INFLUENCE OF PREOPERATIVE KNEE DEFORMATION ON TENSION FORCE IN POSTERIOR STABILIZED TOTAL KNEE ARTHROPLASTY

M. Gramada¹², P. Botez³
1. Ph.D. student at University of Medicine and Pharmacy “Grigore T. Popa” - Iasi
   „Sf. Ioan cel Nou” Emergency County Hospital - Suceava
2. Orthopedics-Traumatology Unit
   University of Medicine and Pharmacy “Grigore T. Popa” - Iasi
   School of Medicine
3. Discipline of Orthopedics-Traumatology

INFLUENCE OF PREOPERATIVE KNEE DEFORMATION ON TENSION FORCE IN POSTERIOR STABILIZED KNEE ARTHROPLASTY (Abstract): Gap-dependent total knee arthroplasty involves applying a tension force to open the joint space. Intuitively, this force is dependent on the degree of joint deformity. **Aim:** The study aims at determining the amount of force and its influence on morphological parameters. **Material and methods:** In a group of 70 patients in whom total knee arthroplasty was performed ligament tension force was calculated and the influence of various individual morphological parameters was evaluated. **Results:** Statistical analysis showed that tension force is individual, dependent on knee deformation. **Conclusions:** Ligament tension force cannot be determined preoperatively, it requiring the use of appropriate tensioning devices. **Key words:** TENSOR, BALANCE, PRESSURE, PROTHESES

The two ways to place a total knee endoprosthesis are the controlled resection technique and gap-dependent technique. There are no data showing superiority of one of them, although some studies show a better positioning of the femoral component in the second case (1, 2). In both cases, the use of computer technology has made an improvement (2, 3). It helps in calculating directions and angles in the first case, and pressures/forces in the second, to prevent unstable knee (4, 5). In both cases ligamentous tension will determine the subsequent behavior of the knee. Of course, too low tension will cause laxity. Instead, there are articles showing that too much tension will cause increased imbalance (6). This is logical because if two different rigidity ligaments are stretched the tension difference increases. The question is: what the optimal ligamentous tension is. During the last period, ligament tensioning devices became available. Some of them generate a fixed force; others allow the force to be adjusted by the surgeon. However, a currently widespread idea is that a fixed force of 177-200 N regardless of the patient is necessary (7 - 13). Certainly the opening force must be applied with reduced patella. But it is curious that for different people, we create different spaces and fill them with prostheses of different sizes by applying the same force. Apparently, the greater the opening, the ligamentous tension is
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even greater. Muratsu has shown that increasing the force size increases the gap (6). This paper aims at clarifying what is the balance force and the factors that determine it.

MATERIAL AND METHODS

Patients group

Seventy patients with a mean age of 73 years (range 60-90), height 1.62 ±0.07 m, weight 796±160 N, BMI 30.85 ±5.93 kg/m², and a body moment (weight * height) of 1296±285 Nm entered this study. Patients were operated between July 2010 and May 2011 by the same surgeon. Exclusion criteria were the use of a surgical approach other than anterior-medial, personal history of rheumatic disease, injury, osteotomy or knee arthroplasty, conditions that could alter the capsular structure, and the absence of data. All parameters showed a normal distribution. Patients presented preoperative mechanical axis deviation of -5.65 ± 8.44 ° HKA, range 22°(varus) - 13°(valgus), flexion of 115 ± 14° (range 80-135°), and extension deficit of 4 ± 5 ° ( range 0-20 °). The investigations included a preoperative conventional goniometry based on which HKA, alpha, beta angles, tibial slope, and Caton index were calculated (14, 15).

Device

We used a fourth generation E-libra® digital ligament tensor (Synvasive Technology, Inc., Reno, Nevada, USA) (fig.1). It is able to achieve ligament balancing in position of 90° knee flexion by opening the lateral side and mark this point by measuring and displaying the relative pressures in the two compartments. Balance is achieved with reduced patella. The device consists of 3 components: a femoral component, a tibial component, and ligament balance measuring system by pressure sensors. Femoral component includes two parts: a fixed part, which is applied to the distal femoral osteotomy surface, and a moving part. This allows tension adjustment by opening the lateral ligament. The adjustment is made via an actuator (screw-gear). The center of rotation in the axial plane corresponds to the geometric center of the medial femoral condyle. This allows the natural movement of rotation. Tibial component is a classic spacer thicknesses corresponding to a gap of 10, 12, 14, 16 mm. Ligament balance measurement system consists of pressure sensors disposed within each medial/lateral compartment. The processor transmits a known voltage to the two sensors, and pressure variations are converted into electric current variations. This analog signal is converted to digital and then it is processed. The signals are transmitted through a transceiver to the display. The power source is batteries. All items are covered and sealed in a single device that is calibrated and sterilized by

Fig. 1. E-libra www.synvasive.com
the manufacturer. The read-out unit displays the relative pressure values. Since the tensor comprises a worm-gear mechanism, the operator torque force $M_{op}$ is amplified by the device to $M_{ap}$. To quantify the force distraction we have attached a Tochnichi torque screwdriver with a 10-100 cNm measuring scale. The assembly was calibrated using a Kirstler type force platform. The force generated by applying a progressive torque of 5 cNm was measured. For each value five determinations were made. The results revealed an excellent correlation coefficient $R^2 = 0.952$, and allowed us to calculate the multiplication factor.

