

Technical Note

Axial and oblique C2 pedicle diameters and feasibility of C2 pedicle screw placement: Technical note

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Abstract

Background: For C2 pedicle screw placement/instrumentation, it is critical to adequately measure the axial and oblique C2 pedicle diameters utilizing the intraoperative O-arm.

Methods: Thirty-three patients who underwent C2 pedicle screw placement (2013–2016) utilizing the O-arm with tri-planar reconstruction. As O-arm software does not allow calibrated measurements with the application's measurement tool, we directly measured axial and oblique widths of the C2 pedicles on the screen with a regular ruler (e.g., "screen width of C2 pedicle").

Results: The axial width of the C2 pedicles ranged from 6 to 15 mm on the right (mean 10.44 ± 2.15 mm) to 7 to 14 mm (10.29 ± 1.72 mm) on the left. The oblique width of C2 pedicles ranged from 10 to 19 mm on the right (mean, 14.73 ± 1.85 mm) and from 12 to 19 mm on the left (mean, of 15.33 ± 1.67 mm). These measurements indicated that oblique screen widths of the C2 pedicles were 1.4 and 1.5 times higher than their axial screen widths on the right and left sides, respectively.

Conclusions: The oblique screen widths of the C2 pedicles better predict the feasibility of C2 pedicle screw placement vs. their axial screen width as measured with a regular ruler.

Key Words: C2 pedicle width, O-arm, pedicle screw placement

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INTRODUCTION

Three-dimensional intraoperative computed tomography (CT)-based O-arm surgical imaging facilitates C2 pedicle screw placement,^[6] and it is critical for avoiding perforation of adjacent critical neurovascular structures.^[1-5,7] Here, we directly measured the C2 pedicle right and left-sided diameters on axial and oblique images to more safely place C2 pedicle screw instrumentation.

PATIENTS AND METHODS

Patients

After institutional review board (IRB) approval, we retrospectively reviewed intraoperative O-arm

placement of C2 pedicle screws in all 33 patients (2013–2016) [Table 1]. All C2 pedicle screw placements were confirmed utilizing the intraoperative O-arm.

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Placement of C2 pedicle screws and posterior cervical fusion

Prone and immobilized in a three-pin head holder, a linear incision was performed in the midline to expose the posterior elements of C2 and the cervical/thoracic vertebra, as needed. The C2 pedicle was palpated using a #1 Penfield instrument between the interspace of C1–C2; C2 pedicle screws were placed bilaterally using the free-hand technique. The O-arm spin was performed after C2 screws were placed to confirm their position [Figure 1]. Subsequently, lateral mass screws (C3–C6), pedicle screws (T1–T4), laminectomies, titanium rods, and posterior lateral bone graft (C2–T1) were applied.

O-arm surgical imaging system and measurements of C2 pedicle width

Utilizing the full spin technique combined with triplanar reconstruction, the O-arm surgical imaging system (Medtronic, Inc. Minneapolis, MN) verifies intraoperative C2 screw placement. The widths of C2 pedicles were measured (mediolateral diameter of the pedicle isthmus, perpendicular to the pedicle axis) using a bone window for documentation of osseous anatomy. The right and left C2 pedicle diameters were measured on the axial images utilizing a regular ruler (e.g., in millimeters; “screen width of C2 pedicle”); this was followed by oblique pedicle measurements [Figure 2]. Notably, the O-arm software does not provide the measurement tool.

Table 1: Patient information

Sex	20 M/13 F
Age	44-89 year (mean 63.7)
Cervical Myelopathy	14
Cervical Fracture	9
Cervical Kyphotic deformity	6
Failure of Cervical Construct	2
C2-3 Subluxation	1
Cervical lesion	1

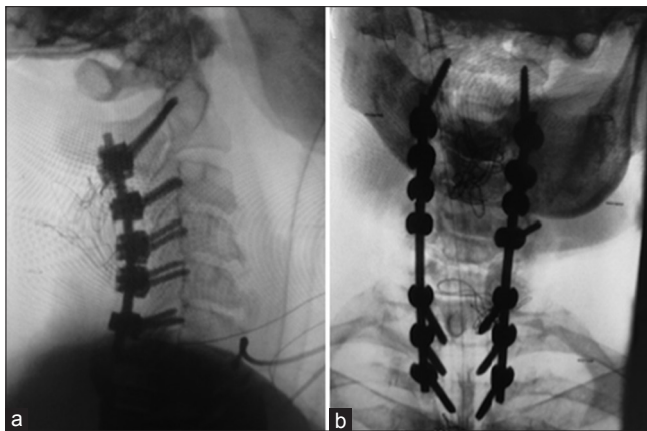


Figure 1: Confirmation of screw and rod placement. (a) Lateral view. (b) Anteroposterior view

Statistical analysis

Differences between axial and oblique width of C2 pedicles were analyzed with paired Student's *t*-test. Results are expressed as mean \pm standard error (SEM). A *P* value of less than 0.05 was considered statistically significant.

