Original Article

Novel use of percutaneous cervical pedicle inlet screws for supplemental posterior fixation after anterior cervical deformity correction

ABSTRACT

Introduction: Correction of cervical deformity can be achieved using anterior cervical fixation and fusion techniques. However, supplemental posterior fixation is a critical component for ensuring biomechanical longevity and favorable patient outcomes. We present a novel percutaneous technique for posterior cervical fixation in patients where cervical pedicle (CP) screws may not be feasible and midline muscle dissection is not needed.

Methods: Three patients presented to our hospital with cervical pathology amendable to circumferential cervical fusion. After adequate deformity correction was performed through an anterior cervical decompression and fusion, staged posterior supplemental fixation was achieved using percutaneous CP inlet (CPI) screws using a percutaneous muscle-sparing approach.

Results: All three patients underwent CPI screw placement without postoperative neurovascular complications. Postoperative radiographic follow-up showed the desired, proper screw placement, with continued maintained cervical alignment.

Conclusions: CPI screw placement may be alternative hybrid screw that achieves a advantageous safety profile while also avoiding an open midline exposure.

Keywords: Cervical, pedicle, percutaneous

INTRODUCTION

Patients requiring circumferential cervical fusion are often subjected to the risks and substantial morbidity of spinal exposure and placement of spinal hardware from both anterior and posterior aspects of the spine. This is known to increase the complication rates and recovery time from surgical intervention.[1] For patients that only require neural element decompression or deformity correction from an anterior approach, full exposure of the posterior spinal elements may not be needed if percutaneous cervical fixation is available. Conventionally, lateral mass (LM) screws have been the work horse of posterior cervical fusion due to their advantageous safety profile.[2] The standard Magerl and Roy-Camille approaches to LM screw placement, however, require a substantial midline muscle detachment from spinal elements, likely increasing wound-related complications and significant postoperative pain during recovery.[3] Cervical pedicle (CP) screws have, however, been applied through percutaneous, muscle sparing incisions.[4] While able to provide higher biomechanical strength, CP screws are associated with a greater risk of malposition and associated vascular and neurologic complications.[5,6]

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To minimize these risks while maintaining the ability to place posterior fixation from a paramedian, muscle-sparing approach, we have adapted the CP screw into a CP inlet (CPI) screw to allow for percutaneous hardware placement while maintaining conventional safety characteristics where CP screw placement is not feasible. This article serves to describe the percutaneous CPI screw technique and present the initial cohort of patients that have been treated in this manner at our institution.

METHODS

This study is a prospective consecutive case series performed at a single academic institution reporting all patients undergoing circumferential fixation for the treatment of various cervical pathologies. Informed consent was obtained on all patients before surgical intervention. All data were stored in electronic medical records to ensure patient privacy was maintained and IRB approval was obtained before collection and analysis of patient data.

Description of surgical technique

All surgeries were performed by a board certified neurosurgeon with subspecialty training in spinal surgery. The patient was placed prone in the operating room in neutral head position using rigid fixation with a Mayfield head holder. A intra-operative computed tomography (CT) scan was performed for the purposes of three-dimensional stereotactic navigation. Based on the cervical levels of interest, paramedian incisions were made bilaterally. Deep dissection was then carried out to the LM at each intended level for screw fixation. Screw entry point and placement was done using previously described techniques for CP screws with the exception of depth.[6-9] Briefly, an entry point was confirmed anatomically approximately 3 mm below the superior facet joint near the lateral border of the articular mass. A high speed drill and tap was used under stereotactic navigation and confirmed with fluoroscopy. The drill guide was directed medially approximately 30° medially from the starting point, directed parallel to the superior endplate. Extended tab pedicle inlet screws measuring 3.8 mm in diameter (Proficient Extended Tab, SpineWave, Shelton, CT) were placed such that the tip terminated at the entry funnel of the pedicle. Once screws were placed, a percutaneous rod guide was utilized to pass rods sub-facially to connect the screw heads.

RESULTS

Three patients underwent posterior CP screw inlet fixation for supplemental fixation after anterior fusion [Table 1]. A total of 15 screws were placed without radiographic evidence of screw malposition on postoperative CT imaging. All patients were followed postoperatively at our institution without evidence neurovascular complication over a minimum of a 6-week follow-up. Postoperative cervical X-rays and CT were obtained to evaluate alignment, hardware placement, and bony fusion [Figure 1]. There were no incidences of early hardware failure within the follow-up time period.

Case 1

A 30-year-old female with no significant past medical history presented after a motor vehicle crash with complete loss of motor and sensory function in her upper and lower extremities. On imaging studies, she was found to have a fracture dislocation with spondyloptosis at C5–6 as well as bilateral vertebral artery dissections. The patient was placed in cervical traction with partial reduction of her fracture followed by a C4–7 anterior cervical discectomy and fusion with anterior plate fixation. Staged posterior fixation from C4 to 7 was planned after medical stabilization of the patient and adequate management of other traumatic injuries. A signed patient consent form was obtained for all surgeries performed in this study. The patient underwent percutaneous CPI screw placement for supplemental posterior fixation 1 week after initial anterior surgery. The patient had a prolonged ventilator-dependent hospitalization due to her spinal cord injury. Postoperative CT imaging showed placement of screws within the pedicle inlet without breach of the neural foramina or foramen transversarium of the instrumented levels. Postoperatively, she has ongoing fusion with stable cervical lordosis and fracture reduction. There were no noted wound complications despite her dependent condition.

