VALIDATION OF TRAINING EFFECT OF VERTEBRAL BONE MODEL ON SURGICAL SKILLS

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INTRODUCTION

The education of residents in the proper placement of pedicle screws is key to the safety of the surgery. The more experienced the surgeon, the more accurately the pedicle screws tend to be placed (Samdani 2010). The learning curve of spinal surgeons has been documented, with higher risk of malplacement of the screw in earlier surgeries (Atesok 2012; Samdani 2010). As resident work hours become restricted (Atesok 2012) the need for a concentrated learning environment to learn specific skills becomes important, and simulators are being developed to address this learning gap (Luciano 2011). A physical bone model was developed, with properties and tactile feel similar to human bone with the intention of using the bone model to train residents in the proper feel and proper trajectory for safe pedicle cannulation. The purpose of this study was to test whether the model improves orthopaedic residents' performance when cannulating the spinal pedicles of a synthetic bone analogue, as judged by the number of breaches, as well as to gain feedback from the residents on their experiences.

MATERIALS AND METHODS

Six orthopaedic residents were recruited, with ethics approval. The residents had varying levels of experience in the placement of pedicle screws. Two residents claimed good confidence in placing pedicle screws, and the rest had moderate to no experience. Prior to testing, the residents were given a short instructional video describing the correct cannulation of a lumbar vertebrae.

The residents were provided with bone models of three different strengths: weak, normal, and strong (Fig. 1). In total, the residents were given twelve bone models: three for initial skills assessment (one of each bone strength), six for free practice (two of each strength), and three for final skills assessment (one of each strength). During the initial and final skills assessment, the forces were recorded using a custom lumbar probe fitted with a six degree-of-freedom (6 DOF) load cell ATI-25 Nano (ATI Industrial Automation, Apex, NC, USA). The residents were asked to complete both pre and post-testing questionnaires.

Figure 1: Resident practicing pedicle cannulation on vertebral bone models of different strengths.

After the pre and post-training skills assessments, as well as during the free practice time, the residents were encouraged to assess their bones. During free practice time, they were encouraged to explore mistakes, including breaches and misdirections, as well as correct actions.

The number of breaches was counted in the initial and final testing bones and compared using a paired Student's t-test ($p<0.05$ significant). The practice bones were not counted, as they were intentionally breached in many cases. Entry points used by the residents were assessed based on the video instructions. The forces for each bone model were compared using an ANOVA followed by post-hoc t-tests if significant ($p<0.05$).

RESULTS

All but one of the residents improved their number of breaches with practice (Fig. 2), and the one that did not improve did not make the same breaches twice. The total number of breaches fell from 31 in the initial testing to 14 in the final testing, with a mean reduction of 2.8 per resident. The resident with the most surgical experience (Resident 1) had the fewest initial breaches, and reduced to zero breaches after practice with the model. The resident with the least experience (Resident 6) had the most number of initial breaches. The mistakes made were both directional and in depth. Anterior breach of the vertebral wall was the most common mistake. The entry points chosen by the residents were all deemed appropriate as per the video description.

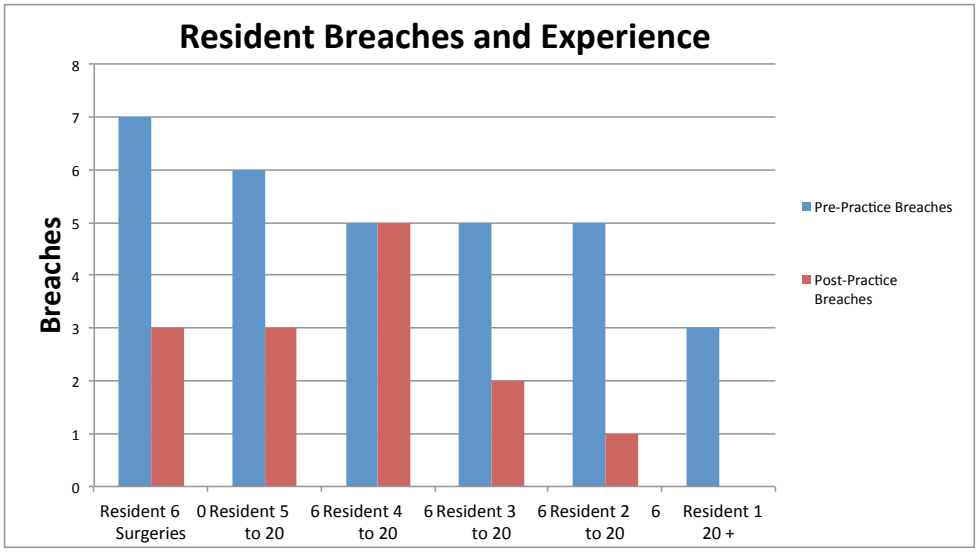

Figure 2: Pre-training and post-training breaches in order from least experienced (Resident 6, with 0 experience) to most experienced (Resident 1, with 20+ surgeries).

Axial forces for the weak and normal bone models were significantly different than those for the strong model ($p = 0.04$, and 0.0005, respectively), but not from each other ($p = 0.10$). The continuously-measured forces did not give any indication of a pending breach of the bones. Whether the forces were higher before or after practice varied by resident.

The questionnaire responses from the residents indicated that the bone models feel similar to real bone, and that the residents would be interested in using such a training system.

DISCUSSION

Reduction in the number of breaches between the initial and final testing indicates that the residents did learn through practicing with the bone models. Transfer of this skill to the

operating room (OR) needs to be validated. The probe forces were similar to those measured previously in cadaveric specimens (Blair-Pattison 2014).

Concentrated practice time using an accurate simulator is an efficient way of practicing a skill (Podolsky 2010). As mentioned by the residents in the questionnaires, more practice outside of the OR gives more competence to a skill that they are then more likely to be allowed to practice within the OR: practice begets practice. The placement of pedicle screws is a skill that requires experienced-based judgement (Manbachi 2013). With more practice, the more confident the resident will be and also the more confident the attending surgeon will be in the resident's abilities.

The main limitation of this pilot study was the small number of residents. A much larger multi-centre trial, with modified bone models, is planned. Also, the residents' breaches did not include classical lateral or medial breaches, possibly due to the bone model design, i.e. the diameter of the pedicle or thickness of the cortical layer of the bone model; this has been modified as a result of the testing.

Overall the response from the residents was positive; they all indicated interest in such a simulator, in most cases even outside of normal hours, and almost all indicated that the bones felt more realistic than those currently available (if they were aware of them). Positively, the more surgical experience the resident had, the more their survey responses indicated a positive impression of the bones.

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