Lumbar Spinal Fixation with Cortical Bone Trajectory Pedicle Screws in 79 Patients with Degenerative Disease: Perioperative Outcomes and Complications

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■ OBJECTIVE: **Biomechanical studies demonstrate that cortical bone trajectory pedicle screws (CBTPS) have greater pullout strength than traditional pedicle screws with a lateral-medial trajectory. CBTPS start on the pars and angulate in a mediolateral-caudocranial direction. To our knowledge, no large series exists evaluating the perioperative outcomes and safety of CBTPS.**

■ METHODS: **We retrospectively reviewed all patients who received lumbar CBTPS at our institution. Data were collected regarding patient demographics, use of image guidance, operative blood loss, hospital stay, and post-operative complications.**

■ RESULTS: **A total of 79 patients undergoing CBTPS fusion for degenerative lumbosacral disease with back pain were included in the analysis (42 female, 37 male; October 2011—January 2015). Twenty patients (25.3%) had previous lumbar spine surgery, 39 (49.4%) had a smoking history, and mean body mass index was 28.7. Mean length of stay was 3.5 days, and mean operative blood loss was 306.3 mL. Image guidance was used in 69 (87.3%) cases. A total of 66 (83.5%) fusions were single level, and 54 (68.4%) fusions were single level without previous surgery. There were 9 complications in 7 (8.9%) patients; these included hardware failure, pseudarthrosis, deep vein thrombosis, pulmonary embolism, epidural hematoma, and wound infection. No complications were caused by misplaced screws. Mean follow-up was 13.2 months.**

■ CONCLUSIONS: **As CBTPS becomes increasingly popular among spine surgeons performing lumbar fusion, this report provides an important evaluation of technique safety and acceptable perioperative outcomes.**

INTRODUCTION

Posterior lumbar screw-rod fixation and fusion is a well-accepted treatment for patients in whom conservative treatment has failed to adequately treat degenerative lumbosacral disease because of segmental instability.[1-3] Minimally invasive surgery (MIS) techniques were developed to mitigate approach-related morbidity by decreasing tissue trauma during exposure, but many critics argue that this benefit is obtained at the cost of fusion augmentation using decortication and posterolateral arthrodesis compared with the open approach.[4-10] In contrast, the recently described cortical bone trajectory pedicle screw (CBTPS) approach to lumbar fusion may offer a compromise: a minimally invasive approach with less tissue disruption, a robust fixation construct, and effective interbody fusion.

Biomechanical studies demonstrate superior pullout force for the CBTPS compared with traditional approaches.[11-15] In addition, the entry point for the CBTPS requires less manipulation of the paravertebral musculature, which is thought to generate post-operative pain in conventional approaches.[16-19] A diversity of constructs can be coupled with the CBTPS to augment fusion, including lateral lumbar interbody fusion (LLIF), transforaminal

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- Pedicle screw
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- Posterior spinal fixation
- Transforaminal

Abbreviations and Acronyms
ALIF: anterior lumbar interbody fusion
CBTPS: cortical bone trajectory pedicle screw
LLIF: lateral lumbar interbody fusion
MIS: minimally invasive surgery
PJK: proximal junctional kyphosis
PLIF: posterior lumbar interbody fusion
TLIF: transforaminal lumbar interbody fusion

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lumbar interbody fusion (TLIF), posterior lumbar interbody fusion (PLIF), and anterior lumbar interbody fusion (ALIF).

Because of smaller incisions and reduced soft tissue dissection, mini–open surgery with CBTPS may be associated with reduced morbidity and expedited recovery compared with open surgery with traditional pedicle screws. To our knowledge, there are no perioperative clinical series that evaluate these purported advantages. Because our experience with the CBTPS approach has increased since 2011, we have expanded our indications for the approach beyond lumbar degenerative disease to traumatic fractures, infection, extension into the thoracic spine, and scoliotic deformities, and thus, we have sought to evaluate its safety. We present perioperative data, including complication rates, for 79 consecutive patients who underwent CBTPS for degenerative disease. The goal of this study is not to compare CBTPS outcomes with those for traditional pedicle screw techniques but rather to evaluate the feasibility and safety of the CBTPS constructs in a clinical population.