Case 2

A 38-year-old female with past medical history significant for intravenous drug use presented with bilateral upper extremity weakness, numbness, and lower extremity clonus suggestive of cervical myelopathy. She was found to have multilevel osteophytes at C3–4, C4–5, C5–6 causing severe cervical stenosis with intrinsic spinal cord signal and loss of cervical lordosis. She underwent a C3–7 anterior discectomy and fusion using interbody cages followed by percutaneous posterior CPI screw placement and fixation at C3–7. No neurovascular complications were noted during her postoperative hospitalization and CT imaging showed all screws placed within the pedicle inlet without bony breach of foramina. Six weeks postoperatively, she had significant improvement in her upper extremity weakness with correction of her cervical lordosis and ongoing fusion without hardware or wound complication.

Case 3

A 81-year-old male with past medical history significant for stroke, diabetes, and hypertension presented with

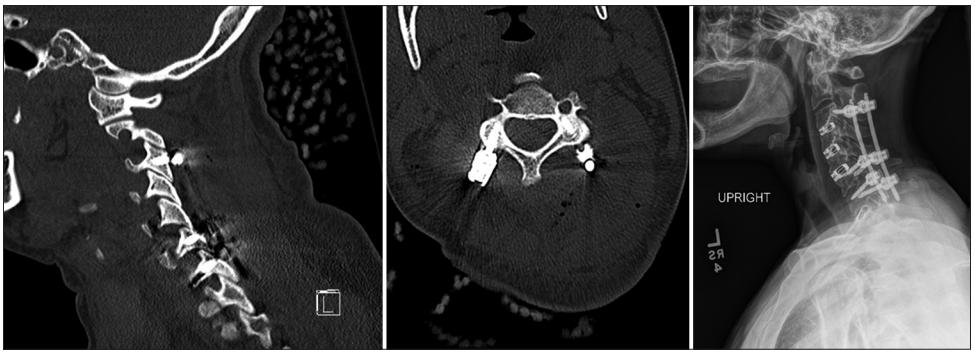

Figure 1: Left: Sagittal postoperative cervical computed tomography scan, middle: Postoperative axial computed tomography scan, Right: 6 weeks postoperative upright cervical X-rays

Table 1: Summary of cases

Patient	Etiology	Symptoms	Reason for surgery	Outcome
30 female	Motor vehicle crash	Complete spinal cord injury at C5	C5-6 anterior spondyloptosis	Ongoing fusion, reduction of fracture, correction of cervical lordosis, no return of neurologic function below C5 (6 weeks)
38 female	Arthritic degeneration	Cervical myelopathy	C3-4, C4-5, C5-6 severe cervical stenosis with spinal cord signal change, loss of cervical lordosis	Maintained cervical lordosis, ongoing fusion, significant improvement in upper extremity weakness (3 months)
81 male	Arthritic degeneration	Cervical myelopathy	C3-4 posterior osteophyte, C5-6 disc bulge with severe cervical stenosis and associated cord signal change, loss of cervical lordosis, C4-5 anterolisthesis	Stable upper extremity weakness and numbness, ongoing fusion, continued C4-5 anterolisthesis and lordotic deformity (6 weeks)

upper and lower extremity weakness with gait instability suggestive of cervical myelopathy. He was found to have multi-level degenerative changes with a C3–4 posterior osteophyte, C5–6 disc bulge causing severe cervical stenosis with cord signal change and loss of cervical lordosis. He first underwent a C3–6 anterior cervical discectomy and fusion using interbody cages. Due to the extent of his cervical deformity, it was felt that posterior fixation was required to improve his long-term stability. He underwent supplemental percutaneous CPI screw fixation at C3 and T1 pedicle screw fixation. Postoperatively, he had good fixation and restoration of cervical lordosis with some improvement in his extremity weakness. No neurovascular complications or hardware failure were noted on clinical and radiographic follow-up.

DISCUSSION

The findings of this case series are 2-fold: (1) CPI screws can be placed percutaneously using previously adopted surgical techniques for CP screws for supplemental posterior fixation while avoiding extensive midline dissection and (2) CPI screws achieve adequate fixation without evidence of neurovascular complication in the immediate postoperative period.

It has been suggested in the literature that CP screws provide the strongest biomechanical stability which results in superior restoration of cervical lordosis and higher fusion rates.[10-13] CP screw trajectories also allow for percutaneous placement in minimally invasive surgical applications.[4] Despite these advantages, many surgeons are hesitant to adopt this technique due to the higher risk of neurovascular complications and technical difficulty of CP screw placement.[2,14-16] Here, we report the feasibility of a CPI screw that we believe achieves a similar safety profile to LM screws while still allowing for percutaneous cervical fixation without midline muscle dissection. Biomechanical strength and long-term follow-up for hardware complications will still need to be investigated in future studies.

CONCLUSIONS

CPI screws can safely be used to achieve adequate posterior fixation in a percutaneous fashion using well-adopted techniques for CP screws. Further studies are needed to fully evaluate the biomechanical characteristics and complications associated with this type of screw placement to determine if they are advantageous compared to other means of posterior cervical fixation.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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