Ultrasound-based vertebral landmark localization using deformable spine models

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Introduction

- Identifying vertebral landmarks in ultrasound (US) images is non-trivial
- Landmarks are difficult to locate in US images of patients with diseased spines (Ungi, 2014)
- Easily identifiable vertebral landmarks often scanned and segmented first, though these landmarks not clinically relevant
- With only half of all vertebral landmarks identified, accurate models can be created (Church, 2017)

Methods

Proposed Solution

- Take easily identifiable landmarks, and every subsequently identified one, digitally overlay updating "visual aid" on ultrasound images (Fig. 1)
- Visual aid can orient the clinician in further scanning and landmark segmentation in clinically relevant regions

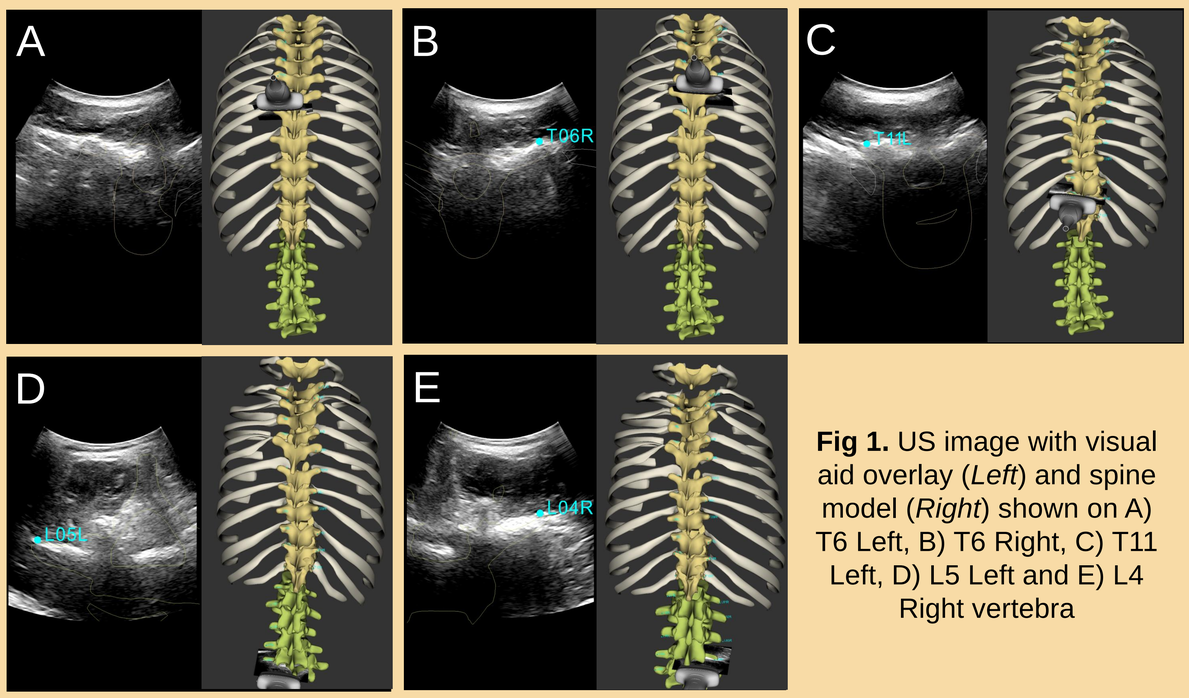

Fig 1. US image with visual aid overlay (*Left*) and spine model (*Right*) shown on A) T6 Left, B) T6 Right, C) T11 Left, D) L5 Left and E) L4 Right vertebra

Implementation

- Spatially tracked US system used to acquire images for study (Fig. 2)
- Tracking information and ultrasound images captured in real-time

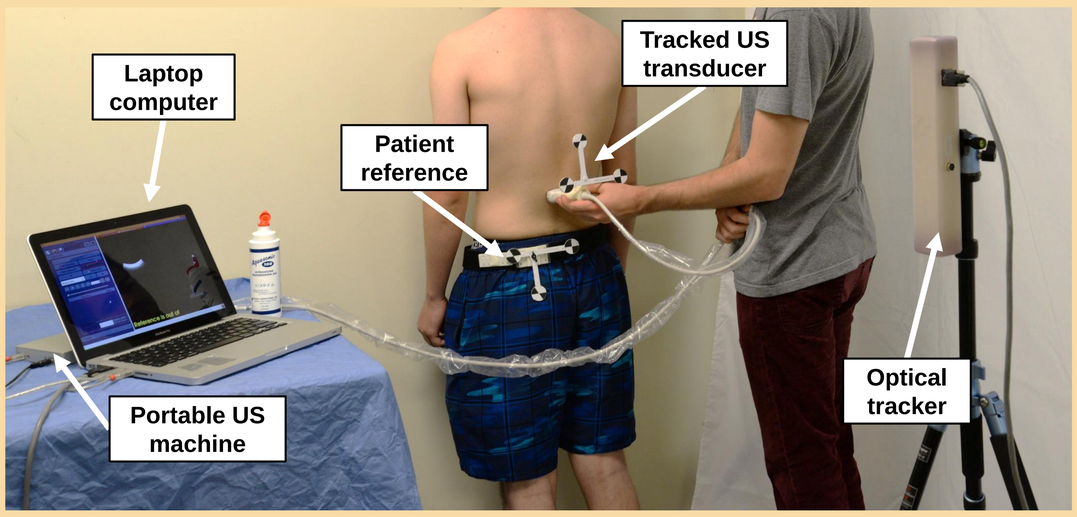

Fig 2. Tracked US imaging system in use

Experimental Design

- Six operators identified transverse processes in US images independently.
- Operators randomly assigned two series of images
- One where landmarks identified using only US images, one where, landmarks were identified using visual aid and US images (Fig.1)

