Design and Validation of a Synthetic Pediatric Spinal Simulator for Tethered Cord Syndrome

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Introduction

Simulation is becoming an important part of medical education as part of tbe complex process aiming to improve patient safety. Simulators have already been presented for a variety of neurosurgical procedures such as: third-ventriculostomy, foramen ovale puncture, skull base endoscopic endonasal surgery as well as other virtual computer-based systems. Nevertheless spine simulators are still at their infancy and at the present moment there is no available simulator for congenital spinal pathologies.

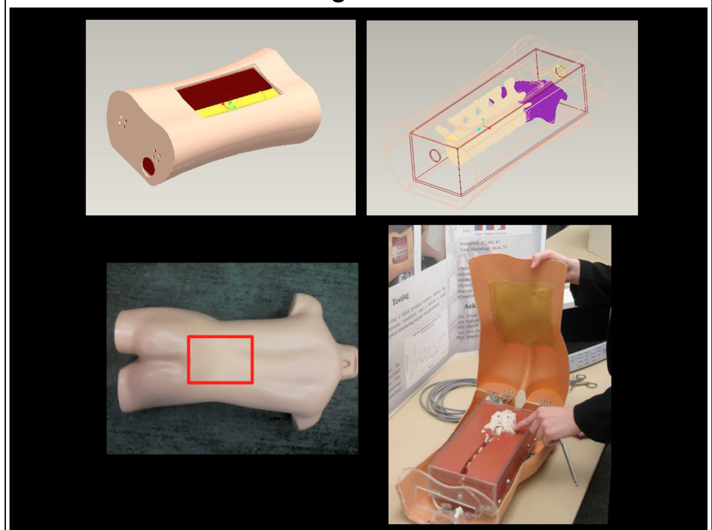
Methods

The bony elements of the pediatric (one and five-years old) spines were fabricated using rapid prototype machines with basis on CT-scan (DICOM) images (Figure 1). In order to simulate soft tissues such as skin, fat and muscle the authors evaluated and selected synthetic materials commercially available that most closely simulated the haptic feedback of the 'in-vivo' tissue (Figure 2). The artificial filum terminale connected to the distal portion of the spinal cord was attached to the dura with different types of glues in order to simulate progressively more challenging levels of spinal cord tethering (Figure 3). A pressure transducer and a motion detector were used to evaluate the degree of manipulation of the spinal cord.

Results

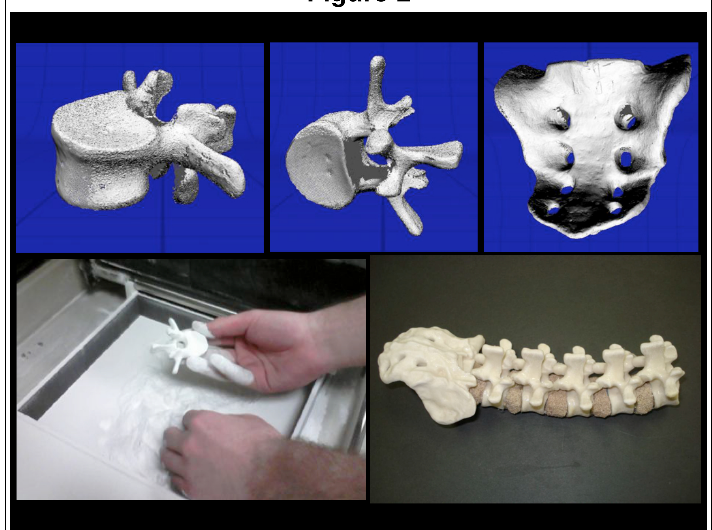
Trainee performance variables such as timing and degree of manipulation were recorded. The authors correlate such variable with interfering factors such as fatigue, number of repetitions of the task and trainee experience based on PGY level. A throughout analysis of the microsurgical technique of each video was performed by a board-certified pediatric neurosurgeon.

Figure 2



Computer-simulated design (upper); retail mannequin and final prototype (bottom).

Figure 1

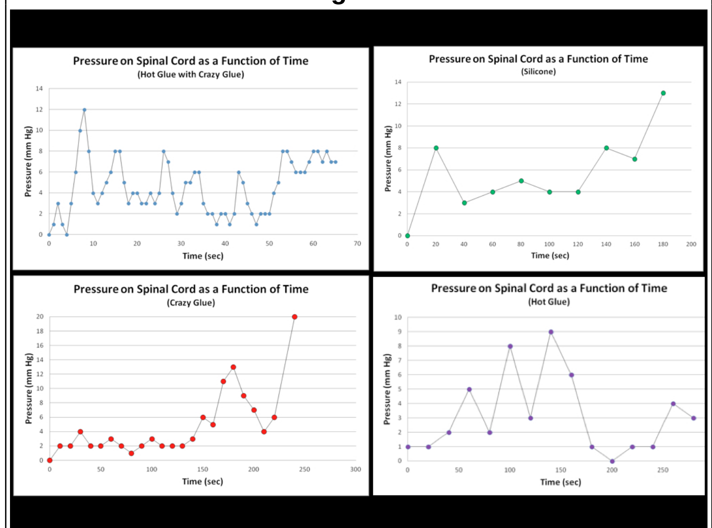


3D scanning of lumbar and sacral vertebrae from CT-scans, rapid prototyping using elastomeric powder and final model

Conclusions

The authors successfully built and tested a spinal cord detethering model. The proposed model has been able to sucessfully simulate different levels of spinal cord tethering (as measured by motion and pressure analysis) and, therefore, provide a significant contribution for pediatric neurosurgical education.

Figure 3



Graphics depicting the pressure needed to detach the dura from the spinal cord in a thirty seconds simulation with 4 different types of adhesives.

References

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