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Applying 3D Modelling and Numerical Simulation Techniques for Precise Orthotic Design in Scoliosis Treatment

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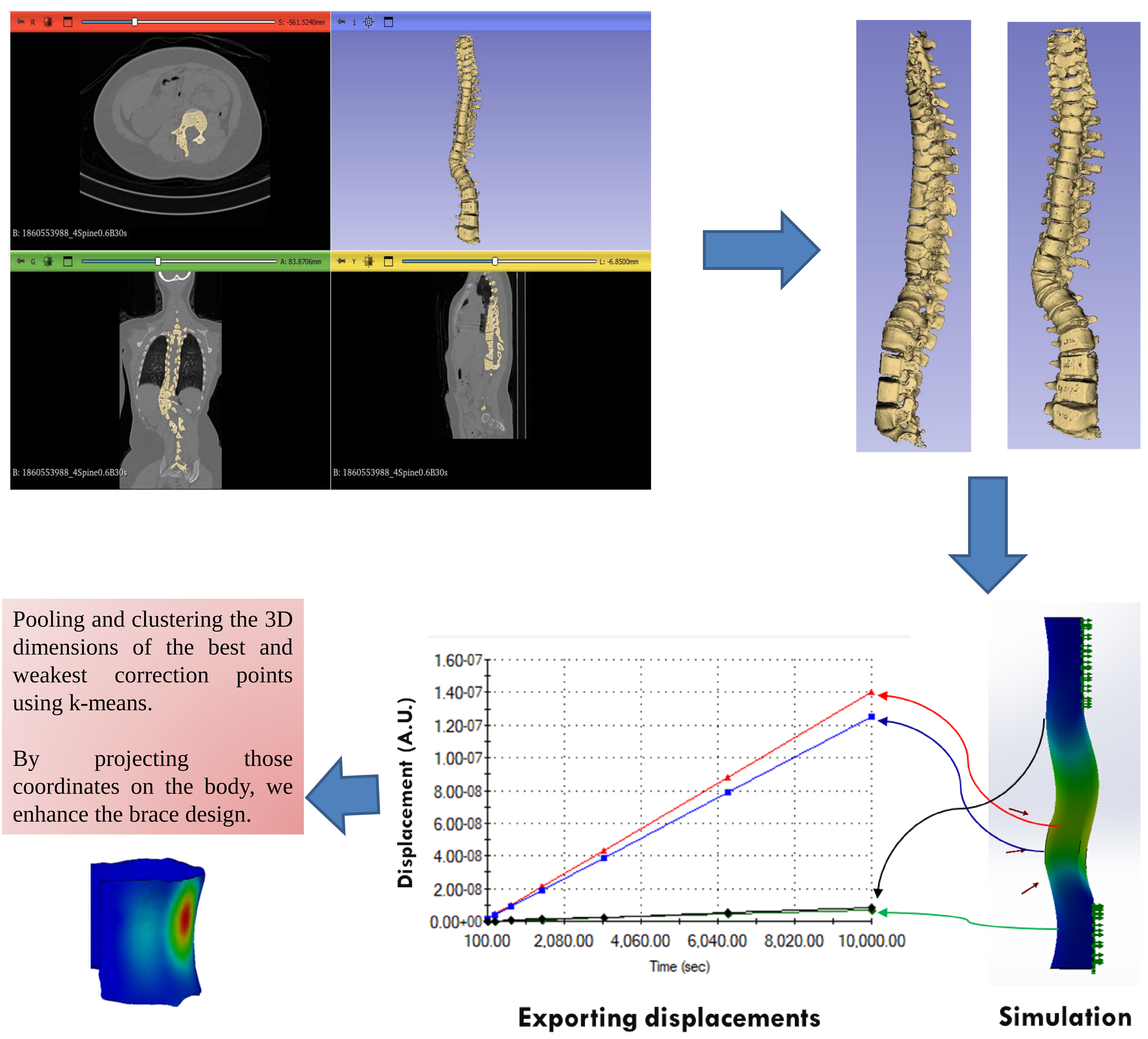
INTRODUCTION

Scoliosis is a three-dimensional deformity of the trunk and spine that can develop significantly during growth stages. Recently, computer-aided design has played a crucial role in various physical rehabilitation and orthotic applications. This study focuses on designing medical orthotics using 3D modelling and force simulation techniques, aiming to improve the accuracy and effectiveness of scoliosis treatments.

