CALCULATION OF TIBIOFEMORAL FORCE DURING KNEE EXTENSION BASED ON MRI SCANS AND ISOKINETIC TEST

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Introduction

Meniscus is a semi-lunar fibrocartilage structure that is integral to the proper knee joint functioning, due to load distribution and amortization. Although knee joint forces (KJF) during isokinetic knee extensions have been already described, none of these studies have analyzed a change in KJF after surgical intervention, especially in meniscus treatment. This is an important problem because proper healing of a meniscus can be a key factor in osteoarthritis prevention.

The aim of this study was to create a simple mechanical model of the knee extension, that will use data usually collected in the treatment process in order to calculate tibiofemoral force (TF) and to investigate a change in its course after the meniscus treatment.

Materials and methods

Data were selected from the patients included and analyzed in study [3] and treated according to the arthroscopic surgical technique presented in [1]. The study group was restricted to 28 patients (8 women and 20 men) according to the following inclusion criteria: medial meniscus tear, without lateral meniscus lesions and with at least one isokinetic test of the operated knee joint in the follow-up period up to five years after the surgery. Exclusion criteria were tears of the ligaments, their reconstruction, as well as partial meniscectomy.

In order to calculate TF, we formulated a two-dimensional mechanical model of the shank and tibial articular surface during isokinetic examination. The model was based on the model presented in [4] and it can be applied only to knee extension. We assumed that the temporary center of rotation during shank extension is localized at the point of contact between tibia and femur, and torque measured in isokinetic test in concentric-concentric mode is balanced by torque exerted by patellar tendon.

The coordinate system in this study was placed on tibial plateau, according to the methodology described in [6]. The distance between tuberosity of the tibia and the center of rotation (tibiofemoral contact point) as well as angle between patellar tendon and tibial long axis were measured separately for every patient, based on MRI scan of extended knee. Then, in order to calculate location of contact point in a function of knee flexion, we applied results of the study [2], where authors provided tibiofemoral cartilage contact points on the medial tibial plateau at different flexion angles during in vivo weight-bearing lunge. Similarly, we applied results from the paper [5] to calculate angle between patellar tendon and tibial long axis in every knee flexion, so it could be used with data measured in isokinetic test.

Results

The mechanical model formulated in this study estimates tibiofemoral force as a function of the knee flexion, dependent on torque measured in isokinetic test. This characteristic was calculated for every patient, separately for every isokinetic test performed postoperatively, usually 6, 12 and 24 months after meniscus regeneration. Results presented as the example in Fig.1 shows that the course of tibiofemoral force changes with time after the surgery what may be a result of meniscus healing and restoration of its biomechanical function in the knee joint.

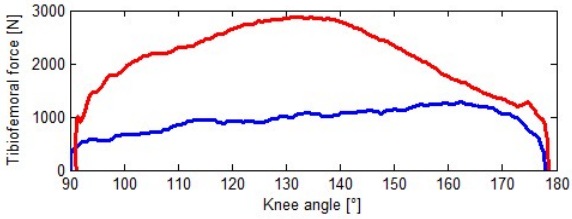

Figure 1: TF calculated with the use of developed model: 6 (blue) and 24 months (red) after the surgery.

Discussion

The point seems to be not the difference in the magnitude of the TF, but the nature of its change together with the change of knee flexion.

Mechanical model presented in this study allows to merge clinical data usually collected during patient treatment process, like MRI scans in knee extension and isokinetic tests of the knee joint, in order to estimate TF course, which is believed to be an important parameter in meniscus treatment and osteoarthritis prevention.

References

1. Piontek et al, Polish Orthop. Traumatol., 77:39-45, 2012.
2. Qi et al, J Biomech, 46:1576-1582, 2013.
3. Piontek et al, Cartilage, 7:123-139, 2016.
4. Masouros et al, Orthopaedics and Trauma, 24:84-91, 2010.
5. Varadarajan et al, J Orthop Res, 28:322-328, 2010.
6. Beynnon et al, J Orthop Res, 32:61-8, 2014.

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