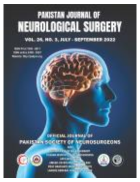


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Original Article

# Intraoperative Computed Tomography Scanner-Guided Junctional Zone Spinal Surgery in Fluoroscopic Limitation Zone-An Early Experience

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## ABSTRACT

**Objective:** Confirmation of the level for surgery at the junctional zones of the spine is associated with unique difficulties. C-Arm has its limitations in these areas. The use of intraoperative CT scan with navigation greatly helps in the surgery at junctional zones. These junctional zones include the craniocervical junction, cervico-dorsal junction, and sacroiliac junction. In 2019, we installed an Airo Brain Lab 32-slice MDCT in our facility and researched to evaluate its advantages in junctional zone fluoroscopy-restricted spine operations.

**Material and Methods**: We performed 20 complex surgeries in all these 3 junctional zones with the use of an intraoperative computed tomography scanner. 3 patients had craniovertebral junction fixation under intra-op CT while 6 had lateral mass fixation. 3 patients had cervicodorsal junction fixation and 4 patients had lumbosacral fixation.

**Results:** 2 out of 3patients with cervicodorsal fixation had correction of screws trajectory after usage of intra-op CT and 1 patient with lumbosacral fixation. All patients were discharged home with neurology better or the same as compared to pre-op. status while 13 patients had a favorable outcome.

**Conclusion:** Intraoperative computed tomography scanner is opening new horizons for complex spinal surgeries.

**Keywords:** Intraoperative CT scanner, Type 2 Odontoid Fracture, Junctional Zone Surgery, craniovertebral junction surgery.

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## INTRODUCTION

Junctional zones in the spine are complex regions.

Conventional fluoroscopic guided surgeries have limitations in junctional zones. At the craniovertebral junction, the surrounding occiput and condyles limit the visualization of structures on fluoroscopy and similarly at cervicothoracic, thoracolumbar, and lumbosacral junctions. Real-time monitoring of ongoing surgeries has long been a point of interest for neurosurgeons.

Over the past two decades, there have been great advancements that have revolutionized the approach to brain and spinal image-guided interventions. Neuronavigation was a great breakthrough in this regard. Being specific about spinal navigation, despite the sound technological advances, their penetration is limited. However, they have favorable surgical outcomes.[1-2]

Conventionally, C-arm-based spinal navigation has been used by neurosurgeons in augmenting posterior pedicular screw implantation. But, since its limitation over accuracy and assessment at certain spinal zones, its use has been a debate among neurosurgeons over the years.[1,3,6,10-12]

The occipitocervical area extends from the base of the occiput to the second cervical interspace. This area consists of the occiput, atlas, and axis held together mainly by alar and transverse ligaments.[2,12] As the main support of the cervical spine comes from its ligaments, visualization of this area through fluoroscopic techniques consists of a lot of discrepancies due to various superimposed structures and fails in providing optimal trajectory for screw implantation.[2,9,13]

Cervicothoracic and lumbosacral junctions are other areas that challenge the accuracy and precision of fluoroscopic guided imaging.[14-15] The cervicothoracic region extends from C6 to T2 and due to its variable pedicle dimensions (downgrading pedicle width from C6 to T1) and angulation, there is a need for higher accuracy and optimal screw placement to avoid mal-positioning of screws and to prevent any neurovascular damage.[4,9]

In the past ten years, spinal navigation has greatly been complemented by the introduction of intraoperative CT in neurosurgery operation theaters. It has greatly improved the accuracy in screw placement and assessment of certain challenging zones.[1] With multi-detector CT, which provides more specific bone details with a feature of focal spot wobble, the quality of image resolution and assessment of pathologic area has been improved.[5-6] Due to its easy incorporation, convenient handling, and few modifications requirements, its application is quite convenient and cost-effective.[5,10-11]

We acquired Airo Brain lab 32-slice MDCT in our setup in 2019 and conducted the study for evaluating its benefits in junctional zone fluoroscopy limited spine surgeries.

## MATERIALS AND METHODS

### Study Design & Setting

A Retrospective study was conducted at the Department of Neurosurgery Jinnah Hospital Lahore, from January 2019 to December 2021.

### Inclusion Criteria

Patients of both genders, of age above 15 years with junctional zone injury were included in the study. Patients planned for occipitocervical fixation, lateral mass fixation, cervicodorsal junction, upper dorsal fixation (D1 – D4), and lumbosacral fixation were enrolled in the study.

### Exclusion Criteria

Patients with junctional zone instability due to tumors or infections were excluded. Pediatric patients were not included in the study. Patients with multilevel injuries were also not included.

