hysteresis-curve in short distance from 20 to 60 degrees in a patient after meniscectomy (dark gray is biorheogram before physical activity, light gray is biorheogram after physical activity)

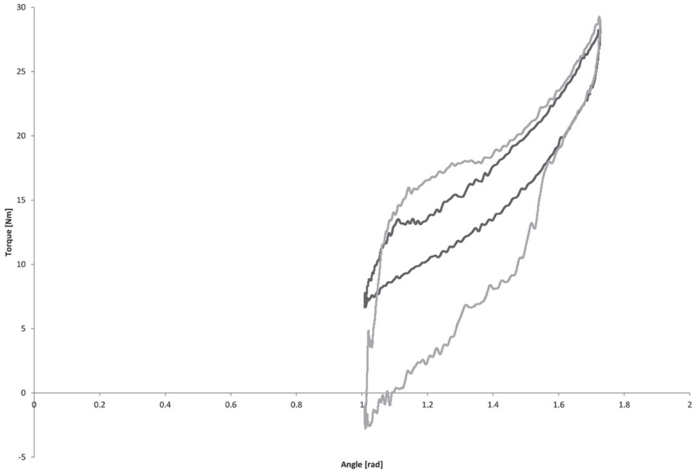

Figure 4. Example of hysteresis-curve in short distance from 60 to 100 degrees in a patient after meniscectomy (dark gray is biorheogram before physical activity, light gray is biorheogram after physical activity)

In second group with recent meniscectomy the rising of hysteresis-curve was present as well, but the following fall was small or wasn't evident at all (Figure 5 and 6). We suppose this could be due to increasing contact pressure and abrasions of the knee cartilage. These rheological changes occur more frequently after longer period of time after meniscectomy.

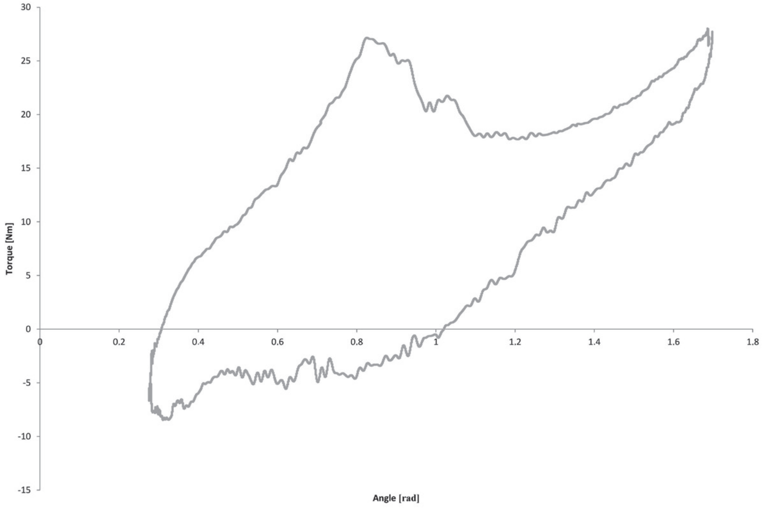

Figure 5. Typical hysteresis-curve rising and fall of patient from group 1 with older meniscectomy (5–7 years old) which had been recorded after physical activity

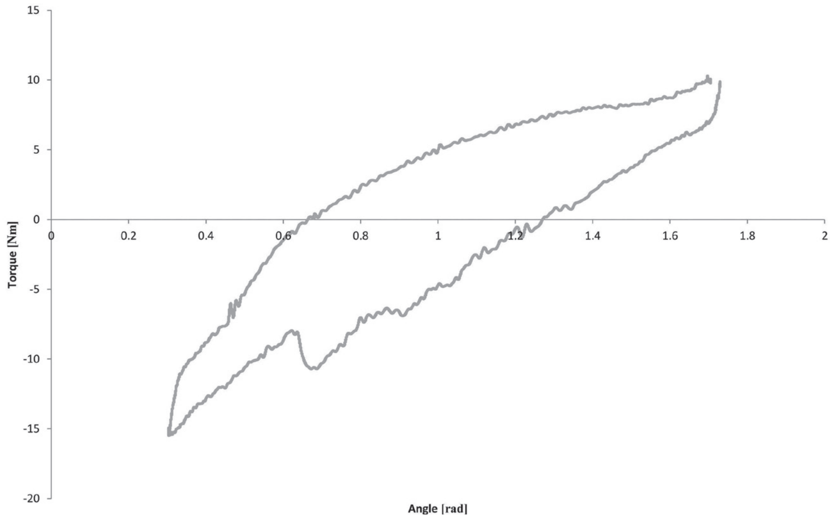

Figure 6. Hysteresis-curve of patient from group 2 with recent meniscectomy (1 year) which has been recorded after physical activity. Typical hysteresis-curve rising and fall, which is obvious in figure 5, is not present here.

DISCUSSION

Results of the WOMET didn't answer to results of biorheometry in two patients, because they had unknown clinical symptoms in their relatively healthy knee.

Vedi et al. (1999) says that meniscal movement turns up with increasing knee flexion. In Guerrero's study (2008) there is a typical medial meniscal translation in 70 degrees, when the posterior horn is gripped firmly between the posterior flare of the femoral condyle and the tibial plateau. After dividing hysteresis-curve into two small sequences, in section 20 to 60 degrees we found sheer increase of the curve which responses to increasing growth of resistance. In section from 60 to 100 degrees there was typical decreasing of the curve after 80 degrees. These changes were more remarkable after physical activity. This can correspond to meniscal translation mentioned above.

Biorheometer measures viscoelastic properties of the entire knee joint, so the result can be influenced by changes is articular capsule, ligaments or menisci.

The most important result of our study was that we found out typical sheer increase followed by decrease of biorheograf in angle around 70 degrees in group 1. The group contained patients with meniscectomy older than 5 years. This change of the hysteresis-curve wasn't present in patients from group 2 with recent meniscectomy. Difference can be caused by presence of rheological changes in knee joint after meniscectomy. As an example could be mentioned increasing contact pressure or abrasions of the knee cartilage.

Williams et al. (2007) found degenerative changes on MRI in knee joint after meniscectomy 5 years after surgery. Degenerative changes and local cartilage abrasion were present in people after meniscectomy.

Englund (2009) found out that meniscal tear is potential risk factor for developing osteoarthritis.

This study is suitable for another research, because we could use only 6 patients after meniscectomy. The verification of typical changes of hysteresis-curve after meniscectomy is obvious only in 3 patients.

Biorheometry is a non-invasive method for detection viscoelastic properties of the knee joint.

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Monika Šorfová
sorfova@seznam.cz