The Spine Journal 16 (2016) 835–841

THE SPINE JOURNAL

Clinical Study

Differences in bone mineral density of fixation points between lumbar cortical and traditional pedicle screws

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Received 4 August 2015; revised 16 October 2015; accepted 4 November 2015

Abstract

BACKGROUND CONTEXT: The use of a novel lumbar pedicle cortical bone trajectory (CBT) screw has recently gained popularity, allowing for a minimally invasive approach and potentially improved screw purchase. However, to date, no studies have identified the ideal patient population to utilize this technology.

PURPOSE: This study reports the bone mineral density (BMD) using Hounsfield units (HUs) along a CBT screw pathway. Patients with a greater difference in density of bone in the lumbar vertebrae between the fixation points of the CBT and traditional pedicle screw may be optimal candidates to realize the advantages of this technique.

STUDY DESIGN/SETTING: A cross-sectional observational anatomic study was carried out.

PATIENT SAMPLE: The sample comprised 180 randomly selected patients with lumbar computed tomography imaging from L1 to L5 spinal levels.

OUTCOME MEASURES: This study used computed tomography image-derived HUs as a metric for BMD.

METHODS: A total of 180 patients without previous lumbar surgery with computed tomography imaging of the lumbar spine met the inclusion criteria. Patients were chosen randomly from an institutional database based on age (evenly distributed by decade of life) and gender. Hounsfield units were measured at the expected end fixation point for both a cortical (superior/posterior portion of the vertebral body) and traditional pedicle trajectory (mid-vertebral body).

RESULTS: Hounsfield unit values measured at the end fixation point for the CBT screw were significantly greater than that of the traditional pedicle screw in all age groups. The relative difference in HU values significantly increased with each decade of age ($p<.001$) and caudal lumbar level ($p<.001$). In the osteoporotic group, as determined by well-established HU values, there was a significantly greater difference in the BMD of the CBT fixation point compared with the traditional trajectory ($p=.048$–$<.001$).

CONCLUSIONS: Bone mineral density as measured by HU values for the fixation point of the CBT screw is significantly greater than that of the traditional pedicle screw. This difference is even more pronounced when comparing osteoporotic and elderly patients to the general population. The data in this study suggest that the potential advantages from the CBT screw such as screw purchase may increase linearly with age and in osteoporotic patients.

FDA device/drug status: Not applicable.

Author disclosures: ***HTM:*** Nothing to disclose. ***SMM:*** Nothing to disclose. ***SZH:*** Nothing to disclose. ***TJJ:*** Nothing to disclose. ***AAP:*** Royalties: Amedica (C), Ulrich (C), Biomet (C); Private Investments: Amedica (<1%), Cytonics (<1%), Nocimed (<1%), Vital5 (<1%); Consulting: Biomet (B), Stryker (B), DePuy (B); Board of Directors: Cervical Spine Research Society (None), outside the submitted work. ***WKH:*** Consulting: Medtronic, Inc (B), Stryker (E), Bacterin (B), Graftys (A), Lifenet (A), AONA (Nonfinancial), Bioventus (B), Globus (B), Spinesmith (Nonfinancial), outside the submitted work.

The disclosure key can be found on the Table of Contents and at www.TheSpineJournalOnline.com.

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http://dx.doi.org/10.1016/j.spinee.2015.11.034

1529-9430/

Keywords: Bone mineral density; Cortical bone trajectory screw; Hounsfield units; Lumbar cortical screw; Lumbar pedicle screw; Quantitative computed tomogaphy

Introduction

Traditional lumbar pedicle screws are widely used in the treatment of lumbar spinal pathology. Despite its success in achieving stability in these patients, complications such as screw loosening, migration, and pullout lead to suboptimal outcomes and the need for reoperation [1,2]. In 2009, Santoni et al. introduced data demonstrating that a cortical bone trajectory (CBT) screw in the pedicle enhanced pullout strength by 30% when compared with the traditional pedicle screw [3]. Similarly, Baluch et al. reported that cortical screws had superior resistance to craniocaudal toggling and required force for displacement [4]. This has led to clinical adoption of this technique in certain clinical situations. The technique of insertion for the cortical screw allows for a smaller incision and less exposure in comparison to the traditional lumbar pedicle screw where the transverse processes need to be visualized. Because its insertion point is just medial to the lateral aspect of the pars interarticularis and uses an 8° lateral and 25° cranial screw angulation, operative time and, potentially, recover time are reduced [5]. Although limited in sample size, early clinical studies have reported good outcomes with the use of CBT for a variety of pathologies [6–8].