### Radiological Investigation

All patients underwent intraoperative CT of the instrumented region after fixation was done under fluoroscopic guidance and intraoperative CT confirmed the trajectory of screws, and in cases of malposition, the trajectory was redirected and later confirmed on intraoperative CT during the same anesthesia. Preoperative neurological status was documented according to the modified MRC scale. The outcome was labeled as favorable and unfavorable.

## Data Analysis

Data was analyzed for age, gender distribution, neurological status, region of neurosurgical intervention, and complications. Screw malposition and wound infection were documented as complications.

## Favorable Outcome

The outcome was labeled as favorable if there is an improvement of 1 grade postoperatively.

## RESULTS

20 patients were included in the study who met the inclusion criteria.

## Age and Gender Distribution

The age ranged from 15 years to 50 years. 13 (65%) patients were male while 7 (35%) patients were female.

## Region Operated

Regarding the region, 6 (30%) patients underwent lateral mass fixation (Figure 1) for subaxial cervical spinal injury, 4 (20%) patients underwent upper dorsal and lumbosacral fixation each while 3 (15%) patients had occipitocervical (Figure 2) and cervicodorsal intervention respectively (Table 1).

## Pre-op Neurological Status

Pre-op Neurological status was analyzed and 9 (45%) patients had grade 3/5 power, 5 (25%) had grade 2/5, and 3 (15%) patients had 4/5 power in the affected areas (Table 2).

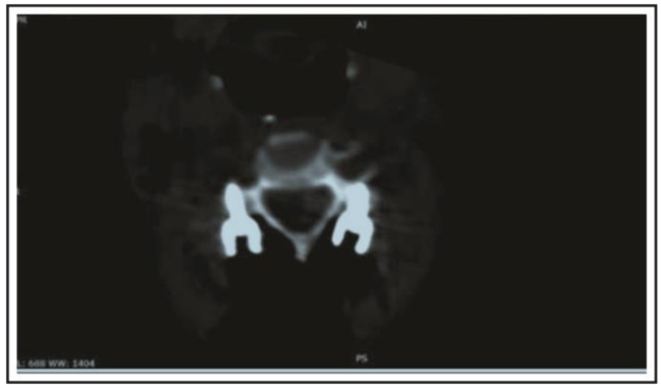

**Figure 1:** Final intraoperative CT scan confirming appropriate screw trajectory (published with permission).

**Figure 2:** Craniovertebral junction instability with odontoid fracture and C1-2 subluxation (published with permission).

**Table 1:** Region of fixation.

| Region | Frequency (n) | Percentage (%) |
|---|---|---|
| Subaxial cervical spine | 6 | 30% |
| Upper dorsal(D1-4) | 4 | 20% |
| Lumbosacral | 4 | 20% |
| Occipitocervical | 3 | 15% |
| Cervicodorsal | 3 | 15% |

**Table 2:** Modified MRC scale pre-op neurological status.

| Grade | Frequency (n) | Percentage (%) |
|---|---|---|
| 0 | 1 | 5% |
| 1 | 1 | 5% |
| 2 | 5 | 25% |
| 3 | 9 | 45% |
| 4 | 3 | 15% |
| 5 | 1 | 5% |

## Outcome

A favorable outcome was observed in 13 (65%) patients while it was unfavorable in 7 (35%) patients (Table 3).

**Table 3:** Outcome.

| Outcome | Frequency (n) | Percentage (%) |
|---|---|---|
| Favorable | 13 | 65% |
| Unfavorable | 07 | 35% |

## COMPLICATIONS

As regards complications, screw malposition was found in 3 patients on intraoperative CT which was corrected intraoperatively while one patient got a wound infection (Table 4).

**Table 4:** Complications.

| Complications | Frequency (n) | Percentage (%) |
|---|---|---|
| Screw malposition | 3 | 15% |
| Wound infection | 1 | 5% |

# DISCUSSION

## Craniovertebral Junction

Previously a study by Waschke et al concluded that computed tomography-based navigation is dispensable in thoracolumbar screw placement.[15] Craniovertebral junction injury is also technically challenging even for experienced surgeons. There is an 8% risk of vertebral artery injury during posterior instrumentation of the cervical spine and this risk increases if there is a complex craniovertebral junction injury.[16,17] Fluoroscope-guided instrumentation becomes risky for C1/C2 fixation as the vertebral artery in this region is embryologically anomalous.[18] We performed three occipitocervical fixations under fluoroscopic guidance and confirmed the trajectory on intraoperative CT. In one patient, we had to redirect one pars screw after intraoperative CT and reconfirmed the trajectory on intraoperative CT. One of our cases of complex craniovertebral junction injury who had transoral odontoidectomy followed by occipitocervical fixation is already published (Fig. 1, 2). It was performed with the help of intraoperative CT.[19] Intraoperative CT is a useful tool for complex and routine craniovertebral junction fixation.