METHODS

We retrospectively reviewed data for all patients who received lumbar CBTPS at Barrow Neurological Institute, St. Joseph's Hospital and Medical Center, Phoenix, Arizona, USA from 1 October 2011, to 31 January 2015. Preoperative clinic charts and radiographic imaging were reviewed to extract demographic data, symptoms, and clinical outcomes. Operative reports and inpatient hospital records were reviewed to collect information on use of image guidance, operative blood loss, complications, and length of stay. Clinic notes were reviewed to identify any patients who returned to clinic with complications. Complications were defined as hemorrhage, hematoma, seroma, infection, neurologic complications, thromboembolic complications (including deep venous thrombosis and pulmonary embolus), cardiac complications (including myocardial infarction), and urinary and renal complications (including acute renal failure), failure of hardware, and pseudarthrosis. Postoperative radiographic imaging was reviewed to confirm proper cortical screw placement. Time of last follow-up was defined as the last time the surgeon's office had contact with the patient via either office visit or telephone call. GraphPad software (GraphPad Software Inc., La Jolla, California, USA) was used for statistical analysis. Means were compared using paired t tests, and P values of <0.05 were considered statistically significant. This study was approved by the St. Joseph's Hospital and Medical Center institutional review board.

Surgical Approach

All patients underwent a CBTPS approach using the following method. A midline incision was tailored above the level of interest using preoperative fluoroscopy. Subperiosteal dissection was performed to expose the pars at the cranial level and the caudal level, but no farther. Only a portion of the transverse processes was exposed, if at all. The superior facet required minimal exposure, if at all. The entry point for the pedicle screw started at the pars at the junction of the center of the superior articular process, 1 mm inferior to the inferior border of the transverse process, angulating the screw in a mediolateral and caudocranial direction (Figures 1 and 2). Depending on surgeon comfort and patient anatomy, navigation was used to tailor the screw trajectory.

If the patient required decompression of the thecal sac or nerve roots via laminectomy, foraminotomy, or discectomy, the procedure was performed before or after placement of screws. Unilateral or bilateral facet removal was performed based on whether the surgeon preferred placement of a unilateral TLIF (Figure 1) or bilateral PLIF grafts. In select cases, posterior fixation and fusion using CBTPS was performed in a second-stage surgery the next day after a first-stage LLIF (Figure 2) or ALIF (Figure 3) had been performed. In cases with minimal disc degeneration or spondylolysis alone, no interbody graft was placed. When possible, additional arthrodesis was achieved by placing morselized local autograft and allograft bilaterally at exposed decorticated bone sites.

RESULTS

During the study period, 84 patients underwent CBTPS fusion at our institution. Four of these patients had thoracolumbar fusions for traumatic fractures and thus were excluded from the final analysis. One patient was excluded because of the use of CBTPS for thoracolumbar fixation after corpectomy for Pott disease. Seventy-nine patients underwent CBTPS for lumbar degenerative disease with back pain and were included in the final analysis. Thus, patients were excluded if they had CBTPS for indications other than lumbar degenerative disease with back pain or CBTPS placed in conjunction with thoracic screws.

Most of the cases in this series were those of the senior author (S.C.), who performs only CBTPS for his patients with degenerative lumbar disease. In degenerative cases, the significant facet hypertrophy allows autograft to be placed for fusion over the posterior elements. The senior author reserves traditional pedicle screws for cases of 1) trauma, although biomechanical laboratories are testing various uses for CBTPS in traumatic injuries; 2) revision surgery with significant bony removal that precludes a screw through the pars; and 3) tumor resection in which a more significant bony removal for decompression precludes placement of cortical screws. Most patients were female (n = 42, 53.2%), 20 patients (25.3%) had received previous lumbar spine surgery, and 39 (49.4%) had a history of smoking. The mean (standard deviation) body mass index (weight in kg/height in m^2) was 28.7 ± 6.6 (range, 15.7–45.4). The most common preoperative comorbidities were hypertension (33, 41.8%) and obesity (28, 35.4%) (Table 1). Preoperative symptoms are summarized in Table 2.

Of the 79 patients undergoing CBTPS fusions, 54 (68.4%) received a single-level fusion without previous surgery (Table 3). Of all 79 patients, 13 (16.5%) had multiple-level instrumentation, ranging from 2 to 7 levels; of these 13 patients, 8 (61.5%) had received previous lumbar spine surgery.

Mean length of stay after CBTPS fusion was 3.5 ± 2.2 days (range, 1–10) for all patients, and mean operative blood loss was 306.3 ± 254 mL (range, 50–1400 mL). Image guidance was used in 69 (87.3%) of the 79 cases. Implants included TLIF/PLIF (n = 46, 58.2%), LLIF (n = 11, 13.9%), ALIF (n = 6, 7.6%), and ALIF combined with LLIF (n = 1, 1.3%); 15 patients (19%) did not have an interbody device implanted. In a comparative