RESULTS

The oblique screen widths of C2 pedicles were 1.4 and 1.5 times higher than axial screen widths on the right and left sides, respectively [Table 2]. Although the axial and oblique widths of C2 pedicle in males were slightly longer than that in females, and axial and oblique widths of C2 pedicle in patients less than 60 years were longer than those over the age of 60; none of these differences were significant [Table 2].

DISCUSSION

A major risk of C2 pedicle screw placement includes improper screw placement that may result in damaging the vertebral artery, the nerve roots, and/or spinal cord.^[8] Safer placement of C2 pedicle screws is critical and requires better documentation of the pedicle widths. Here, using the O-arm we directly measured right/left-sided C2 pedicle widths; the oblique screen width of C2 pedicles were 1.4 and 1.5 times higher than axial widths on the right and left sides, respectively. The oblique screen width of C2 pedicles better predicted the feasibility of C2 pedicle screw placement vs. axial screen widths. Future utilization of the intraoperative O-arm spin for these procedures is, therefore, essential to more safely place C2 pedicle screws.

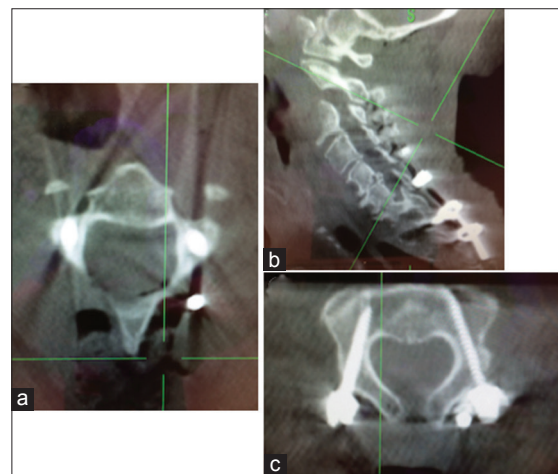


Figure 2: The axial (a) and oblique (c) widths of C2 pedicle on the screen were measured on the axial and oblique images using a regular ruler in millimeters, and therefore called “screen width of C2 pedicle”. The plane was positioned parallel to the C2 pedicle (b) using plane rotation function of the O-arm, oblique measurements (c) were then performed

Table 2: C2 pedicle width

	Axial width (mm)		Oblique width (mm)	
	RT	Lt	RT	LT
All patients	6-15 (11.10±2.07)	7-14 (10.83±1.63)	10-19 (14.68±1.96)	12-19 (15.30±2.0)
Male	7-15 (10.47±2.01)	7-14 (10.45±1.52)	10-19 (14.87±1.50)	13-19 (15.42±1.67)
Female	7-14 (10.25±2.24)	7-12 (10.00±1.82)	13-17 (14.25±2.09)	12-17 (14.70±1.81)
<60 year	9-15 (11.50±1.88)	8-14 (10.71±1.52)	13-19 (15.75±1.50)	13-19 (15.75±1.67)
>60 yaer	6-13 (9.83±2.24)	7-13 (10.05±1.82)	12-19 (14.14±2.09)	12-17 (15.10±1.81)

Table 3: Cervical pathologies for C2 pedicle screws

Cervical Pathologies	Case numbers
Cervical Myelopathy	55
Cervical Fracture	31
Cervical Kyphotic Deformity	10
Cervical Osteomyelitis	8
Failure of Instrumentations	7
Cervical pseudoarthrosis	5
Basilar Invagination	3
Cervical Mass	3
Cervical Abscess	3
Cervical cord compression	2
Ossification Posterior Longitudinal Ligament	2
Cervical Stenosis	1
Cervical Spinal Cord Injury	1
Thoracic Lesion	1
Arteriovenous Fistula	1

The O-arm produced real-time three-dimensional images, providing information regarding C2 anatomy to more accurately place C2 screws. Of the 266 C2 screws placed in 133 patients addressing different cervical pathologies [Table 3], all were accurately placed, none required removal, and there were no neurovascular injuries implant failures or complications.

CONCLUSIONS

The intraoperative O-arm with multiplanar reconstruction facilitates C2 pedicle screw placement by allowing

real-time on-screen measurement of the width (using a ruler) of the C2 pedicles.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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