Fluoroscope-assisted lateral mass screws are performed in routine for subaxial spine injuries and usually, they don’t require intraoperative CTbut we performed intraoperative CT in all of our patients with subaxial spine injuries and none of our patients required redirection of screw trajectory. We recommend that if sub-axial spine visualization is adequate on fluoroscope then there is no need for intraoperative CT in routine for such cases.

## Cervicodorsal Junction

The cervicodorsal junction is the transition zone from a lordosis to kyphosis which makes the fixation in this region challenging for surgeons. Moreover, this region is poorly visualized due to the shoulders of the patient which make the fluoroscope inefficient in such cases. The use of intraoperative CT can overcome this problem.

## Upper Dorsal spine

The upper dorsal spinal canal (D1-D4) has a narrow diameter along with thin pedicles as compared to the whole dorsal spine. Fluoroscopic visualization of pedicles in this region is hampered by the overshadowing of shoulders and bulky chest wall. Moreover, the AP and lateral orientation in this region is difficult to maintain along with the instrumentation. Therefore, the misplacement rates are very high in this region, reported at up to 40%.[20-21] In one study by Rampersaud et al,[22] 31.6% of patients had pedicle breaches. In a randomized controlled trial that compared navigated and unnavigated screw fixation, there were 23% of pedicle breaches in the unnavigated group as compared to 2% in navigated group.[23] We performed 4 patients of upper dorsal fixation with intraoperative CT, and one patient (20%) had a revision of screw direction after we performed intraoperative CT. The role of intraoperative CT in this zone is proving its role in an effective outcome.

## Lumbosacral Region

Lumbosacral region is visualized on a routine fluoroscope and fixed with safety, as also seen in previous studies. A meta-analysis conducted by Kosmopoulos and Shizas[24] reported only a marginal but statistically significant difference between CT – navigated and unnavigated screws. We operated on 4 patients with lumbosacral injuries and used intraoperative CT. All patients had fixation under fluoroscope followed by intraoperative CT which confirmed the accurate position of screws, none of the patients had a revision which reaffirms that fluoroscope-guided fixation has satisfactory results for the lumbosacral region. The same was the results in a more recent study[25] regarding pedicle screw fixation of the lumbar region. The role of intraoperative CT in complex lumbo-sacro-pelvic fixation is yet to be determined.

## LIMITATIONS

Small sample size and single-center study.

## RECOMMENDATIONS

We recommend the use of an intraoperative marker for confirmation of the trajectory and then screw insertion followed by intraoperative CT in the same anesthesia. A larger sample size and the involvement of more centers are recommended.

## CONCLUSION

Intraoperative computed tomography scanner is opening new horizons for safe and complex spinal surgeries. Craniocervical and cervicodorsal junctions, and upper dorsal spine fixation mandate the use of Intraoperative CT for a safe and effective outcome.

## REFERENCES

1. Scarone P, Vincenzo G, Distefano D, Del Grande F, Cianfoni A, Presilla S, Reinert M. Use of the Airo mobile intraoperative CT system versus the O-arm for transpedicular screw fixation in the thoracic and lumbar spine: a retrospective cohort study of 263 patients. Journal of Neurosurgery: Spine, 2018; 29 (4): 397-406.
2. Rauschning W. Surgical Anatomy of the Spine, Revisited. Spine, 2017; 42: 1-2.
3. Hirsch BP, Vaynrub M, Siow M, Zou A, Anil U, Montes DV, Protopsaltis TS. Visualization of the cervicothoracic junction with EOS imaging is superior to conventional lateral cervical radiographs. Global Spine Journal, 2021; 11 (6): 925-30.
4. Faghih-Jouibari M, Moazzeni K, Amini-Navai A, Hanaei S, Abdollahzadeh S, Khan Mohammadi R. Anatomical considerations for insertion of the

pedicular screw in cervicothoracic junction. Iranian Journal of Neurology, 2016; 15 (4): 228.

