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Basic Science

Surgical training using three-dimensional simulation in placement of cervical lateral mass screws: a blinded randomized control trial

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Abstract

BACKGROUND CONTEXT: The skills and knowledge that residents have to master has increased, yet the amount of hours that the residents are allowed to work has been reduced. There is a strong need to improve training techniques to compensate for these changes. One approach is to use simulation-training methods to shorten the learning curve for surgeons in training.
PURPOSE: To analyze the effect of surgical training using three-dimensional (3D) simulation on the placement of lateral mass screws in the cervical spine on either cadavers or sawbones.
STUDY DESIGN: A blinded randomized control study.
METHODS: Fifteen orthopedic residents, postgraduate year (PGY) 1 to 6, were asked to simulate Magerl lateral mass screw trajectories from C3–C7 on cadavers using a navigated drill guide, but with no feedback as to the actual trajectory within the bone (Baseline 1). This was repeated to determine baseline accuracy (Baseline 2). They were then randomized into three groups: Group 1, control, did not receive any training, whereas Groups 2 and 3 received 3D navigational feedback as to the intended drill trajectory on sawbones and cadavers, respectively. All three groups then performed final simulated drilling (final test). All 3D images were deidentified and reviewed by a blinded single fellowship-trained orthopedic spine surgeon. Each image/screw was measured for the starting site, caudad/cephalad angle, and medial/lateral angle to determine trajectory accuracy.
RESULTS: The aggregate mean difference from a perfect screw was compiled for each session for each group. A negative difference shows improvement, whereas a positive difference shows regression. The difference between final test and Baseline 1 in the control group was 2.4°, suggesting regression. In contrast, the differences for groups sawbone and cadaver were −8.2° and −7.2°, respectively, suggesting improvement. When comparing the difference in aggregate sum angle for the sawbones and cadaver groups with the control group, the difference was statistically significant ($p<.0001$).
CONCLUSIONS: Training with 3D navigation significantly improved the ability of orthopedic residents to properly drill simulated lateral mass screws. As such, training with 3D navigation may be a useful adjunct in resident surgical education. Published by Elsevier Inc.

Keywords: Training; Cervical lateral mass; 3D; Resident; Navigation; Education

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Introduction

Orthopedic resident training has changed dramatically over the years. Several mandated resident work-hour decreases have occurred, spurring a large debate about resident education, case logs, and the need for objective training tools and measures [1]. In particular, spine training is sparse despite the complexity of spinal anatomy [2]. Adequate concern has been raised about the orthopedic resident's comfort level for spine surgery. To our knowledge, only a few studies have investigated surgical spine training tools and their efficacy. However, the use of three-dimensional (3D) navigation and its applications continue to be studied and expanded [3]. More recently, studies have investigated its accuracy and training applications, whereas others continue to investigate the use of cadavers in surgical training [3,4]. Despite differences in training methods around the country, there has been a large push for Objective Structured Clinical Examinations in orthopedic surgery [5].

The complex anatomy of spine surgery and the proximity to neurovascular structures increases the risk of severe complications. This is of particular concern with the insertion of lateral mass screws as even a small error in the angle or insertion site can lead to neurovascular injury [6–8]. Some of the known complications include injury to the vertebral artery, ventral nerve root, spinal cord, and violation of the facet joint [6,7,9]. To our knowledge, there are no current studies investigating training methods for cervical spine surgery and, in particular, lateral mass screw insertion.

The purpose of this study was to analyze whether resident training on sawbones or cadavers using 3D navigation in the placement of lateral mass screws increased accuracy. A secondary objective was to analyze the effect of sawbones versus cadavers on training and the accuracy of screw placement.

Methods

Institutional review board approval was waived for this study as it was considered a part of resident training. The Cervical Spine Research Society provided funding of $12,000 for this study. No other conflicts of interests were noted as our institution supplied the financial support.

Fifteen orthopedic residents, postgraduate year (PGY) 1 to 6, were randomly divided into three parallel groups: control, sawbones, or cadaver. Group designation of sawbones or cadaver describes the medium in which the residents underwent 3D training, whereas the control group did not undergo training. Randomization of residents involved the use of a random number generator from Excel (Microsoft, Seattle, WA, USA) and the allocation of a number between one and three, designating groups control, sawbones, and cadaver, respectively. Before randomization, residents were subdivided by PGY level to allow for equal amount of previous training in each group and provide a mutually exclusive randomization process (Fig. 1 for flow diagram).

Each group started with an instruction pamphlet and demonstration with regard to placement of lateral mass screws using the Magerl technique. The instruction pamphlet included a detailed anatomy guide with facet parameters including medial/lateral dimension, superior/inferior dimension, anterior/posterior dimension, and associated intimate anatomy such as the transverse foramen and its contents. Furthermore, a ‘‘perfect’’ Magerl screw, aimed 25° laterally and parallel to the facet joints (~45° in relation to the lateral mass) with a starting point 1 mm medial and cephalad from the middle of the lateral mass, was depicted on coronal, sagittal, and axial images. Lastly, bony landmarks, structures at risk, and orientation of the spine were demonstrated to each participant before performing any testing.

All residents were asked to simulate Magerl lateral mass screw trajectories from C3–C7 on cadavers using a navigated drill guide, but with no feedback as to the actual trajectory within bone (Baseline1). Virtual images were stored for each screw level. This was repeated to determine the baseline accuracy (Baseline2). For baseline testing, a total of 10 screws were placed for each session (ie, one at each level per side).

The sawbones and cadaver groups then received real time 3D navigational feedback as to the intended drill trajectory on sawbones and cadavers, respectively (training). This included the ability to not only place 10 ‘‘perfect’’ screws as deemed per 3D navigation, but also included guidance from a more experienced surgeon about what changes could be made to allow for a ‘‘perfect’’ screw. Training also required that each participant be able to demonstrate the superior, inferior, medial, and lateral borders of the lateral mass (at each level). Finally, each participant was required to simulate a ‘‘perfect’’ screw at each level based on 3D navigation, with the experienced surgeon verifying each level.

All three groups then performed final simulated drilling (final test). To standardize testing, each resident started on the left C3 lateral mass and worked down to the left C7 lateral mass. This was then repeated on the right side. To allow ample time at each level to find the appropriate starting point and the angle of the screw, residents would signal ‘‘mark’’ when they felt confident about their screw position. This in turn would save the virtual image for measurement at a later date.

Cadavers, including the occiput and upper torso, underwent routine posterior cervical dissection before testing. As cadavers are considered the gold standard for surgical training, all groups used cadavers for Baseline 1, Baseline 2, and final test sessions. To simulate a real operative experience, the cadavers were draped out in standard fashion. The sawbones and cadaver groups used their respective sawbones or cadavers for their training sessions. The sawbones included vertebrae from C1–C7 and a molded holding station. All