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Original Research Article

CT MORPHOMETRY OF TYPICAL CERVICAL VERTEBRAL PEDICLES FOR CLINICAL ACCURACY IN CERVICAL PEDICLE SCREW INSERTION

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ABSTRACT

Background: Pedicle screw fixation for mid- and lower cervical spine reconstruction has a potential risk of injury to surrounding structures. To achieve optimal surgical outcomes, it is therefore necessary that pertinent anatomical data, especially with regard to pedicles and vertebral bodies be considered prior to surgery.

Methods: 63 patients were scanned using axial CT parallel to the upper endplate of the vertebral body (C3–C6) with a helical CT scanner. Foramen width (FW), Foramen height (FH), Pedicle width (PW), Foramen angle (FA), Pedicle transverse angle (PTA), Lateral mass angle (LMA) were measured. Mean value and standard deviation of each parameter were calculated.

Results: Mean FW ranged from 5.8 to 6.1 mm with non-significant difference from C3 to C6.The mean FH ranged from 4.9 to 5.1 mm, with non-significant differences between each vertebra. The mean PW ranged from 5.3 to 5.8 mm. There were significant differences between each vertebra, except for the PW between C3 and C4. The FA ranged from 17.5 to 18.5. There were significant differences between each vertebra, except for the FA between C3 and C6. The mean PTA ranged from 39.8 to 35.8. The mean LMA ranged from 0.9 to 3.1.There were significant differences between each vertebra, except for the LMA between C4 and C5. The FW and FH exhibited no correlations with PW, PTA or LMA. FA was found to be positively correlated with both PTA and LMA. There was also a positive correlation between PTA and LMA.

Conclusion: Anatomical features of the cervical spine using CT to select safer screw insertion techniques are highly recommended. In cases in which insertion of pedicle screws is difficult, Lateral Mass Screw (LMS) can be inserted safely. Whereas when insertion of LMS is difficult, insertion of pedicle screws can be performed easily.

KEY WORDS: Pedicle screw fixation, Cervical spine reconstruction, Injury to surrounding structures, Surgical outcomes.

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INTRODUCTION

Trauma to lateral articular mass of cervical vertebrae and their fracture-separation accounts for 9% of the fractures of the lower cervical spine. Neurologic complications are frequent and are usually radicular in nature [1]. Apart from Cervical spine injury, instability, degenerative diseases, cancer, osteoporosis and other pathological diseases affecting anterior vertebral bodies are also commonly encountered by spinal surgeons [2].

Small diameter of mid- cervical pedicles, large obliquity of the cervical pedicle axis and individual variations in cervical pedicle size limit the application of pedicle screws for cervical spine stabilization [3].

The concept of pedicle screw fixation for mid- and lower cervical spine reconstruction was introduced by Abumi et al. Who along with others have reported good clinical results and relatively low rates of complications from this procedure [4]. Authors recommended surgical decompression and stabilization is required to treat most of the cases of cervical spinal injuries with neurological impairment [5].

Wellington et al reports vertebral artery injuries as potentially catastrophic complications that can be sustained from either anterior or posterior approaches of the cervical spine. Outcomes can range from asymptomatic to more serious sequelae including pseudoaneurysm, neurologic deficit, late-onset hemorrhage, infarction, and death. While reporting other causes authors mention anterior approach to the cervical spine can be associated with potential complications such as dysphagia, recurrent laryngeal nerve palsy, Horner's syndrome, and esophageal perforation whereas posterior approaches are also associated with epidural hematomas, dural tear, nerve root injuries and spinal cord infarcts [6].

So a unique method of fixation that has all the advantages of circumferential surgery without of the disadvantages of increased morbidity and cost. Koller et al [7] described anterior cervical transpedicular screw (ATPS) fixation to solve the above problems in 2008 and reported his results from a study on morphological feasibility, indications, and technical prerequisites for the same. To achieve optimal surgical outcomes, it is therefore necessary that pertinent anatomical data, especially with regard to pedicles and vertebral bodies, be obtained. This study was done to measure morphometric parameters of different typical cervical vertebrae in the Indian population on CT scan indicated for various reasons.

MATERIALS AND METHODS

Sixty three patients (age group 23 to 68) who underwent multiplanar CT reconstruction were included. There were 34 males and 29 females. The underlying disorders included cervical spondylotic myelopathy, disc herniation, ossification of the posterior longitudinal ligament and patients with cervical spondylotic amyotrophy. Patients with exhibited evidence of infection, neoplasms, traumatic diseases or congenital spinal malformations were excluded [8].

