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FEASIBILITY OF PEDICLE SCREW INSTRUMENTATION IN SUBAXIAL CERVICAL SPINE IN INDIAN POPULATION WITH REGARD TO TRANSVERSE PEDICLE DIAMETER: CADAVERIC STUDY

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ABSTRACT

Background: Instability in cervical spine can be caused by various conditions such as trauma, infection, neoplasm or posterior decompression procedures. Of all the fixation methods in cervical spine transpedicular screw fixation has reported to be most effective overall. However cervical pedicle screw insertion carries risk of catastrophic complications and several cadaveric studies have reported high perforation rates. Morphometric studies of cervical spine in Indian population is scanty. We studied the transverse cervical pedicle diameter in 20 cadavers to assess feasibility of pedicle screw fixation with regard to screw diameter.

Material & Methods: CT scan of 20 cadaveric cervical spine blocks was performed and reformatted images at the mid pedicular levels were obtained for the measurement of transverse pedicle width. Subsequently direct measurement of transverse width of pedicle was performed on dissected vertebrae from the blocks.

Results: Mean transverse diameter on direct measurement and CT measurement were noted to be less as compared to the white population. The transverse pedicle diameter was less at all levels in females as compared to males. Transverse diameter was minimum at C3 and maximum at C7.

Conclusion: We conclude that transverse pedicle diameter is less as compared to white population. Pedicle screw fixation may not be feasible at all levels in Indian population especially females with 3.5 mm screw option available currently. Hence smaller diameter screw option should be available. Also pre operative multiplanar CT morphometric evaluation of each level should be done to determine appropriate screw dimensions, trajectory and entry point.

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INTRODUCTION

Surgical fixation in cervical spine is needed to correct or maintain spinal alignment (treat instability), to enhance fusion rates and to allow early mobilization [1]. Instability in cervical spine can be caused by various conditions such as trauma, infection, neoplasm or posterior decompression procedures. Various techniques to achieve surgical fixation of cervical spine include spinous process wiring, triple wire technique, sublaminar wiring, lateral mass plating, anterior vertebral body plating and transpedicular screw fixation [2]. Type of pathology and surgeon experience determines the choice of fixation method. Situations with absent or deficient spinous process prevent the use of wiring techniques. A study has reported that amongst the seven anterior and posterior fixation techniques, transpedicular screw fixation was found to be overall most effective in terms of stiffness, for flexion, extension, torsion, and compression in posterior column and three column instabilities [3]. Also as compared to bicortical lateral mass screws, which is a preferred method of posterior cervical spine fixation, pedicle screws have been shown to have a higher pullout strength and lower risk of loosening during cyclic loading [3].

Panjabi et al in 1991 in their anatomic study of cervical vertebrae reported that transpedicular screw fixation is possible in cervical spine [4]. In 1994 Abumi et al reported the use pedicle screws in 13 patients with subaxial cervical trauma without complication. Subsequently many have reported morphometric parameters of cervical pedicle [1, 6-9] and also several biomechanical [10] and clinical studies have been published [5, 11-13]. However cervical pedicle screw insertion carries risk of catastrophic complications [14] and several cadaveric studies have reported high perforation rates [15].

Few morphometric studies have been reported for cervical pedicle in Indian population [16-18]. More studies are needed to ascertain the feasibility of cervical pedicle screw fixation in Indian population. Most of the morphometric studies have reported that transverse pedicle diameter is less than the sagittal diameter, hence transverse diameter can be limiting factor with regard to screw diameter. In this study we have studied the transverse pedicle diameter in cadavers.

MATERIAL & METHODS

20 adult cadaveric (14 male & 6 female) cervical spine blocks from T1 to occiput obtained from Department of Anatomy, Government Medical College & Hospital, Nagpur, India were studied. CT and anatomic measurements were done for the transverse pedicle diameter. First CT scan of the cadaveric blocks was done and reformatted mid pedicular axial and sagittal cuts were obtained. Transverse diameter was measured in mid pedicular axial cut. Following dissection of individual vertebra actual transverse pedicle diameter was measured with a Vernier caliper.

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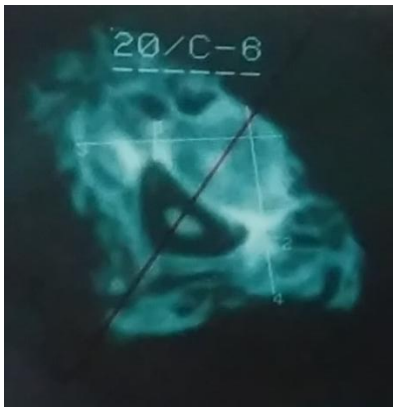
Fig 1.

a) 

b) 

a) Reformatted mid pedicular axial image of C6, b) Direct measurement of transverse diameter on dissected vertebra.

OBSERVATION & RESULTS

On CT mean transverse pedicle diameter in male was maximum at C7 (6.05 mm) and minimum at C3 (4.32). In females it was maximum at C7 (6.52 mm) and minimum at C3 (3.83 mm).

In male specimens on direct measurement the mean transverse pedicle diameter was found to be maximum at C7 (6.29 mm) and minimum at C3 (4.85). Transverse diameter was noted to increase from C3 to C7.

In female specimens on direct measurement mean transverse diameter was found to be maximum at C7 (6.15 mm) and minimum at C3 (4.55 mm). Similarly the transverse diameter increased from C3 to C7.

