CLINICAL THREE-DIMENSIONAL MOTION ANALYSIS OF THE UPPER LIMB

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SUMMARY
The purpose of this paper is to present a protocol for shoulder complex clinical evaluation using optoelectronic motion analysis device, palpation approach and medical imaging. The 3D shoulder kinematics implies quantification of rotations of the clavicula, scapula, humerus bones relative to the thorax (bone rotations) or rotations between adjacent bones (joint rotations). The precision and accuracy of 3D evaluation techniques are required to give results with confidence. The reproducibility of palpation and the propagation of palpation error on movements performed by the same examiner were also estimated.

METHODS
The data of one healthy subject was presented to explain the data fusion methodology. The volunteer was seated. An optoelectronic stereophotogrammetric system (8 cameras Vicon 612, UK) was used for data acquisition. First, in the anatomical landmarks calibration step, we built technical frames (TFs) attached to thorax, scapula and arm from marker clusters which have no relation with the underlying bones. For the scapula, six anatomical landmarks (ALs) were palpated by the examiner and these AL coordinates were expressed in their local technical frame. These ALs allow building the anatomical reference frames.

INTRODUCTION
The evaluation of shoulder range of motion is one aspect of the physical examination in patients with shoulder complaints. This shoulder complex remains difficult to document in clinics with a highly variable reliability between various estimated movements and between examiners. The 3D shoulder kinematics implies quantification of rotations of the clavicula, scapula, humerus bones relative to the thorax (bone rotations) or rotations between adjacent bones (joint rotations). The precision and accuracy of 3D evaluation techniques are required to give results with confidence. To ensure patient follow-up, kinematic analysis must be repeatable and reproducible between days. Previously, a new technique of anatomical landmark (AL) palpation using a newly-developed finger gauntlet including a technical frame (TF) was developed to study the 3D shoulder joint kinematics. The precision and accuracy of this method of shoulder AL calibration have been previously evaluated.

In summary, we can visualize the fusion output of all data (kinematics, medical imaging, EMG,..) of a subject specific MAF library (www.openmaf.org). In the case of clinical setting, we can use and register bone models extracted from a database. The same methodology is now applied in patients and we will show an example of an adult patient with a Brachial Plexus Birth Palsy before surgery.
RESULTS AND DISCUSSION
All available data were inputted in the software hierarchy (Fig. 1A) and fused. Bone rotations (relative to the thorax) are shown together with the real-time motion representation. Results for the humero thoracic and glenohumeral joints are shown (Fig 1B and Fig. 1C, respectively). On Fig 1B, the camera is attached to thorax and on Fig 1C attached to scapula allowing to appreciate the glenohumeral mobility. From these data, the scapulo humeral rhythm is assessed.

CONCLUSIONS
The above protocol is very promising and the next step is to include muscle lines-of-action of muscle and EMG (similar to the paper “Data customization pipeline for in-vivo motion analysis and modelling” also presented at ISB2011).

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REFERENCES

Figure 1. This subject-specific model includes all heterogeneous data collected. Different aspects of upper limb kinematics 
are visible on animated surface and biomechanical views (see text for details).