Results

- Mean identification rate (p=0.001, n=6), time to completion (p=0.047, n=6) both significantly higher with visual aid than US only (Fig. 3)
- Issues reported in distinguishing landmarks from ribs in thoracic region
- Difficulties occurred most notably between T6 and T12 in US-only
- Using visual aid in these regions operators repeatedly attained higher identification rates

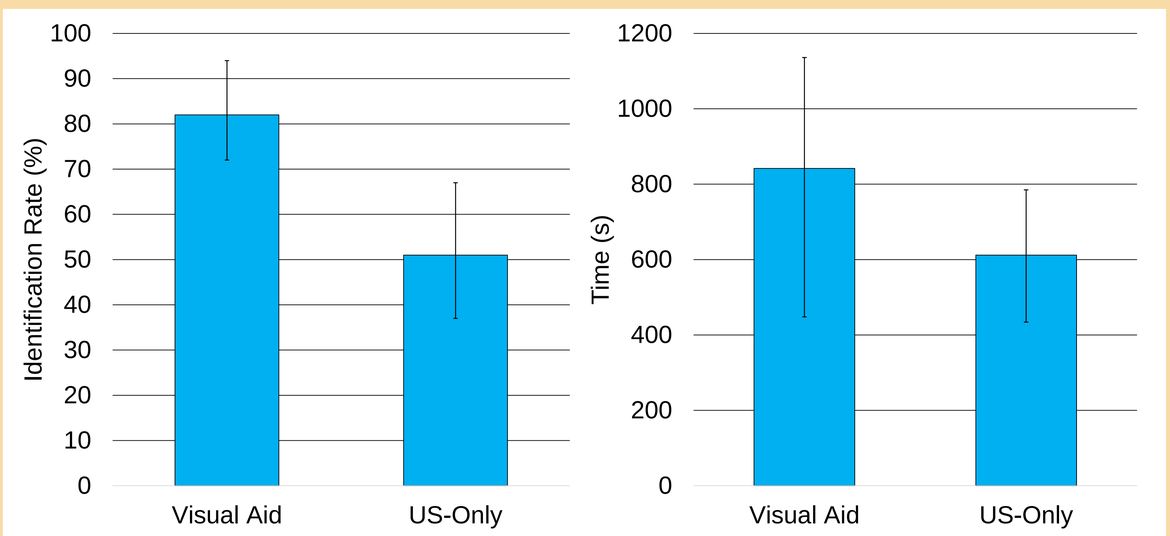

Fig 3. Mean and IQR plots of: mean landmark identification rate (*Left*) and mean time to completion (*Right*)

- Likert scale evaluation of the spatially tracked US system (Fig. 4)

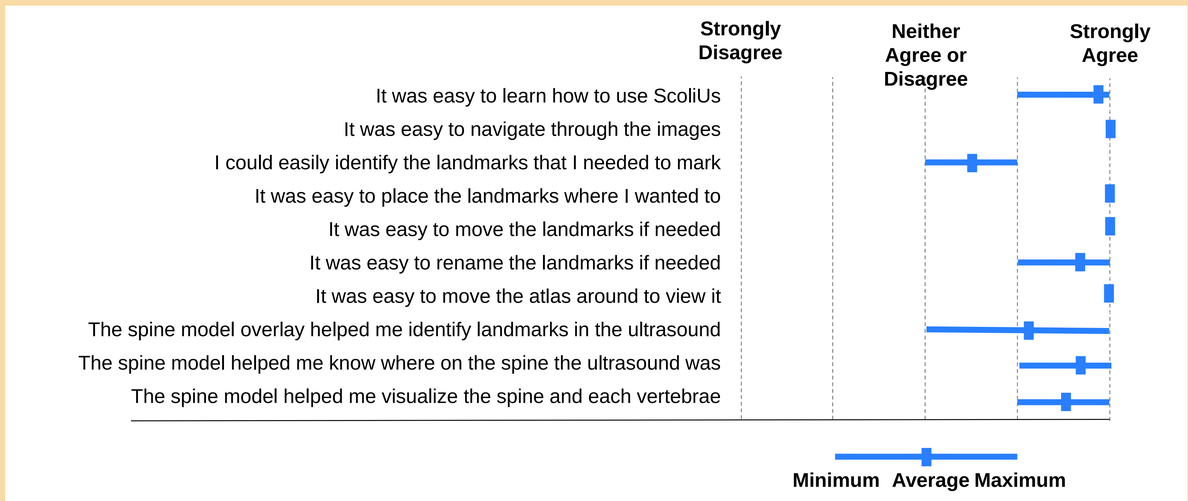

Fig 4. Min-Max-Average chart assessment of usability questionnaire responses

Conclusion

- 3D visual aid developed to assist in vertebral landmark identification
- Operators found deformable spine visual aid useful for landmark identification
- Operators identified significantly more landmarks with visual aid than without
- Demonstrated effectiveness of 3D visual aid in US landmark identification

References

[1] Ungi *et al*., "Spinal curvature measurement by tracked ultrasound snapshots," *Ultrasound in Medicine & Biology*, 2014.

[2] Church *et al*., "Visualization of scoliotic spine using ultrasound-accessible skeletal landmarks," SPIE Medical Imaging, 2017.

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