The approach starts by reconstructing a 3D model of the scoliosis case using computed tomography (CT) data and then employs Solidworks software to analyse and simulate the mechanical properties. The numerical simulation of applying different pressure points with varying values generates a comprehensive dataset of curves that express the spine's deformity, simulating correction using different braces with distinct pressure points in Solidworks. By selecting the optimal pressure points in various planes, we were able to manufacture a precise 3D model that addresses scoliosis based on pre-examined pressure points.

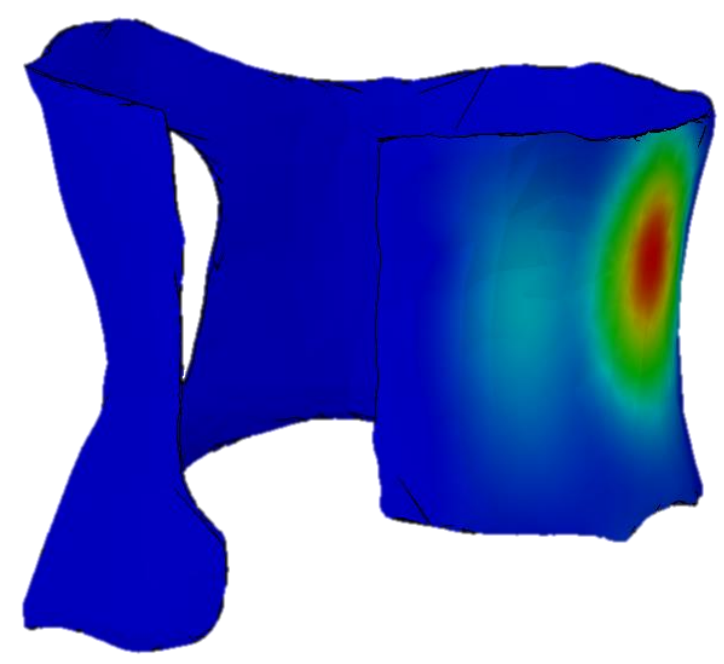
METHOD

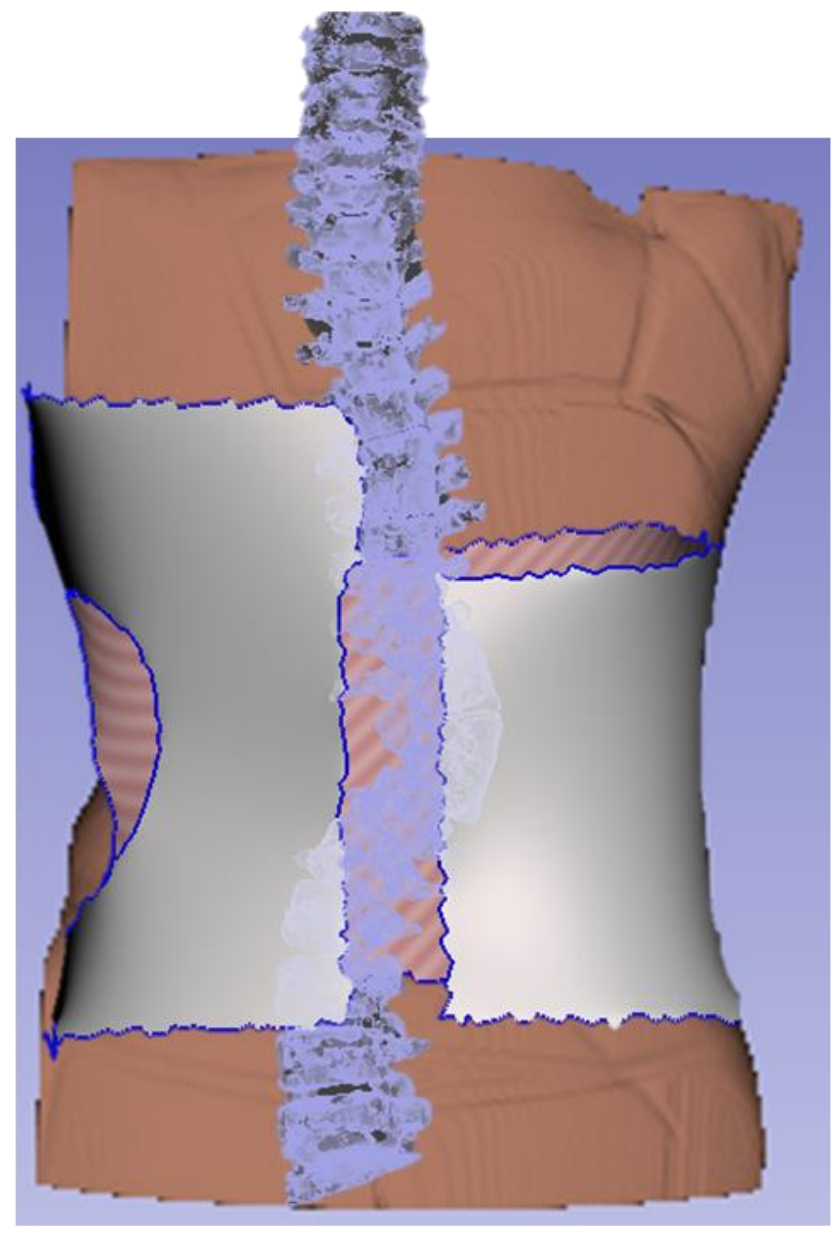
The process begins with the 3D reconstruction of the patient's spine from medical imaging data. SolidWorks is used to identify and analyze critical correction points through k-means clustering and to simulate the spine's response to different force applications. The results guide the design of a customized brace that targets the most curved areas, ensuring that the necessary corrective forces are applied to realign the spine effectively.