All patients were scanned using axial CT parallel to the upper endplate of the vertebral body (C3–C6) with a helical CT scanner. An algorithm that provided the most detail, a slice thickness of 1 mm and a slice spacing of 1 mm were used. We evaluated the dimensions of the pedicles from C3 to C6. CT images in which each pedicle appeared the largest were selected, and the following dimensions were determined. All parameters were measured three times by the first author, and the mean was used as the final value.

The parameters included the following measurements

1. Foramen width (FW).

Anteroposterior diameter of transverse foramen

2. Foramen height (FH).

Transverse diameter of transverse foramen

3. Pedicle width (PW).

Distance between approximating points of vertebral canal and transverse foramen

4. Foramen angle (FA) - Denotes the position of the transverse foramen

Angle made by imaginary line passing from posterior border of vertebral canal and center of transverse foramen

5. Pedicle transverse angle (PTA).

Angle made by imaginary line passing from center of pedicular width with sagittal plane

6. Lateral mass angle (LMA).

Angle made by parasagittal line passing from center of transverse foramen with line bisecting lateral mass width.

A statistical analysis of all results was performed, and the range values, mean value and standard deviation of each parameter were calculated.

Significant differences were considered to exist at P values of\0.05

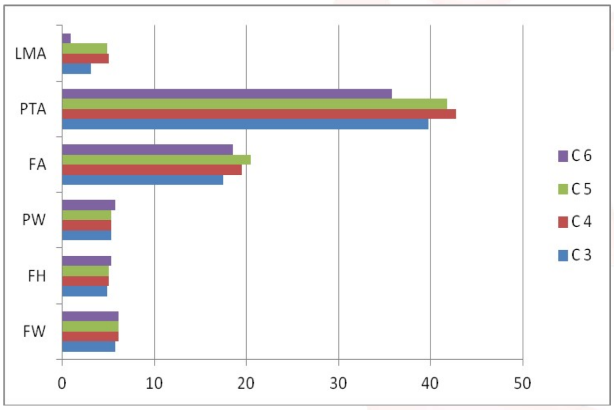
RESULTS

Mean FW ranged from 5.8 to 6.1 mm with non-significant difference from C3 to C6.The

Table 1: Showing measurements of parameters.

Vertebra	Gender	FW (mm)	FH(mm)	PW(mm)	FA (deg)	PTA(deg)	LMA(deg)
C3	Mean	5.8 ± 0.9	4.9 ± 0.6	5.3 ± 0.8	17.5 ± 3	39.8 ± 1.2	3.1 ± 2
	Female	5.7 ± 0.7	4.9 ± 0.7	5.0 ± 0.9	17.1 ± 4	38.7 ± 4.3	3 ± 2.5
	Male	5.8 ± 0.8	4.9 ± 0.6	5.5 ± 0.7	17.5 ± 2.7	40.2 ±3.4	3.3 ± 3
C4	Mean	6.1 ± 0.9	5.1 ± 0.6	5.3 ± 0.8	19.5 ± 3	42.8 ± 1.2	5.1 ± 2.6
	Female	6.0 ± 0.7	5.1 ± 0.7	5.2 ± 0.9	17.1 ± 4	41.7 ± 4.3	5.0 ± 2.5
	Male	6.2 ± 0.9	5.2 ± 0.8	5.6 ± 0.7	21.5 ± 2.7	44.2 ±3.4	5.3 ± 3
C5	Mean	6.1 ± 0.9	5.1 ± 0.6	5.3 ± 0.8	20.5 ± 3	41.8 ± 1.2	4.9 ± 2.5
	Female	6.0 ± 0.7	5.1 ± 0.7	5.2 ± 0.9	19.1 ± 4	40.7 ± 4.3	4.8 ± 2.5
	Male	6.2 ± 0.9	5.3 ± 0.8	5.7 ± 0.7	21.5 ± 2.7	43.2 ±3.4	5.0 ± 3.1
C6	Mean	6.1 ± 0.9	5.3 ± 0.6	5.8 ± 0.8	18.5 ± 3	35.8 ± 1.2	0.9 ± 2.5
	Female	6.0 ± 0.8	5.2 ± 0.7	5.6 ± 0.9	18.2 ± 4	33.7 ± 4.3	0.7 ± 2.5
	Male	6.2 ± 0.9	5.5 ± 0.8	6.2 ± 0.7	19.5 ± 2.7	38.2 ±3.4	1.1 ± 3.1

Fig. 1: Showing comparative measurements of C3,C4,C5,C6.



mean FH ranged from 4.9 to 5.1 mm, with non-significant differences between each vertebra. The mean PW ranged from 5.3 to 5.8 mm. There were significant differences between each vertebra, except for the PW between C3 and C4. The FA ranged from 17.5 to 18.5. There were significant differences between each vertebra, except for the FA between C3 and C6. The mean PTA ranged from 39.8 to 35.8. The mean LMA ranged from 0.9 to 3.1.There were significant differences between each vertebra, except for the LMA between C4 and C5. The FW and FH exhibited no correlations with PW, PTA or LMA. FA was found to be positively correlated with both PTA and LMA. There was also a positive correlation between PTA and LM

