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Cervical Spine Stability: Segmental vs. Multi-Level Plating

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BACKGROUND

Spinal conditions like Degenerative Disc Disease and Osteoporosis cause instability, pain, and nerve complications. Anterior Cervical Discectomy and Fusion (ACDF) restores stability using interbody implants and anterior cervical plates, which must withstand physiological loads to prevent failure. This research evaluates the mechanical performance and reliability of differing constructs of these plates under various loading conditions.

PROBLEM STATEMENT

There is limited understanding of the mechanical differences between multi-level cervical plating and stacked segmental constructs, including their impact on stress distribution and failure modes, requiring further investigation.

OBJECTIVE

Establish test protocols and design custom test fixtures, guided by ASTM F1717 principles, to evaluate multi-level and stacked segmental cervical plate systems under static compression and torsion. Use Finite Element Analysis (FEA) to validate mechanical testing, assess stress distribution and determine failure modes. Provide valuable data to assist in advancing spinal plate development.

ACKNOWLEDGEMENTS

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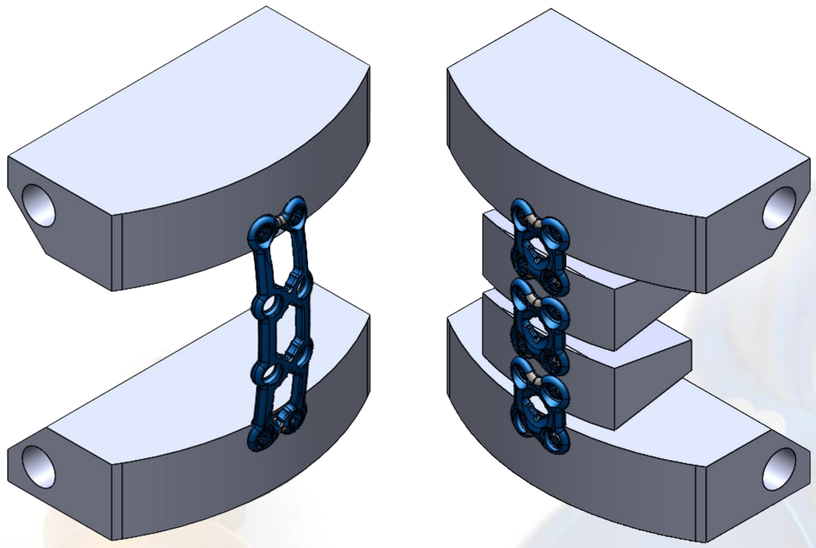
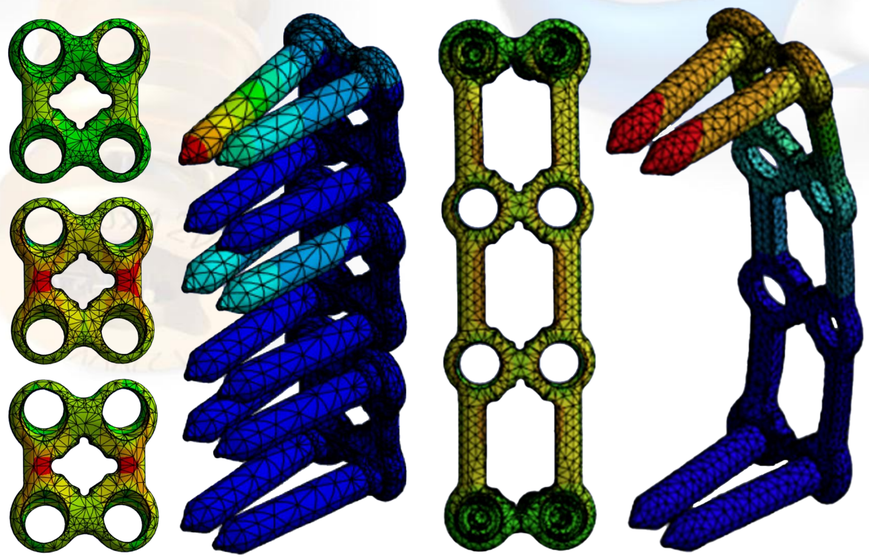
FIXTURE DESIGN



FINITE ELEMENT ANALYSIS (FEA)



RESULTS

FEA demonstrated that stacked segmental plates distributed stresses more evenly under both compression and torsion, with individual plates bearing localized loads, while multi-level plates exhibited higher stress concentrations and deformation at critical areas such as the plate center and screw holes. Mechanical testing revealed that stacked plates displayed higher stiffness under compression, while both stacked and multi-level constructs showed similar torsional stiffness and yield torque. These results illustrate differences in how the two plating systems respond to mechanical loading, with stacked plates offering improved stress distribution and multi-level plates concentrating loads in specific regions.

CONCLUSION

T-tests conducted for mechanical testing revealed a significant difference in stiffness between stacked segmental and multi-level constructs under compression bending, while differences in yield load were inconclusive. Under static torsion, no significant differences were observed in stiffness or yield torque. In conclusion, the outcome of this research hopes to be a beneficial aid in future investigations of ACDF methodologies as well as degenerative spine interventions as a whole.

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