

# Validation of Freehand Cervical Pedicle Screw Placement in Subaxial Spine Using the “Burcev Technique”: A Cadaveric Study

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## Abstract

The present study attempted to validate the “Burcev freehand method” based on anatomical observations in Indian cadavers. The study was conducted on 32 cervical pedicle screws (CPSs) that were placed in four cadavers by the authors according to the “freehand technique,” described by Burcev et al, without the aid of fluoroscopy and the trajectory verified by computed tomography scans. The screws were designated as satisfactory, permissible, or unacceptable. Descriptive variables were represented in number and percentages, continuous variables were represented as mean  $\pm$  standard deviation (SD). Of the 32 CPSs placed, 24 (75%) exhibited a satisfactory position, 1 (3%) exhibited a permissible position, and 7 (22%) exhibited an unacceptable position. Of the seven CPSs in the unacceptable group, four exhibited a lateral breach and three exhibited a medial breach, whereas the CPS in the permissible group exhibited a medial breach. The overall angle with contralateral lamina in the horizontal plane in terms of mean  $\pm$  SD was  $175.43 \pm 2.82$ ,  $169.49$ , and  $169.65 \pm 6.46$  degrees in the satisfactory, permissible, and unacceptable groups, respectively. In the sagittal plane, the screws exhibited an angle of  $88.15 \pm 3.56$  degrees. No breach was observed superiorly or inferiorly. The “Burcev technique” is replicable with similar results in cadavers. Further studies must be conducted in a clinical setting to ensure its safety.

## Keywords

- cervical pedicle screw
- freehand technique
- Burcev’s method
- cadaver

## Introduction

Pedicle screws have been the cornerstone in spine instrumentation, particularly in the lumbar and thoracic spine.<sup>1–3</sup> The cervical spine is complicated in anatomy because of its close relationship with the cervical spinal cord medially and the

vertebral artery laterally. Thus, the placement of the screw without causing injury to the neurovascular structures is challenging because a wrong placement could be catastrophic for patients.<sup>4,5</sup> In the cervical spine, C2 and C7 pedicle screws have been universally accepted to be “safe” and routinely used freehand technique.<sup>6,7</sup> However, screw insertion in the

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subaxial spine, namely, C3–6, is still challenging for surgeons and the optimal approach remains unknown. In 1994, Abumi et al first described a technique of freehand cervical pedicle screw (CPS) placement, and the technique has been subsequently modified.<sup>4</sup>

In 2017, Burcev et al described a “freehand” technique, which they described as an “easy and fast method” for safe CPS placement.<sup>8</sup> Although the anatomical observation of the authors was appealing and straightforward, none of the authors have reiterated their findings. The present study aims to validate the “freehand technique,” described by the authors, in Indian cadavers.

## Materials and Methods

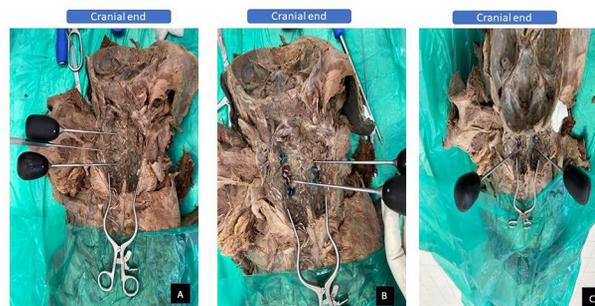
The present study was conducted in four-stored cadavers after obtaining institutional ethics clearance. A waiver of consent was obtained to use the formalin-preserved cadavers in the anatomy department of the institute (T/IM-MF/Ortho/19/62 dated December 16, 2019). The cadavers were placed prone on the dissecting table, and the dissection was performed deep to the bones. One assistant (S.P.) steadied the cadaver, and one spine surgeon (M.J.) performed the procedure described by Burcev et al by using a “freehand technique.”<sup>8</sup> Only the subaxial spine C3–6 was instrumented, omitting the C7, which is now an established technique. The entry point for the CPSs was 2-mm medial and inferior to the facet joint between the involved and rostral vertebrae at a trajectory parallel (180 degrees) to the contralateral lamina and at an angle of 90 degrees to the sagittal plane (► Fig. 1). No fluoroscopic assistance was used in the process. Four screws (3.5 mm × 24–26 mm, Jayon India Limited) were placed on each side in each cadaver. The cadavers were then transferred to the radiology department in a waterproof covering for computed tomography (CT) scans. A 64-slice CT scanner (GE Lightspeed 64 slice CT scanner) was used to take images at a thickness of 3 mm. The axial images were then used to evaluate the screw positions. The assessment was also categorized on the same scale described by Burcev et al (► Table 1).<sup>8</sup>

Data were entered in the excel sheet, and SPSS version 21 (Microsoft, Chicago, Illinois, United States) was used for data analysis. The angle made by the screw with the contralateral lamina was calculated using the Surgimap tool online. Sagittal images were taken to detect a superior or inferior breach.