Bone mineral density (BMD) has been demonstrated to positively correlate with increased pullout strength [3]. Since the end point of the traditional pedicle screw often lies within the cancellous bone of the mid-vertebral body, which preferentially diminishes with age [9,10], there is an increased risk of toggle that may eventually loosen the screw purchase. On the other hand, the CBT screw fixation point lies within the cortical bone of the pedicle and vertebral body, which theoretically reduces this risk. Furthermore, this area of bone maintains its density more effectively than that of the mid-vertebral body during the aging process [11]. This technique also allows for a shorter screw while achieving mechanical purchase equivalent to or better than that of the traditional pedicle screw, most notably in osteopenic or osteoporotic patients in cadaveric studies [12].

Dual X-ray absorptiometry (DXA) is often used to determine BMD in patients. However, recently, the use of Hounsfield units (HU) measured on computed tomography (CT) has been demonstrated to be a reliable proxy for BMD [13–15]. Schreiber et al. noted the distinct advantages that CT imaging provides over traditional DXA to the spine surgeon, including the ability to determine density in specific regions of interest (ROIs) including the vertebral body trabeculae [16], which has been shown to be most predictive of fracture risk [17]. Further, DXA can be unreliable in cases of severe degeneration, scoliosis, or after instrumented surgery [16], which commonly afflicts the patient population who requires spine surgery. Consequently, HUs may provide an equivalent if not improved measure for relative BMD in this patient population.

Several studies investigating the utility of the CBT technique have yielded a favorable outlook regarding its incorporation into surgical practice [4,18]. However, it is yet unclear what the ideal patient population is to utilize this novel technology. Patients who have a greater difference in the BMD along the trajectory of the CBT versus traditional pedicle screw may best realize the advantages of the CBT screws.

Methods

After appropriate Institutional Review Board approval, an institutional medical database was queried for patients with current procedural terminology (CPT) codes 72131, 72132, and 72133 (CT lumbar spine with, without, or with and without contrast) over a time period of one decade (2004–2014). Exclusion criteria included patients less than 30 or greater than 90 years of age, recent trauma to the lumbar spine, incomplete imaging of the lumbar spine, or prior instrumentation of the lumbar vertebra. Patients were de-identified and compiled in a database with demographic information. A total of 180 patients were randomly selected for inclusion based on age and gender. Thirty patients (15 of each gender) in each decade of life (from age 30 to 90) were examined.

Using GE Picture Archiving and Communication Software (PACS) (General Electric Medical Systems, Milwaukee, WI, USA), side-by-side mid-sagittal and axial CT images of the lumbar spine were generated. On cross-referenced axial CT images, ROIs were drawn representative of the end fixation point for both a cortical (Fig. 1) and traditional pedicle screw (Fig. 2). For the cortical screw, a circular area measuring 6 mm was drawn in the supero-lateral portion of the vertebral body on both the left and right side. The HU of the ROIs were averaged. For the traditional screw, an elliptical area measuring 12 mm was drawn in the mid-vertebral, cephalad half of the vertebral body as described by Schreiber et al. [16] (Fig. 2). This process was performed at each lumbar level (L1–L5).

S1 was not included because cortical bone trajectories do not exist at this level. Average values were calculated based on level and gender and compared between cortical and traditional pedicle fixation points. Because of expected variability at each level, differences were reported as a percent increase. Well-established HU values (<78.5±32.4 HU) to