METHODS
Prostheses were implanted using a technique sensor-dependent. Patients were anesthetized for ensuring complete muscle relaxation. After the tourniquet was inflated to 350 mmHg we practiced a medial parapatellar (transvastus) approach. Both cruciate ligaments were removed. The surgical sequence was the following: proximal tibial resection, distal femoral resection, measurement of femoral component, knee flexion, device insertion, knee balancing, cutting guide placement, anterior posterior femoral resection, and prosthesis implantation. All trances osteotomy were measured using a caliper to the tibial femoral contact point. We note the thickness of the tibial trances: medial tibia (MT) and lateral tibia (LT). After creating the space in extension, the surgeon considered the thickness of the meniscus (M) as the thickest that fits under a manual maximum distraction. It was inserted together with LBMS into the joint space in flexion of 90°. At that moment ligamentous tension was adjusted with a torque screwdriver. First we have achieved a maximal opening up, respectively the maximum stress on lateral collateral ligament to prevent the phenomenon of stress relaxation. Then we relaxed the device and achieved ligament balance. This was seen on the display. It noted the applied torque. The absolute force applied to the joints was calculated based on calibration.

Statistical analysis
Statistical analysis focused on the applied force. We studied the influence of various parameters on the force. These were anthropomorphic (height, weight, body moment), radiological (HKA angle, alpha, beta, tibial slope), clinical (flexion, extension), intraoperative and prosthetics (femoral and tibial size) data. Intraoperative parameters were MT, LT, M; medial / lateral opening MO / LO, where the opening is defined as the difference between the thickness of meniscus and the amount of resected bone; tibial tilt (TT) as the difference between the amount of resected bone at lateral tibia (LT) and medial tibia (MT), respectively (fig. 2). The relationship be-

Fig. 2. Intraoperative parameters
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tween the force and different parameters were analyzed using SPSS software. We used bivariate correlation tests, partial correlation, and ANOVA.

RESULTS
When placing the pressure sensor, the pressure was always higher in the medial compartment. Opening the lateral side allowed the two pressures to equalize. Balancing force was different for each patient with an average of 200 ± 124 N, range 72 to 699 N. As the values did not follow Gaussian distribution, the normalization was done by logarithms. The factors that showed a statistical correlation level of 0.01 were in the order of correlation coefficient: tibial tilt (TT), HKA angle, and femoral component size. The greater the tilt more force is required (fig.3). From the partial correlation analysis we found that this is largely due HKA angle, as between TT and HKA there is dependence.

As to the influence of joint line height, ANOVA tests revealed a significant positive/negative relationship between medial/lateral opening (MO/LO) and the force. However, the size of the meniscus (M), thus implant thickness did not correlate with the opening force.

Fig. 3. Correlation between inclination of the tibia (TT) and force F

DISCUSSION
This study suggests the need of using customized force. This seems to come naturally: every individual is unique, with specific parameters. But our findings are in conflict with other studies that use fixed force. Its value derives from their experience in calculating the force needed to
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open the joint space and required to insert total knee prosthesis (12). Even our study did not show an influence of implant thickness on the tension force. But the collateral ligaments have coefficients of elongation that differ from individual to individual. So, a fixed force will cause different openings in different patients. Based on these results, we aimed at finding the factors that influence the amount of force and how many of them are operator controlled or can be controlled. During surgery, the surgeon makes three balance-related gestures: ligamentous release, tibial osteotomy, and meniscus thickness choice. The first gesture is completely subjective. The other two change the joint line height and by default the size space. There are studies that show that if, in the same patient, we apply larger forces we get larger spaces (6, 16). The converse is also true: choosing the thicker meniscus ligament will generate higher tensions. Not only the meniscus thickness is important, but also the amount of resected bone. This explains the positive correlation between force and medial opening. However, lateral opening correlates negatively with force. The logic of these findings is revealed by tibial tilt. For the same elevation of the joint line, a greater tilt of the tibia suggests a greater imbalance between ligaments resulting from osteotomy. Tibia inclination reflects the joint form, a result of the wear process (HKA angle), or its anatomy (posterior - condylar angle). Partial correlation test confirms the dependence of tibia tilt (TT) and wear joint described by HKA angle. However, there is no a strong relationship between the tibia tilt and the tension, probably due to the influence of other unrated factors.

CONCLUSIONS
We find that the ligamentous tension force is individual. It is partly influenced by morphological features, but it cannot be determined preoperatively, this requiring the use of appropriate tensioning devices.

REFERENCES
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**NEWS**

**DEVELOPMENTAL DELAY IN FRONTAL REGIONS OF THE BRAIN IN CHILDREN WITH ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD)**

In a study by Shaw et al regarding the cortical anomalies underpinning attention-deficit/hyperactivity disorder (ADHD), 234 children with ADHD and 231 normally developing children were examined and 837 neuroanatomic magnetic resonance images were acquired. The purpose of the study was to see if the delayed maturation of prefrontal cortical thickness, characteristic for ADHD, also extends to the maturation of cortical surface area and gyrification. The study found that surface area developmental trajectory was delayed in ADHD. According to the researchers, the median age by which 50% of cortical vertices attained peak area in the right prefrontal cortex, was 14.6 years in ADHD, significantly later than in normally developing children at 12.7 years (Shaw P, Malek M, Watson B, Sharp W, Evans A, Greenstein D. Development of cortical surface area and gyrification in attention-deficit/hyperactivity disorder. *Biol Psychiatry* 2012; 72(3): 191-7).

*Teodora Vremera*