A NEW METHOD FOR MEASURING KNEE JOINT LAXITY

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A NEW METHOD FOR MEASURING KNEE JOINT LAXITY

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INTRODUCTION

Knee joint laxity is a subject of great interest in research and orthopedics. However, the current methods for assessing laxity features several limitations e.g. non-quantifiable loads, soft-tissue artifacts and/or one-dimensionality [1]. Until now, the only methods not affected by any of those limitations have been invasive measures primarily performed intraoperatively. We propose a non-invasive method to accurately measure knee joint laxity in 3D.

METHODS

A device composed of a parallel manipulator and a multi-axis force/moment sensor have been developed. The device is capable of imposing multidirectional loads to the knee joint through a mounting unit. The device is designed to be used in conjunction with a low-dose biplanar x-ray system and 3D image data in order to track tibiofemoral kinematics under applied loads.

As proof-of-concept a cadaveric knee (female, age 73) was CT scanned (SOMATOM Definition Flash, Siemens) and subsequently mounted at 30 degrees of flexion in the device and placed inside a biplanar x-ray scanner (EOS, EOS imaging, France). Biplanar x-rays were obtained for eleven static load cases: anteroposterior loading (67 N, 134 N, -67 N and -134 N), mediolateral loading (12 N, 24 N, -12 N and -24 N) and internal/external moment (3 Nm, 6 Nm and -3 Nm). Subsequently, 3D bone geometry of femur and tibia were segmented from the CT image using Mimics (Materialise, Belgium). Bone position for each load case was reconstruction by registering the 3D bone geometry onto the biplanar x-ray images using an iterative closest point match between contours of the x-ray images and projected contours of the bone onto the image planes using Matlab (Mathworks, USA). The relative translations and rotations between the reconstructed tibia and femur were computed in AnyBody Modeling System (AnyBody technology, Denmark) following ISB recommendations.

RESULTS AND DISCUSSION

The primary tibiofemoral translation and rotation from the eleven different load cases is presented in Figure 1. Anteroposterior loading of 67 N, 134 N, -67 N and -134 N resulted in an anteroposterior translation of 3.49 mm, 4.22 mm, -6.55 mm and -7.87 mm respectively. Mediolateral loading of 12 N, 24 N, -12 N and -24 N resulted in a mediolateral translation of 3.11 mm, 4.17 mm, -2.46 mm and -5.48 mm respectively. Internal/external moment of 3 Nm, 6 Nm and -3 Nm resulted in an internal/external rotation of 10.15°, 12.72° and -20.23° respectively.

This method is combining concepts from robotic arthrometry and stress radiography into one unified solution that potentially enables unprecedented 3D joint laxity measurements non-invasively. However, the method is still under development and several aspects must be improved and validated before it becomes clinically relevant.

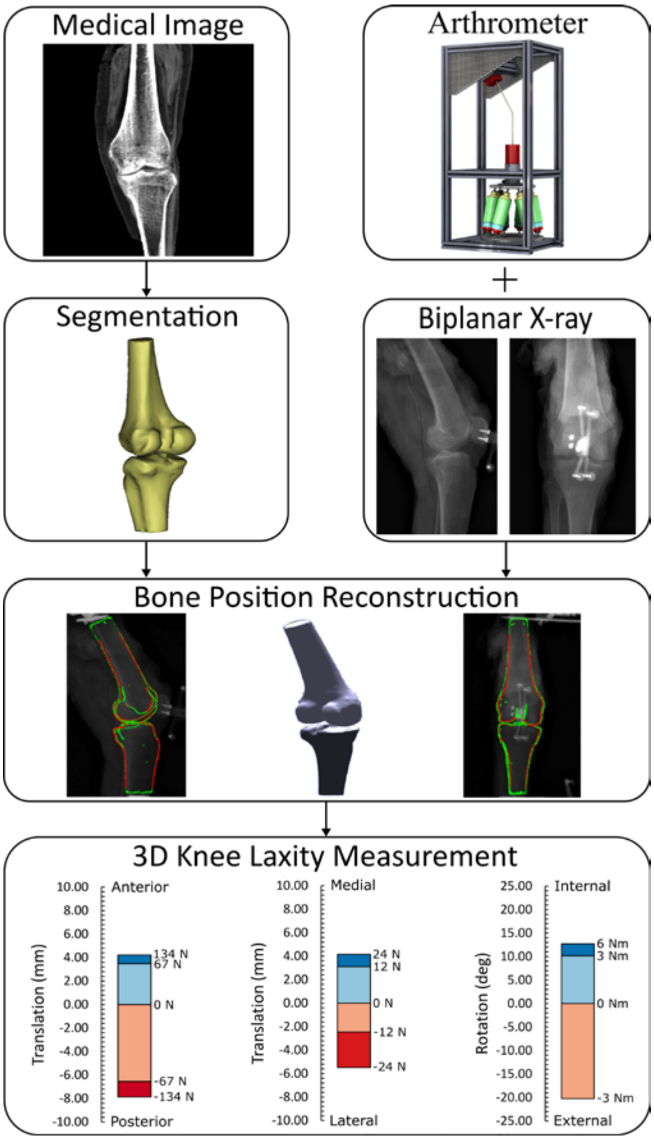

Figure 1: A flowchart representing the different processes in the proposed method. Included in the bottom of the figure are graphs displaying the primary tibiofemoral translation (mm) and rotation (degrees) in the different load cases.

CONCLUSIONS

We have displayed that the presented method is capable of obtaining knee joint laxity in 3D. The method enables advanced assessment of knee joint laxity and the interplay between ligaments. Furthermore, it may be used to improve subject-specificity of musculoskeletal models.

ACKNOWLEDGEMENTS

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REFERENCES

1. Musahl V, et al, Springer International Publishing, 2017

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