## Results

During the cadaveric study, 32 CPSs were inserted in C3–6 pedicles (► Figs. 2 and 3). Of these inserted CPSs, 24 (75%) exhibited a satisfactory position, 1 (3%) exhibited a permissible position, and 7 (22%) exhibited an unacceptable position. In the unacceptable group, four screws exhibited a lateral breach and three screws exhibited a medial breach, whereas the only CPS in the permissible group exhibited a medial breach (► Figs. 2 and 3, arrow marked). The angle

with contralateral lamina measured in mean ± standard deviation (SD) was  $173.98 \pm 4.53$  degrees, with a minimum of 160.77 degrees and a maximum of 179.52 degrees. Angle in the satisfactory, permissible, and unacceptable groups was  $175.43 \pm 2.82$ , 169.49, and  $169.65 \pm 6.46$  degrees, respectively. The mean ± SD for the medial breach was  $173.98 \pm 4.53$  degrees, whereas that for the lateral breach was  $165.84 \pm 4.05$  degrees.



**Fig.1** Images showing the screw insertion in progress. The angle in the horizontal plane is seen one side in (A), and both sides in (C). (B) The parallelism with contralateral lamina done.

In the sagittal plane, the screws made an angle of  $88.15 \pm 3.56$  degrees. No superior or inferior breach was observed (► Fig. 4).

## Discussion

Pedicle screw placement offers three-column stability in the thoracic or lumbar spine and is the most rigid posterior fixation method.<sup>9</sup> However, use of CPS is limited because of the low margin of error that increases the risk of damage to the spinal cord medially, vertebral vessels laterally, and to the exiting nerve that lies in close proximity to the pedicle. Several anatomical and clinical studies have been performed on CPS fixation, with each study having unique trajectories, tricks, and tips to avoid pedicle breach.<sup>4,8–18</sup> However, these “freehand techniques” have not gained widespread popularity among spine surgeons. The last two decades have been an era of digital navigation, and robotic technology has improved the CPS placement technique.<sup>19,20</sup>

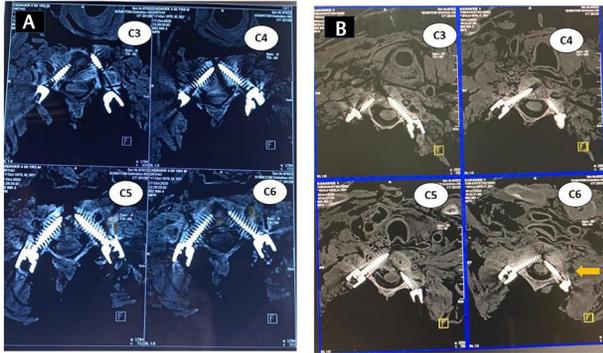
Although navigation offers surgical safety to patients without complications, it requires a sophisticated set up with expensive armamentarium.<sup>21</sup> Sometimes, cervical spine alignment can change intraoperatively that leads to inaccurate placement due to the C-spine.<sup>17</sup> These shortcomings limit the application of the “digital navigation technology” in a few centers. Thus, the search for a universally accepted method for the safe placement of CPS continues.