DISCUSSION

Pedicle screw fixation in the cervical spine has been considered a serious risk to the surrounding structures. Roy-Camille stated that the placement of transpedicular screws into the C3–6 pedicles would be an unacceptable risk for injury to the vertebral artery, spinal cord and nerve roots [9]. Abumi et al has given details biomechanical analysis of preoperative pathology and postoperative stabilization of anatomy. Author states surgical correction of the malalignment and stabilization by the isolated posterior or the combined anterior and posterior approach is common in cases of compressive flexion, compressive extension, distraction flexion, and stage 2 distractive extension injuries [5, 10, and 11].

While comparing mechanical internal stabilizing devices and bio- cortical anatomy of vertebral bodies Abumi et al mentions the stiff internal stabilizing effect of transpedicular screw fixation precludes the need for additional anterior surgery and postoperative external support for extremely unstable cervical spines[12]. As per Richter et al the screw placement should be evaluated according to the diagnostic or therapeutic consequences resulting from the grading of the pedicle screw position [13].

To further improve cervical pedicle screw accuracy in percutaneous stabilization of the cervical and cervicothoracic spine, the use of three-dimensional fluoroscopic navigation can be used. Ito et al demonstrated the usefulness of this technique in posterior screw placement using a traditional open approach [14]. Holly et al were able to demonstrate the benefit of the technique in vitro which demarcates detail anatomical knowledge is crucial [15].

Panjabi et al have reported a detailed anatomical study of the pedicles of the cervical spine.

According to them, the average angle of the pedicle axes from lateral to midline in the transverse plane was 45° at C4, 39° at C5, 29° at C6, and 33° at C7. This study is landmark in delineating direction of screw so as to avoid injury to surrounding structures. It also inspires detail anatomical research for more clinical accuracy [16].

Karaikovic et al [17] and Reinhold et al [18] reported cervical pedicle morphology and angular measurements to determine the direction of pedicle screw insertion in both the transverse and sagittal planes using CT. Sakamoto et al [19] also evaluated cervical pedicle morphology using CT and reported that the screw insertion angle should be as close as possible to 50 degrees in the transverse plane and that the entry point of cervical transpedicular screws should be located as laterally as possible on the posterior surface of the lateral mass

When compared present study with that of Nishinome et al we affirm with authors in getting only significant difference in the angular parameters in FA at C4. Author found that FW and FH exhibited no correlations with PW, PTA or LMA. On the other hand, there were positive correlations between FA and both PTA and LMA. This means that the difficulty of screw insertion changes relatively with the location of the transverse foramen. When the transverse foramen is located more anteriorly and medially (the FA becomes larger), both PTA and LMA are larger. In such cases, insertion of pedicle screws is more difficult, and insertion of Lateral Mass Screw should be used to avoid Vertebral Artery injury and bony violation. Furthermore, this allows for the selection of longer screws .In contrast, when the transverse foramen is located more posteriorly and laterally (the FA becomes smaller), both PTA and LMA are smaller.

Table 2: Showing comparative analysis of present study and study by Nishinome et al.

Parameters	Present study	Nishinome et al
FW (mm)	5.8 to 6.1	6.2 to 6.3
FH (mm)	4.9 to 5.1	5.0 to 5.7
PW (mm)	5.3 to 5.8	5.4 to 6.1
FA (degrees)	17.5 to 18.5	18.8 to 20.5
PTA (degrees)	39.8 to 35.8	37.1 to 45.4
LMA (degrees)	0.9 to 3.1	1.0 to 5.3

The parameters of thus present study indicates how to avoid damaging the vital structures if a screw is directed perpendicular to the posterior aspect of the lateral mass at C3-C5 and denotes approximate angle in degrees to the transverse plane at at the midpoint of the lateral mass.

To enhance the safety of transpedicular screw fixation in the lower cervical spine multi-specialty approach considering anatomical variations between individuals, combined with evaluation of results of preoperative axial computed tomography and conventional radiography, can reduce incidence of post-operative complications and better results for patients.

CONCLUSION

Cadaver studies and careful preoperative CT evaluation with multiplanar reconstructions of pedicle dimensions are essential and contribute to the safety of cervical transpedicular screw placement. Review of literature has shown that introduction of newer surgical techniques

Even could not be significantly decrease risk of injury.

Therefore further investigation using screw sizes matched to the pedicles and modified aiming frame can be performed and compared with computer-assisted of fluoroscopic guidance as to further increase accuracy of a less expensive and technically less demanding surgical technique.

Conflicts of Interests: None

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