

Use of strain gauge in the evaluation of the constraint of tibio-femoral joint in dynamic movement: Development, feasibility and first results

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INTRODUCTION

The mechanism behind medial or lateral tibio-femoral gonarthrosis remains partially unexplained [1]. According to Maquet's theories, the surgical treatment of this pathology seems to give good results [3]. However poor results are observed in more or less 25 % of the cases. It is true that the cartilaginous and osseous lesions of this pathology can explain the long-term pain. The purpose of this work was the development of a new method to record in-vitro tibio-femoral variations of the constraints, during dynamic flexion-extension movement of the knee. Further goals behind this study include analysis of the constraint variations during 3D low femoral osteotomy.

METHODS

Specimens: Five fresh human right lower limbs were used (Age: $84,2 \pm 8,7$; 4 men, 2 women). Each limb was thawed during 24 hours before preparation: - dissection of thigh



muscles; - replacement of muscle tendons by fishing wires for loading (240N on each head of quadriceps and 75N for all flexors). The specimens were placed on a metal bracket allowing their fixing in the hip and femoral bone (Figure 1).

Figure 1: Experimental setup

Strains gauges (SG): Six SGs (FCA-1-17, \varnothing 4.5 mm, 120 Ω , TML) were molded in epoxy resin (LX 112) to obtain sensors that were inserted into the spongy bone of the tibial proximal epiphysis in anterior, posterior and lateral locations of both tibial condyles perpendicular to the cartilaginous surface. The SGs were inserted about 10 mm below the edge of the tibial plateau and below the articular cartilage.

Data logger: Twelve gauges amplifiers were built. These modules consist of low-pass filters and different gains to allow increasing of the sensitivity of the SGs. The amplifiers were connected to a Pc-Data acquisition board Dap2003a (DAP, National Instruments).

Protocol: Cycles of two movements of leg flexion-extension were applied manually. An 6 DOF-electrogoniometer [2] sampled tibio-femoral kinematics, and allowed to normalize results according to the range of motion. Three repetitions were carried out for each specimen. Intra- and inter-observer reproducibility was studied on one specimen. Three observers performed 10 motion cycles at three intervals of time.

RESULTS AND DISCUSSION

Intra- and inter- observer reproducibility: the Root Mean

Square (RMS) difference to the mean curve was compared. The results show small differences between observers and repetitions, compared to the maximal peak value of 3 N/cm² (Table 1).

Table 1: Intra- and inter- observer RMS differences for SG 1

	Experimenter 1	Experimenter 2	Experimenter 3
Intra (N/cm ²)	0.08 to 0.25	0.06 to 0.15	0.05 to 0.09
Inter (N/cm ²)	0.08 to 0.25		

Inter-individual variations: Figure 2 shows the interindividual variability obtained for SG 1. Results also depend on the quality of the spongy bone [4] and the placement of the sensors.

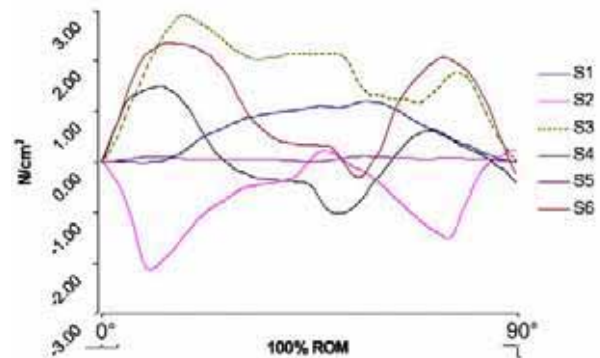


Figure 2: Interindividual variations

CONCLUSIONS

This study shows the feasibility of analyzing articular constraint variations during dynamic movements. Reproducibility of measurements was satisfactory, and a significant inter-individual variability was found. This reinforces the idea to use this technique to study the changes of joint constraints before and after knee surgical procedures (e.g., osteotomy). Such a study is currently being performed by the authors.

REFERENCES

- Goutallier D, et al.. *Rev Chir Orthop* **83**, 613-621, 1997.
- Sholukha V, et al.. *Med Eng Phys* **26(3)**, 251-260, 2004.
- Aglietti P, et al.. *Am J Knee Surg***13(2)**, 89-95, 2000.
- Khodadadyan-Kostermann C, et al.. *Clin Biomech*, **19**, 370-376, 2004.

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