Geometric and Mechanical Resistance Simulation of Scoliosis Correction Prostheses

Introduction

Scoliosis is characterized by a curvature of the spinal cord in the anteroposterior plane, causing the body to become unbalanced. The main symptoms are shoulder height difference, one hip more raised than the other, uneven waist, leaning of the whole body to one side, and a prominence of the ribs, forming a bossa when the patient bends his body.

According to the type and severity of each case, scoliosis may require different kinds of treatments, namely posture exercises, use of special purpose vests, and for more complex cases, surgical intervention.

Scoliosis can have several causes, including genetics, neuromuscular problems or unequal length of the legs, but most cases have an unknown cause (idiopathic), which manifests in childhood or, more commonly, in adolescence. The symptoms may establish quickly, forcing a close surveillance of the patient, particularly during puberty. In the more severe forms, with angles of curvature greater than 45/50 degrees (Cobb angle), the only way to correct scoliosis is by surgery [1,2]. Scoliosis is estimated to affect about 12% of the population, causing a significant impact in the quality of life of patients.

The correction of scoliosis involves a difficult surgery with placement of prosthesis for fixing the position of the column in the estimated correct position. The surgical intervention is carried out based on some previous assessments, usually obtained by specific diagnosis means, such as CAT scans, MRI's and X-rays, among others. However there is no means to predict the correct physical and mechanical adjustments to be performed on the spinal cord during surgery. Furthermore, it is not possible to accurately calculate the impact of the strength involved over the patient tissues after prosthesis implantation. Currently, these procedures are being made by manual calculation and estimation, a process that is time-consuming and often leads to high levels of after surgery pain, bigger recovery times, and in worse cases, the need for a second correction surgery.

Objectives

The main objective of this project is to develop a process which enables the generation of virtual simulations of surgical procedures to be employed on patients suffering from scoliosis. The process should be able to simulate not just the specific phases of the surgical procedure to perform on the patient, but also the prosthesis to use and its correct appliance. The cosmetic result of the surgical procedure and the range of movements the patient will be able to perform after the surgery should also be estimated.

The most relevant data input for the simulation process is information collected from imaging diagnosis, such as CAT scans and MRI's, as well as data formats collected form several types of 3D scanners applied to the patient body. The former data input is a relevant topic of research in this proposal.

The main techniques to be employed in this project are 2D and 3D image processing, in order to analyse the collected data, and virtual reality techniques, for the simulation of the several predicting aspects.

The final practical deliverable of this proposal is a prototype implementing the virtual simulation process described. The prototype will be tested in laboratory with by scoliosis patients with scheduled surgery. This will enable the evaluation of the correctness of the investigated process as well as the assessment of its practical feasibility as a common practice in medicine.

Bibliography

[1] BENZEL, Edward C., Biomechanics of Spine Stabilization, 1995, McGraw-Hill, ISBN 0-07-005091-0, Berkley

[2] Maruyama, T. and Takeshita, K. (2008), Surgical Treatment of Scoliosis: a review of techniques currently applied. ScoliosisJournal, Tokyo, Japan, BioMed Central, 3(6): 1-16.

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