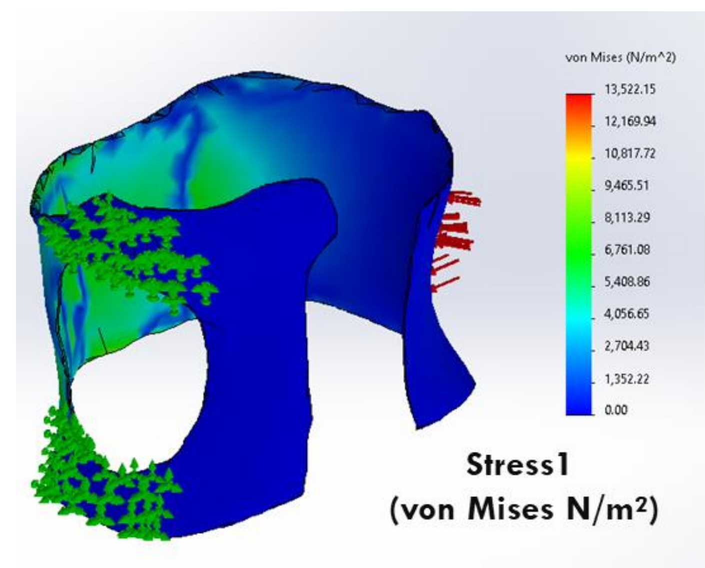
RESULTS

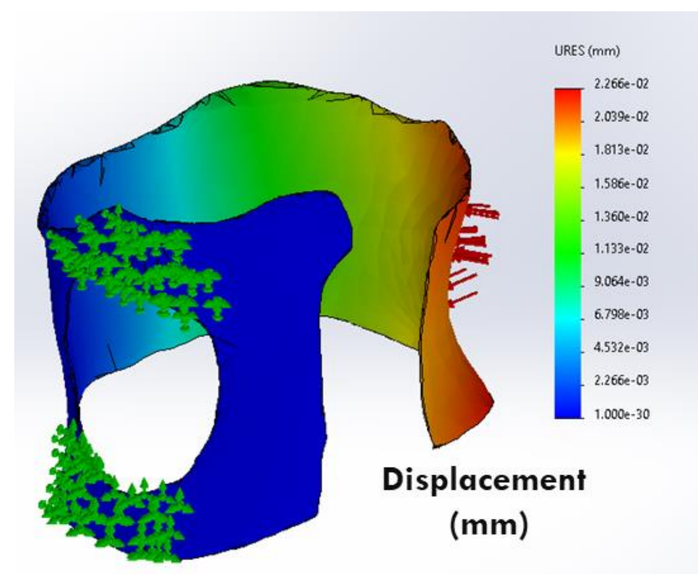
As shown below, on the left, the clustered data shows the regions where corrective forces are most effective, with red areas indicating optimal points for applying pressure based on power and coordinates. On the right, this information has been used to design a prototype brace, reflecting the shape and contours needed to apply the targeted forces accurately on the patient's torso. This ensures that the brace is tailored to the specific correction needs derived from the clustered data, optimizing the performance of correction in realigning the spine.





A static analysis of a scoliosis brace was performed using finite element analysis software to determine its ability to withstand loads and forces while being worn by the patient.





CONCLUSION

This study demonstrates that combining engineering and medical technologies can significantly enhance the quality of treatment and effectively meet patients' needs. Furthermore, advancements in 3D printing technology enable the production of highly accurate and customized orthotic devices, ensuring a perfect fit for each patient's unique anatomical structure.

FUTURE WORK

The integration of deep artificial neural networks could further refine the design process, enabling the reconstruction of appropriate scoliosis braces based on extensive data analysis and predictive modeling.