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Title
Validation of a parametric model of scoliosis

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Summary
3D reconstruction of the spine is necessary data for the design of scoliosis brace by CAD.
The objective of this work is to validate the accuracy of a parametric reconstruction model by comparing it to the results obtained by stereophotogrammetry.

Introduction/ basics
The evaluation of brace design parameters on the effectiveness of correction of scoliotic deformities remains limited. The main reason is that it is ethically dubious to expose patient several times to X-rays. Finite Element Models (FEM) of the human trunk are used to overcome these limitations and better understand the biomechanics of braces. This approach remains dependent on a first X-ray and the time required for the 3D reconstruction of the patients personalized geometry (Desbiens-Blais, 2012). Stereo radiography requires specific X-rays imaging system or regular X-ray system with Direct Linear Transformation (DLT) calibration system. These reconstruction methods have the following limitations: 1) no integration of the external shape of the patient or poor integration giving internal/external collisions; 2) specific radiographic systems are required; 3) highly operator-dependent process that needs time and experience.

Material method; implementation/ process
The Parametric Model is computed for 78 scoliotic patients from an existing database. The modelisation is then compared to the spine reconstructions performed by stereo-radiography. All the data base is constituted of EOS X-rays radiographies of the front and profile of the patient. 2D landmarks were previously identified by one operator and controlled by one supervisor. The Parametric Model is initiated by the estimation of S1 and T1 positions on the external shape of the trunk. Then, for each of the patients, the scoliosis parameters requires

for the Parametric Model are extracted from the 2D radiographies. The error of the model is estimated by the comparison to the gold standard (stereo radiographic reconstruction). The positions of the vertebral bodies computed is compared in three dimensions.

Results

The results obtained for 10 subjects are provided on figure 1. The retroprojections of the 3D models on the radiographies show that the global description of the scoliosis is respected by the parametric model. The 3D comparison of the vertebral positions for the 78 patients of the database are given in figure 2. It seems that the difference of position of the vertebrae is greater on anteroposterior axis, 85% of the patients are within a confidence interval of 10mm. Percentage of patients, for the same confidence interval, are 95% and 99% respectively on the medio-lateral axis and the vertical axis.

Discussion/ conclusion; conclusion for the practice

A parametric model of the spine enriched by the 3D shape of the patient is a possible way to remove several limits to current methods of stereo radiographic reconstructions. The method is fast, does not require specific X-ray system and only needs 10 parameters from the operator. Compared to Desbiens-Blais publication (2012), it improves the accuracy of the registration of the spine in the trunk by integrating it directly into the parametric reconstruction. A drawback of the method is that it does not allow the individual vertebral deformation and therefore does not reflect well the local geometry of the vertebrae. The accuracy on the overall geometry of the spine depends on the context in which one wishes to use the system. The method can be used as part of the brace treatment of scoliosis with a confidence interval of 10mm.

References

Desbiens-Blais F, Clin J, Parent S, Labelle H, Aubin CE. New brace design combining CAD/CAM and biomechanical simulation for the treatment of adolescent idiopathic scoliosis. Clin Biomech (Bristol, Avon). 2012 Dec;27(10):999-1005.

Image: Fig1_271.png

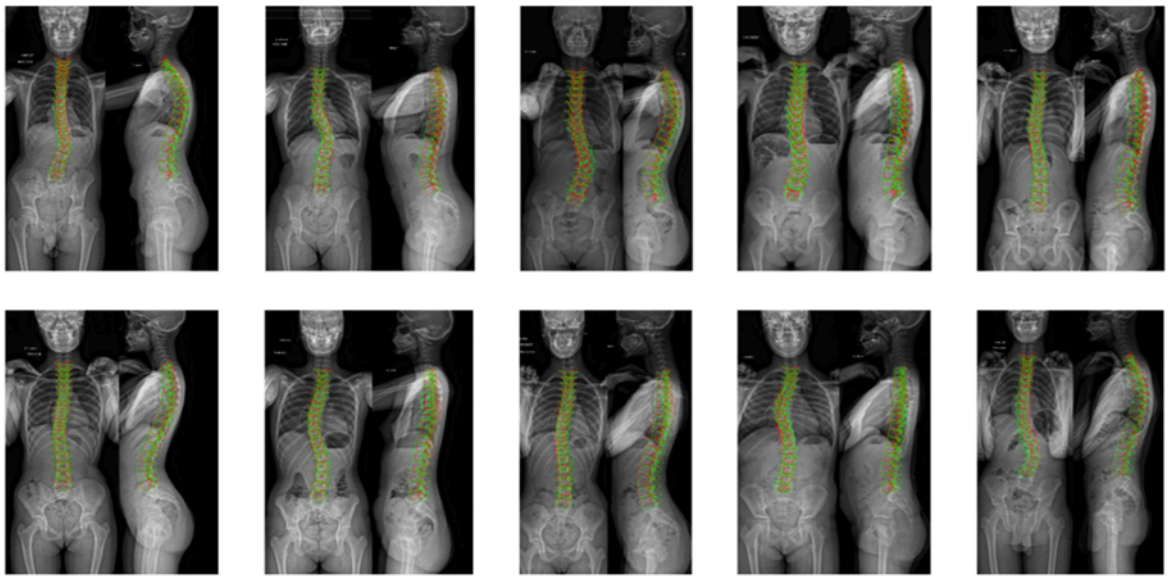

Figure 1 : Classical stereophotogrammetry for spine reconstruction (in green) vs parametric modelisation (in red)

Image: Fig2_272.png

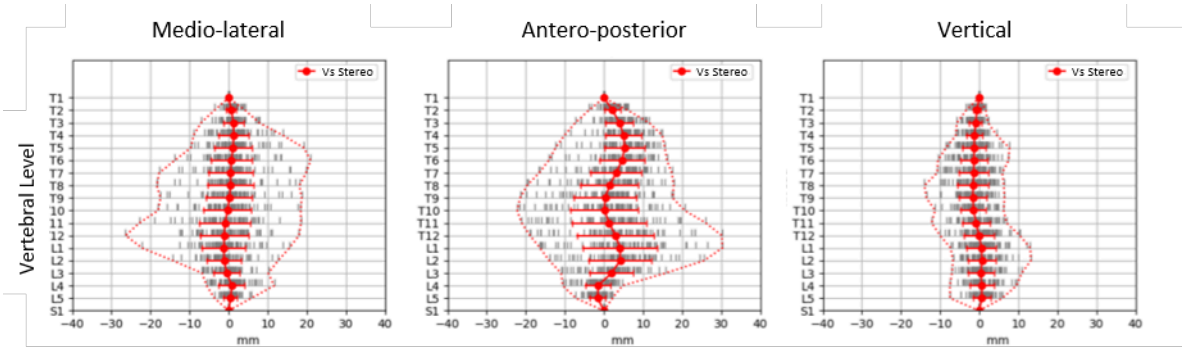

Figure 2 : Differences between classical stereophotogrammetry and the parametric modelisation in the three axis (medio-lateral; antero-posterior; vertical)