Utility of Real-Time Navigated C2 Pedicle Screw Placement for Atlantoaxial Instability Due to Os Odontoideum in Down Syndrome: A Technical Report

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Introduction

Atlantoaxial instability has been reported to occur in 14-24% of patients with Down syndrome. Os odontoideum represents one possible etiology for symptomatic neurologic dysfunction due to atlantoaxial instability. Occipital cervical fusion and C1-2 fusion have been validated as successful treatment strategies after considering various nuances of the O-C1 joint, degree of subluxation and rotation, and need for distraction. Various fixation methods at C2 have been used to achieve solid arthrodesis, including pedicle screws, laminar screws, and transarticular screws. Anatomical studies in os odontoideum patients indicate that up to 34% of patients harbor C2 pedicles that are less than 5 mm, precluding safe cannulation of the C2 pedicles without increasing the risk for vertebral artery injury. Experienced surgeons have shown that C2 pedicle diameters of less than 6mm have a two-fold higher incidence of cortical breach. Navigation-based methods can be employed to reduce the risk of cortical breach and vascular injury, but these techniques also have limitations. In particular, subtle changes in anatomy due to retractor replacement or instability can affect accuracy. Utilization of *in situ* bone fiducials allows for real-time re-registration in the event of intraoperative anatomical shifts.

Methods

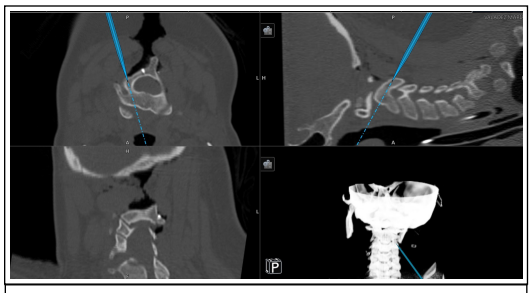
A 21 year-old woman with Down syndrome presented with progressive myelopathy causing tetraparesis and falls. Flexion-extension xrays revealed 12mm of with atlantoaxial subluxation and CT scan showed severe cord compression from the C1 posterior arch. C2 pedicles measured 4.3mm on the right and 3.8mm on the left. C2 laminae measured 3.6 mm on the right and 3.9 mm on the left. Flexion-extension xrays demonstrated 12mm of dynamic subluxation of C1 on C2. Given anatomical limitations and severe instability, we used intraoperative navigation to cannulate the C2 pedicles bilaterally. Four *in situ* bone fiducials were placed on the C2 and C3 lamina that allowed us to re-register in real time as retractors were repositioned and anatomy shifted.

Conclusions

Uitlization of *in situ* bone fiducials allows for safe placement of pedicle screws in challenging cases when surgical anatomy is small or variable. Registration accuracy can be affected as retractors are repositioned and spinal anatomy shifts. The ability to re-register in real time during mutliple instances based on one navigation scan is paramount for preserving accuracy and allows for safe placement of spinal instrumentation without subjecting the patient to multiple intraoperative CT scans or xrays.

Results

C1-3 was exposed in standard fashion. An intraoperative CT scan was used for navigation. Four 4mm titanium screws were placed into the bilateral C2 and C3 laminae prior to obtaining intraoperative CT scan. During cannulation of the C2 pedicles, registration was carried out several times during the case as screw trajectories were adjusted and anatomy shifted slightly. Two C2 pedicle screws [(R) 4mm and (L) 3.5mm] were placed without evidence of vascular injury.



Postoperative CT scan

Sagittal and axial images showing final C2 pedicle trajectories

Learning objectives

- anatomical challenges in C2 pedicle screw placement
- ways to facilitate safe placement of C2 pedicle screws with unfavorable anatomy
- navigation-based spinal instrumentation
- use of *in situ* bone fiducials to allow for intraoperative re-registration
- utilization of *in situ* registration to avoid multiple intraoperative CT scans/xrays

References

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