Table 1. Transverse pedicle diameter in mm

Level	Direct examination		CT examination	
	Male	Female	Male	Female
C3	4.85 +/- 1.12	4.55 +/- 0.69	4.32 +/- 0.98	3.83 +/- 0.32
C4	4.89 +/- 0.75	4.96 +/- 0.97	4.44 +/- 0.92	3.51 +/- 0.20
C5	5.01 +/- 0.94	4.93 +/- 0.94	4.55 +/- 0.92	3.60 +/- 0.45
C6	5.75 +/- 0.92	4.56 +/- 0.84	5.16 +/- 1.05	4.81 +/- 0.45
C7	6.29 +/- 1.04	6.15 +/- 1.16	6.05 +/- 1.41	6.52 +/- 0.73

DISCUSSION

Biomechanical studies have demonstrated that pedicle screw fixation in cervical spine is better than other methods with regards to construct stiffness and pull out strength [3]. But

due to close proximity of neurovascular structures there is risk of complication. So understanding the anatomy and detailed morphometric evaluation is of utmost importance to formulate guidelines for safe use of pedicle screws in cervical spine. Since 1991 when Panjabi et al reported morphometric study of subaxial cervical spine, many morphometric studies of the subaxial cervical spine have been reported with reference to feasibility and techniques for pedicle screw fixation [1-3, 6-10, 14-23]. But as noted earlier few studies have been reported for Indian population. Chanplakorn et al in their evaluation of morphometry of subaxial cervical spine using CT scan reported that the inner pedicle width should be a key parameter to determine the screw dimensions, trajectories and entry point [14]. Reinhold in their cadaveric study of cervical pedicle screw fixation attributed most of the pedicle wall violations to the disproportion between screw diameter and internal pedicle width (transverse diameter) [15]. They also reported that 83.3 % of the pedicles in their series had an internal pedicle width of 3.5 mm or less. Hence transverse pedicle diameter is an important factor in determining the feasibility for pedicle screw fixation in cervical spine.

On comparing our direct measurement with other studies we note that the transverse diameter in white population was slightly greater than current study at all levels (Table 2.)

Table 2. Comparison of mean values of direct measurement with other studies.

Level	Current study		Nabil Ebraheim [6]		E. Ladd Jones [24]	MM Panjabi [4]	
	Male	Female	Male	Female		R	L
C3	4.85	4.55	4.90	4.50	4.80	5.80	5.40
C4	4.89	4.96	4.70	4.60	5.20	5.70	5.10
C5	5.01	4.93	4.90	4.90	6.10	6.10	5.10
C6	5.75	4.56	5.20	5.00	6.50	6.30	5.60
C7	6.29	6.15	-	-	6.90	6.60	6.50

We also compared our CT measurements with other studies (Table 3.)

Table 3. Comparison of mean CT measurements

Level	Current Study		Rao RD et al [3]		Reinhold M et al [15]	Chanplakorn et al [14]			
	Male	Female	Male	Female		Male		Female	
						Rt	Lt	Rt	Lt
C3	4.32	3.83	5.8	4.8	5.7	5.18	5.18	4.43	4.27
C4	4.44	3.51	6.0	5.0	5.6	5.10	4.24	4.59	4.51
C5	4.55	3.60	6.3	5.2	6.2	5.64	5.78	4.91	4.78
C6	5.16	4.81	6.5	5.7	6.7	5.72	5.78	5.27	5.24
C7	6.05	6.52	7.6	6.5	7.9	6.91	7.00	6.16	6.21

In CT comparison also we note that mean transverse pedicle diameter in our study is less as compared to those reported in western population. Our measurements are in agreement with other studies in Indian population [16 – 18]. Although we have not measured the inner pedicle width, other studies have reported it and it is much less as compared to the outer pedicle width (Table 4.)

Table 4. Inner pedicle width reported in some of the studies

Level	Reinhold M et al [15]	Chanplakorn et al [14]			
		Male		Female	
		Rt	Lt	Rt	Lt
C3	2.2	2.67	2.75	2.10	2.13
C4	2.4	2.56	2.89	2.21	2.27
C5	2.5	2.91	3.10	2.54	2.56
C6	2.7	3.16	3.24	2.75	2.91
C7	3.9	4.27	4.51	3.37	3.67

It is recommended that pedicle screw fixation should be avoided in cervical segments with very small inner diameter of pedicle or without medullary canal [15]. Chanplakorn et al [14] pointed out that to determine the screw dimensions, trajectories and entry point, inner pedicle width is a key parameter.

Transverse pedicle diameters in our study are smaller than those reported in other studies [14, 15] and those studies have also reported the inner pedicle width which is much smaller. Reinhold M et al [15] in their study used 3.5 mm screws at all levels and reported high percentage of pedicle violations. Considering these facts and findings from our study, it can be inferred that pedicle screw fixation may not be feasible in Indian population for all or at all levels for a particular patient especially in females. Although we did not measure the cortical thickness of pedicle wall, we noted the medial wall to be thicker than the lateral wall. Multiple authors have reported that medial wall is thicker than the lateral wall and hence pedicle guide probe should be directed towards the medial wall for safe placement of pedicle screw [14]. Many studies [1, 3, 14, 15] have concluded that preoperative evaluation of each level with multiplanar CT is essential if pedicle screw instrumentation is planned in cervical spine.

In our study the transverse diameter was minimum at C3 for both males and females. It increased from C3 to C7. According to the literature 3.5 mm screw may not be suitable and could have violated most of the pedicles from C3-C6 in our study. Hence a smaller size screw should be considered in Indian population.

We conclude that transverse pedicle diameter is less as compared to white population. Pedicle screw fixation may not be feasible at all levels in Indian population especially females with current 3.5 mm screw option and smaller diameter screw option should be available. Also pre operative multiplanar CT morphometric evaluation of each level should be done to determine appropriate screw dimensions, trajectory and entry point.

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