In 1994, Abumi et al first described the early results of 13 patients treated with transpedicular fixation of the cervical spine.<sup>4</sup> The authors suggested that the entry point must be just lateral to the center of the facet and close to the posterior margin of the superior articular surface. While a burr was used initially to enlarge the entrance hole, the screw

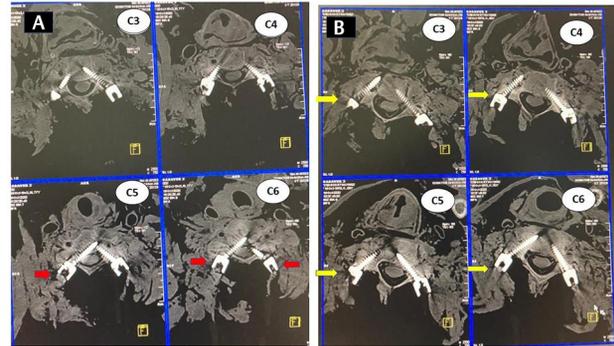
**Table 1** Radiological grading of screws

	x completely in a pedicle with no breach on either side	Spinal canal (medial breach)	Vertebral foramen (lateral breach)
CPS placement	Satisfactory (75%)	Permissible (3.1%) Medial: 1	Unacceptable (22%) Lateral: 4 Medial: 3
Laminar screw angle	173.98 ± 4.53 (160.77–179.52)		Medial: 173.98 ± 4.53 Lateral: 165.84 ± 4.05
Sagittal angle	88.15 ± 3.56		

Abbreviation: CPS, cervical pedicle screw.



**Fig. 2** Axial CT scan pictures of subaxial spine of two cadavers (A, B). The sole medial breach that is permissible is depicted with an arrow. CT, computed tomography.



**Fig. 3** Axial CT scan pictures of subaxial spine of next two cadavers (A, B). The medial breaches are depicted in red arrows and lateral breach in yellow arrows. CT, computed tomography.

was angled from 25 to 45 degrees medially in the horizontal plane, parallel to the upper endplate of the vertebral body in the sagittal plane. The authors used a small nerve retractor to probe the path with the help of an image intensifier. Although neurological improvement was observed in some patients, deterioration though CT could not properly delineate the exact direction.

Jeanneret et al performed a cadaveric study in the same year and placed 33 screws of which 10 had a minor breach of the pedicle. They used a point 3 mm below the facet joint on the midpoint of the lateral mass. The drill was angled medially, averaging 45 degrees aiming toward the cranial third of the vertebral body. The authors performed this method successfully on three patients.<sup>13</sup>

Miller et al in 1996 conducted a comparative study of blind technique versus partial laminectomy and tapping method in eight cadavers. They reported a decreased incidence and severity of pedicle violation in the partial laminectomy group as compared with the blind group. They did not recommend the routine use of this method owing to the risk involved in pedicle screw placement.<sup>11</sup>

In 1996, Ebraheim et al conducted a cadaveric study and observed that the foramen transversarium is in the same sagittal plane as the midpoint of the lateral mass.<sup>6</sup> Therefore, they recommended starting from the superiolateral corner of the lateral mass; the trajectory should be 10-degree cephalad (C6–7), 10-degree caudal (C3–4), vertical for C5 in the sagittal plane, 40–47-degree medially (C3–6), and slightly less for C7.

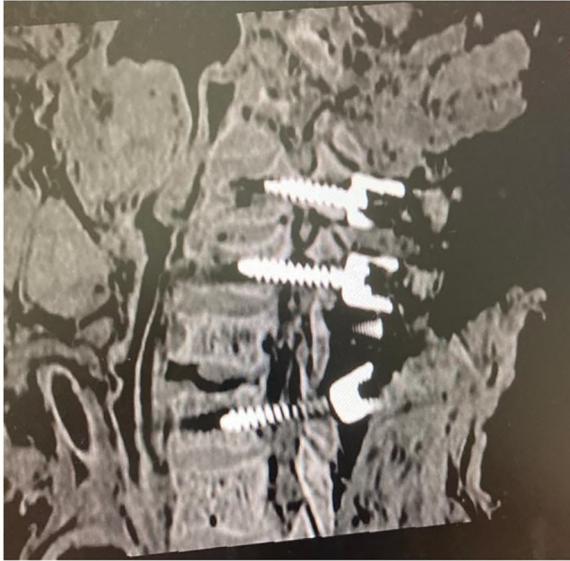
In 2009, Xu et al<sup>15</sup> used Ebraheim's technique to place 114 screws in 36 patients (mostly including patients with cervical trauma). They reported an overall 88.9% satisfactory position with no neurovascular complications. Other studies have also been conducted with some variability in the entry point and trajectory.<sup>10</sup>

