EVALUATION OF 3D RECONSTRUCTION OF THE RIB CAGE FROM BIPLANAR RADIOGRAPHY

David Mitton¹, Maxime Chauvet¹², Sébastien Laporte¹, Chao Yang², Samuel Bertrand¹, Kristin Zhao², Chunfeng Zhao², Kai-Nan. An² and Wafa Skalli¹

¹ Laboratory of Biomechanics ENSAM-CNRS UMR 8005, Paris, FRANCE
² Biomechanics Laboratory, MAYO Clinic, Rochester, MN, USA

INTRODUCTION

A three-dimensional personalized geometrical model of the rib cage is essential for clinical evaluation or for personalized biomechanical finite element modelling (Le Borgne et al. 1998). The 3D information could be obtained by CT-Scan but with a high irradiation dose for the patient. In the specific case of the rib cage, a method based on two antero-posterior views at 20° from each other was previously developed (Dansereau and Stokes 1988). 3D reconstructions based on frontal and lateral radiographs have been applied to the spine (Mitton et al. 2000) and knee (Laporte et al. 2003). The method for the knee is based on contour identification in the X-rays and is called NSCC (Non Stereo Corresponding Contours). More recently, this method was also applied to the rib cage (Laporte et al. 2004).

The purpose of this study was to evaluate the accuracy of this method when applied to the rib cage as compared to CT-scan reconstructions.

METHODS

One fresh cadaveric spine, from vertebrae T3 to L4, was removed of soft tissue and organs. The rib cage, with ligaments and muscles intact, was harvested. T3 and L4 were mounted and fixed to a custom designed stereoradiography apparatus via bone cement. Lateral and frontal radiographs were obtained. The rib cages were then scanned in a CT-scan device (GE Medical System, USA) at Mayo Clinic (Rochester, MN, USA) with 1.3 mm consecutive slices. The 3D reconstruction was performed using the SliceOmatic® software. The accuracy of this technique was evaluated to ± 1mm (Landry et al. 1997).

Eighteen ribs were reconstructed using a method based on biplanar X-rays (frontal and lateral views) with the following steps:

1) calibration of the biplanar radiographic environment (Dumas et al 2003).
2) 3D reconstruction of the whole spine (Pomero et al. 2004).
3) identification of 2D contours in the X-rays.
4) 3D reconstruction using NSCC method (Laporte et al. 2004).

3D reconstructions were performed with a custom software package developed in collaboration between the Laboratoire de recherche en imagerie et orthopédie, (ETS - CRCHUM, Montréal, Canada) and the Laboratoire de biomécanique (CNRS-ENSAM, Paris, France).

The reconstructions obtained from the frontal and lateral X-rays were compared to the gold standard ,CT-scan results (semi-automatic reconstruction).

The comparison between the two modalities was based on parameters computation. For example, the chord length and the maximal
width were computed from biplanar X-rays and CT-scan for each rib.

![Diagram of rib parameters: chord, rib midline, maximal width.]

Figure 1: Rib parameters evaluated on both 3D reconstructions

**RESULTS AND DISCUSSION**

The reconstruction from biplanar X-rays is given as an example (Figure 1). The comparison results are given for the chord length and the maximal width (Table 1).

![3D reconstruction obtained from frontal and lateral X-rays.]

Figure 1: 3D reconstruction obtained from frontal and lateral X-rays.

| Table 1: Differences between biplanar radiographic reconstructions and CT-scan ones. |
|---------------------------------|-----------------|-----------------|
|                                | Mean (SD) mm    | Relative errors % |
| Chord length                   | 2.9 (3.6)       | 5               |
| Maximal width                  | 6.5 (5.5)       | 3               |

The personalized rib cage geometry can accurately be obtained from frontal and lateral X-rays. Because radiographs are commonly obtained in the clinic, the patient would not need to be subjected to the additional radiation exposure with CT-scan evaluations.

**SUMMARY**

Personalized bone geometry is important both for developing successful clinical interventions and developing accurate finite element models. This study evaluated the accuracy of a method to obtain 3D personalized geometry of the rib cage using frontal and lateral X-rays. Results from the biplanar radiographs are similar to those from CT-scan semi-automatic reconstruction using millimetric slices (difference in chord length and maximal width are lower than 5%). This method has the added advantage of a lower radiation dose for the patient.

**REFERENCES**

Laporte S., Mitton D. et al. (2004) *Proceedings of the CARS*
Le Borgne P. Lavaste F. et al. (1998), *Proceedings of 4th IRSSD, Vermont, USA*

**ACKNOWLEDGEMENTS**

The authors wish to acknowledge M. Martinet for his important technical support.