Ultrasound-based vertebral landmark localization using deformable spine models

Zachary Baum¹, T. Ungi¹, A. Lasso¹, B. Church¹, C. Schlenger², G. Fichtinger¹

1. Laboratory for Percutaneous Surgery, Queen’s University, Kingston, Canada
2. Premier Chiropractic, Stockton, California, USA

PURPOSE: Identifying vertebral landmarks in ultrasound (US) is non-trivial. Landmarks may be hidden or difficult to identify in patients with diseased spines [1]. We propose to assist the user in discerning spinal geometry through overlay of a visual aid in the US image space during landmark identification.

METHODS: Users identify several prominent landmarks to create deformably registered generic healthy spine model in the US space with Church et al.’s method [2]. This model is overlaid on the images to provide visual aid to the operator for remaining landmarks (Fig. 1). With each identified landmark, the registration is re-computed. A tracked US system was developed using the open-source 3D Slicer application platform and the PLUS toolkit [3, 4] (Fig. 2). Six operators identified vertebral landmarks using US images, and using visualizations and US images. A one tailed Student’s t-Test for independent unpaired samples compared the mean landmark identification rate between all operators. Analysis of time to task completion is also presented. Software usability was assessed through a questionnaire following the study.

RESULTS: The mean landmark identification rate of operators using visualizations and US was significantly higher than US only (82 [72 – 94] % vs 51 [37 – 67] %, respectively; p = 0.001). Additionally, time to completion was higher using visualizations and US than US only (842 [448 – 1136] s vs 612 [434 – 785] s, respectively; p = 0.047). Operators found visualizations helpful in landmark identification, and in visualizing the spine.

CONCLUSION: A three-dimensional visual aid was developed to assist in vertebral landmark identification in a tracked US system by deformably registering and visualizing a healthy spine model in US space. Operators found visual aids useful and they were able to identify significantly more vertebral landmarks than without it.