Lee et al in 2012 described a key slot technique for CPS placement. These investigators inserted 277 in 50 patients. A right-angled triangle on the axial plane was created in the medial half of the lateral mass with a 3-mm burr. The apex of triangle was at the inlet of pedicle. The authors had a 90% acceptability without any catastrophic neurovascular complication in their cases.<sup>17</sup>

Wang et al in 2013 described a freehand technique of CPS insertion which they assessed using a CT scan. These researchers used a small curette to palpate the thick medial pedicle wall and pass a drill in appropriate trajectory by repeated palpation. The lateral breach of pedicle was found to be 12.64% of which 9.86% was grade I and 2.63% was grade II.<sup>18</sup>

Lee et al in 2017 described a “medial funnel technique” that included visualization of pedicle using laminoforaminotomy and simultaneous probing, the authors used 88 CPS in 28 patients with 94.3% correct placement. There was no neurovascular complication in their series.<sup>12</sup>

Wu et al in 2017 also described an entry point for CPS placement based on coronal multiplane reconstruction image.<sup>22</sup> The authors referred this as the “lateral vertebral notch technique” where the entry point was found to be



**Fig. 4** Sagittal CT scan image of a cadaver showing the screws in position. CT, computed tomography.

consistently 2.2-mm medial and 1.4 mm below the lateral vertebral notch for C3–6 vertebrae. The authors subsequently extrapolated the described technique in human cadaver and found 96.7% acceptability in 120 CPS.<sup>23</sup>

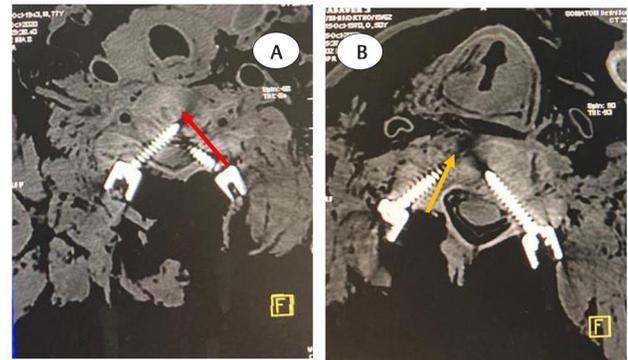
In 2020, Liu et al described a “sliding technique,” wherein they inserted 251 screws in patients with cervical trauma. They exhibited a high (90%) intrapedicular placement with no neurovascular complication. The authors recommended their technique as safe and effective for the placement of pedicle screw in the subaxial spine.<sup>9</sup>

Our findings for CPS placement are concurrent with those described by the original authors.<sup>8</sup> The “Acceptable” (combined “satisfactory” and “Permissible”) percentage of the CPS is same as described by them. We strictly adhered to the author’s method and did not apply the modifications such as “burring deep” described by Abumi et al, use of a smaller probe, sliding method, or a small laminotomy for tactile perception reported by other authors that could have improved the results.<sup>4,9,10,14</sup> We observed that screws having a medial breach had an entry point more medially (>2 mm inside the outer margin of lateral mass), whereas those having a lateral breach had a more lateral entry point (►**Fig. 5**). Intraoperative fluoroscopy can be used to choose the entry point in clinical settings.

### Limitations of the Study

The present study is a cadaveric study that lacks clinical validation. However, the results mirror those of the authors’ cadaveric portion of the study and, hence, the method is reproducible.

The formalin-preserved bones are softer than the actual dried vertebrae or vertebrae of live patients and may give a better tactile perception intraoperatively. Thus, further



**Fig. 5** The error of entry points that lead to (A) medial breach (red arrow) and (B) lateral breach (yellow arrow) are depicted.

clinical studies must be conducted on patients to ensure popularity and acceptability of the method.

### Conclusion

The Burcev technique is an effective and reproducible method of placing subaxial CPSs. The landmarks are easily identifiable, and further studies in clinical settings will help popularize this method. Additionally, certain modifications and tips such as deep burring, use of small probe, sliding method, and fluoroscopic guidance will improve its safety margin.

#### Authors’ Contributions

M.J., R.N.S., M.G., and N.D.B. conceived the idea, and M.J. took the ethical consent. M.J., S.P., and A.T. were involved in dissection where M.J. inserted all screws. Radiological inputs were given by N.D.B. M.J., R.N.S. and M.G. prepared the manuscript and other authors gave the critical input. All authors read the manuscript and agreed on the content.

#### Funding

None.

#### Conflict of Interest

None declared.

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