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SIMULATION OF SPINE SURGERY : MECHANICAL QUANTIFICATION OF SURGICAL REVISION RISK

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1. Introduction

Adolescent idiopathic scoliosis (AIS) when unstable, requires surgical treatment by vertebral arthrodesis. Choice of instrumented levels [1] and sagittal shape are still empirical. An innovative energetic model was implemented to explore AIS in a patient-specific image-based approach [2]. In the presented study, post-operative responses of vertebral segments remaining free were examined and an energy-based revision criterion was proposed.

2. Materials and Methods

The 3D wireframe model of spine is based on the equilibrium by mechanical energy minimization. The numerical inverse algorithm determines equivalent vertebral segments properties from preoperative biplanar X-ray exam (EOS®).

Design parameters of surgical planning are instrumented length, sagittal shape and surgery reduction. Energy distribution along the corrected spine is obtained using the direct problem resolution [2] and energies of free vertebral segments adjacent to arthrodesis are used to propose the revision criterion. The upper and lower instrumented vertebrae are involved, i.e. UIV and LIV. To explore this innovative approach, a monocentric retrospective study of 18 patients was performed. The cohort includes four patients requiring revision because of either “adding-on” or proximal junctional kyphosis (PJK).

3. Results

Computation time for inverse problem was around 1h, and the surgery simulation took around 1 minute. Summed UIV and LIV energies in frontal vs sagittal plane is shown figure 1 and difference is significant between

patients with or without revision ($p < 0.01$). Revision cases showed energy peaks in both planes at the junction between instrumentation and free segments.

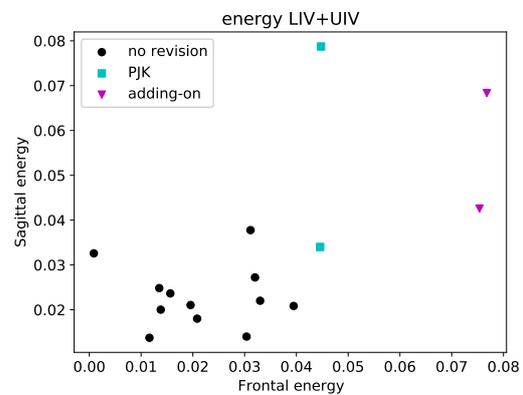


Figure 1: Frontal versus sagittal summed strain energy of LIV and UIV segments. No revision group is in black and revision group in color.

4. Discussion and Conclusions

An innovative spine model based upon energy balance was faced to an AIS cohort to predict post-operative surgery outcomes. It appeared that strain energies at arthrodesis extremities was a good predictor of post-operative instability and revision risk.

The robustness of our preliminary results could be enhanced by a larger multicenter cohort that would support preoperative planning for clinical teams.

5. References

1. Compagnon R et al., OTSR. Vol 108, Iss 6, 2022.
2. Brun-Cottan B et al., Biomechanic and modeling in mecanobiology. 20,359-370 (2021).

Acknowledgments:

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