
# AN INNOVATIVE ENERGY METHOD TO INFORM SURGICAL PLANNING OF ADOLESCENT IDIOPATHIC SCOLIOSIS

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## 1. Introduction

Despite the critical role of surgery in managing adolescent idiopathic scoliosis (AIS), the choice of instrumented levels and the sagittal balance remains challenging [1]. We proposed an image-driven energetic model [2] to reduce empiricism. The objective is to simulate the impact of the instrumentation length, *ie.* the choice of lower and upper instrumented vertebra (LIV and UIV), on the spine response.

## 2. Materials and Methods

The 3D wire-frame model of the spine was obtained from the mechanical energy minimization using inverse algorithm and by preoperative biplanar X-rays (EOS®) [2], figures 1(a,b). Surgery simulation inputs are preoperative stiffness parameters, instrumented length, sagittal shape, and LIV and UIV angles, figure 1(c). Perfect balance is the alignment of vertebral bodies along the vertical axis of the frontal plane. Evaluation of the simulated surgery balance is defined by the residual area A between non instrumented vertebrae and the first thoracic vertebra - sacrum T1-S1 axis, figures 1(d,e,f).

## 3. Results

The methodology enabled us to simulate various instrumentation lengths in few seconds using the 3D wireframe model and the input inverse problem results [2] obtained in about one hour on 10 CPU cores (Intel Xeon w7-3545). The predictive model gives a correlation between LIV variations and predicted area A. Figure 1(c) shows that simulated (blue) and post-operative (red) results are in good agreement for a T4–L1 thoracic-lumbar surgery. Figures 1(e,f) illustrate the LIV variations, respectively the T4-L2 and T4-T12 simulations and compared to the T4-L1 post-operative simulated geometry as reference (d). Notably, the area A increases with instrumented length, measuring 940 mm$^2$, 1348 mm$^2$ and 1796 mm$^2$. This result showed retrospectively that a shorter surgical strategy could have improved the spine balance.

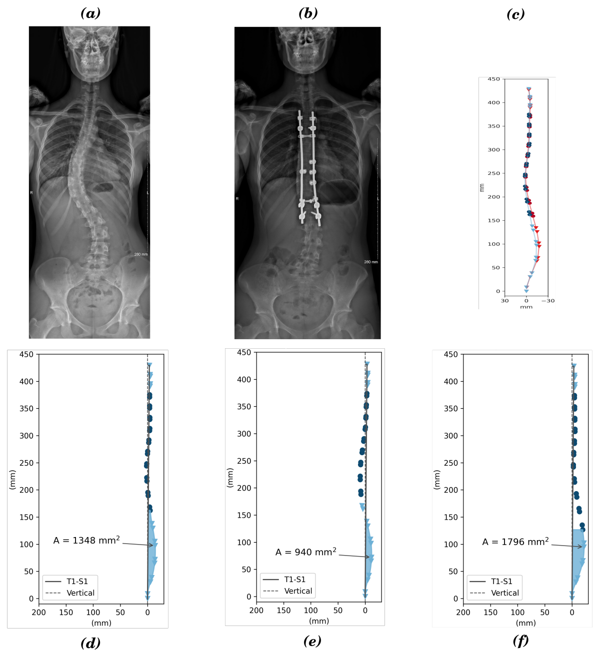


Figure 1: (a) Pre-operative frontal X-rays. (b) Post-operative frontal X-rays. (c) Comparison of the extracted geometry from (b) with T4–L1 instrumentation (red) and surgical simulation (blue) in the frontal plane. (d–f) Comparison of area A for three instrumentation simulations: T4–L1 (d), T4–T12 (e) and T4–L2 (f).

## 4. Discussion and Conclusions

These preliminary findings pave the way for further refinement of our predictive model and the development of an effective decision-support tool (Spinergy®). Ultimately, such a tool could assist surgeons in optimally selecting the number of instrumented levels, thereby improving surgical outcomes and patient well-being.

## 5. References

1. Compagnon, R. et al., Orthopaedics & Traumatology: Surgery & Research, Volume 108, Issue 6, 2022.
2. Brun-Cottan, B. et al., *Biomechanic and modeling in mecanobiology.* 20, 359–370, 2021.

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