Design and Evaluation of a Prone Positioning System for Complex Spinal Surgery

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Summary

Complex spinal surgeries require patients to be placed in the prone position, a process fraught with challenges that impact both surgical teams and patient outcomes. Unfortunately, commercial devices do not currently position the patient to enable the required spinal alignment, so this is performed manually by the surgical team. This risks both manual handling injury and poor biomechanical spine alignment. This project used focus group discussions and user centered design to develop an advanced positioning system to enhance patient safety, minimize staff injury risks, and move towards improved biomechanical outcomes for spinal surgery.

Introduction

The increasing rates of spinal surgery—63% in the UK (2005–2015) and 77% in the US (2002–2011) [1,2]—highlight significant challenges in patient positioning. Manual prone positioning poses injury risks to surgical teams, while existing tables like the Allen and Jackson Tables lack precise local adjustments, hindering safe and efficient patient alignment. This underscores the need for advanced, standardized, and shareable solutions to improve safety, outcomes, and widespread applicability in spinal surgery. Previously our team of engineers and healthcare professionals worked together to develop a first- and second-generation prototype [3]. This study aims to review the biomechanical function and move towards a clinically usable device.

Methods

The project used user-centered design methods to develop a second-generation prototype spinal lifting system to fit on an Allen Table. A focus group discussion with the clinical professionals enabled evaluation of the design and decisions for the next generation device (see Figure 1). The evaluation was conducted with a health participant of 85Kg.

Results and Discussion

Insights from clinical focus groups reveal the novel lifting system's potential to improve the accuracy and safety of complex spinal surgeries, addressing key limitations in patient positioning (Table 1). However, its current design and non-standardized materials hinder broader adoption and limit its applicability in other hospitals. To address these challenges, the system should use standardized materials like anodized aluminum profiles and medical-grade linear actuators, ensuring compatibility with medical device standards. Additionally, making the design sharable would allow hospitals to freely download, adapt, and implement it, with minimum workshop facilities promoting widespread adoption and greater clinical impact.

Conclusions

The development of an advanced prone positioning system would enable improvements in clinical outcomes and reduce manual handling injury for clinical professionals. Future work is required to analyze the biomechanical function in more detail and develop a sharable design using off-the-shelf materials available globally.

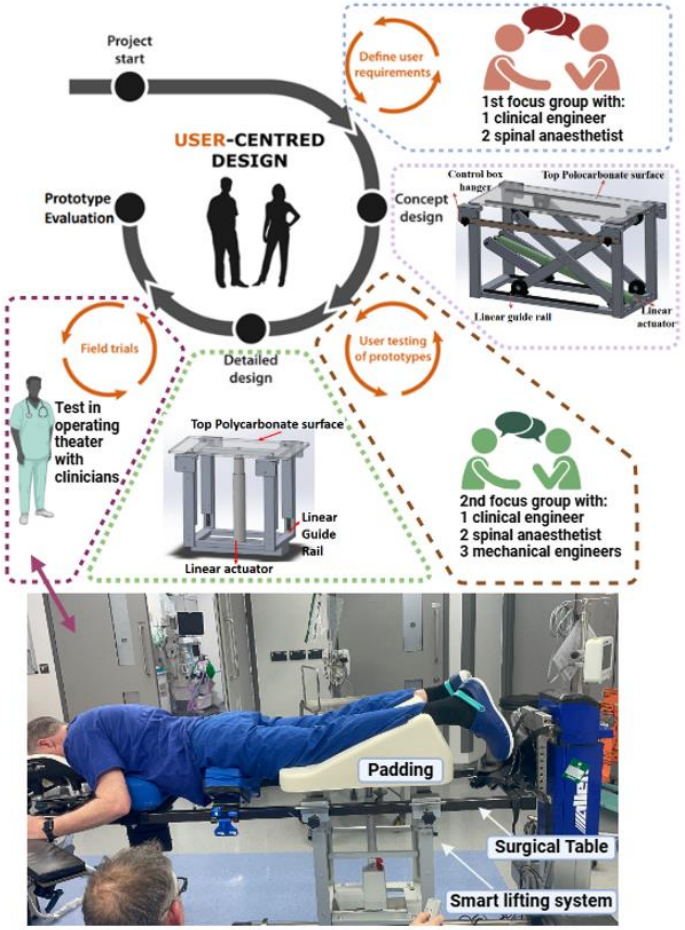

Figure 1: User centered- design methods for prototype design and evaluation.

Table 1. Evaluation results of prone positioning system

Functionality	Original method	Current design	Next generation
Positioning	Manual	Powered	Powered
Accuracy	Low	High	High
Stability	Low	High	Adjustable
Size	N/A	Fit to surgical table	Smaller height and larger width
Risk of injury	High	Low	Low
Design and application	N/A	Unique	Sharable and standardized

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References

[1] K. Kobayashi et al., (2022) *Nagoya J Med Sci*,155-162.
[2] E. Provaggi, et al., (2018) *Medicine*, 97: 11169.
[3] Li, L, et al., (2024) *EMBEC 2024*, 112.