5. Ashraf M, Choudhary N, Hussain SS, Kamboh UA, Ashraf N. Role of intraoperative computed tomography scanner in modern neurosurgery-An early experience. Surgical neurology international, 2020; 11: 247.
6. Hecht N, Yassin H, Czabanka M, Föhre B, Arden K, Liebig T, Vajkoczy P. Intraoperative computed tomography versus 3D C-arm imaging for navigated spinal instrumentation. Spine, 2018; 43 (5): 370-7.
7. Patrick H, Robert T, Steven H, David S. Spinal Navigation and Imaging: History, Trends, and Future. Ieeexplore, 2015; 34: 1738-46.
8. O'Brien JR. The use of intraoperative CT and navigation for the treatment of spinal deformity in open and minimally invasive surgery. Spine, 2017; 42: 28-9.
9. Rojas CA, Bertozzi JC, Martinez CR, Whitlow J. Reassessment of the craniocervical junction: normal values on CT. American journal of Neuroradiology, 2007; 28 (9): 1819-23.
10. Tehli Ö, Harman F, Temiz Ç, Kaçar Y, Kazancı B, Daneyemez M, Kural C. The use of neuronavigation and intraoperative imaging in spinal stabilization surgery. Turkish Neurosurgery, 2016; 26 (5): 771-6.
11. Hecht AC, Koehler SM, Laudone JC, Jenkins A, Qureshi S. Is intraoperative CT of posterior cervical spine instrumentation cost-effective and does it reduce complications? Clinical Orthopaedics and Related Research® 2011; 469: 1035-41.
12. Verma S, Singh PK, Agrawal M, Sawarkar D, Borkar, SA, Kumar A, Kale SS. Use of Intraoperative Imaging to Preserve C1-C2 Mobility in Complex Atlas-Hangman Fractures. Neurology India, 2022; 70 (1): 209.
13. Du YK, Li SY, Yang WJ, Wang XY, Bi YF, Dong J, Xi YM. Morphometric trajectory analysis for occipital condyle screws. Orthopaedic Surgery, 2020; 12 (3): 931-7.
14. Shimokawa N, Takami T. Surgical safety of cervical pedicle screw placement with computer navigation system. Neurosurgical review, 2017; 40: 251-8.
15. Waschke A, Walter J, Duenisch P, Reichart R, Kalff R, Ewald C. CT-navigation versus fluoroscopy-guided placement of pedicle screws at the thoracolumbar spine: single center experience of 4,500 screws. Eur Spine J. 2013; 22 (3): 654-60.
16. Boudissa M, Girard P, Kerschbaumer G, Ruatti S, Tonetti J. Does intraoperative 3D navigation improve SpineJack vertebral augmentation in thoracic and lumbar compression fracture? Orthopaedics & Traumatology: Surgery & Research, 2021; 107 (7): 103028.
17. Ekşi MŞ, Toktaş ZO, Yılmaz B, et al. Vertebral artery loops insurgical perspective. Eur Spine J 2016; 25 (12): 4171-80.
18. Rampersaud YR, Moro ER, Neary MA, et al. Intraoperative adverse events and related postoperative complications in spine surgery: implications for enhancing patient safety founded on evidence-based protocols. Spine, 2006; 31 (13): 1503-10.
19. Wright NM, Lauryssen C. American Association of Neurological Surgeons/Congress of Neurological Surgeons. Vertebral artery injury in C1 – 2 transarticular screw fixation: results of a surveyof the AANS/CNS section on disorders of the spine and peripheral nerves. J Neurosurg 1998; 88 (4): 634-40.
20. Ashraf, M, Kamboh UA, Naveed A. Intraoperative Computed Tomography Scanner-Guided Craniovertebral Junction Surgery in a Patient with an Occipitalized C1. Journal of Neurosciences in Rural Practice, 2021; 10: 1055-9.
21. Rampersaud YR, Pik JH, Salonen D, Farooq S. Clinical accuracy of fluoroscopic computer-assisted pedicle screw fixation: a CT analysis. Spine, 2005; 30: 183-90.
22. Liljenqvist UR, Halm HF, Link TM. Pedicle screw instrumentation of the thoracic spine in idiopathic scoliosis. Spine, 1997; 22: 2239-45.
23. Rajasekaran S, Vidyadhara S, Ramesh P, Shetty AP. Randomized clinical study to compare the accuracy of navigated and non-navigated thoracic pedicle screws in deformity correction surgeries. Spine, 2007; 32: 56-64.
24. Kosmopoulos V, Schizas C. Pedicle screw placement accuracy: a meta-analysis. Spine, 2007; 32: 111-20.
25. Banat M, Wach J, Salemdawod A, Domurath L, Scorzin J and Vatter H. Can Postoperative CT

Imaging in Spine Surgery Be Replaced by Intraoperative 3D Rotation With the C-Arm? Results of a Prospective Single Center Cohort Study. Front. Surg. 2021; 8: 692189.

## Additional Information

**Disclosures:** Authors report no conflict of interest.
**Ethical Review Board Approval:** The study was retrospective.
**Conflicts of Interest:**
In compliance with the ICMJE uniform disclosure form, all authors declare the following:
**Financial Relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.
**Other Relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

## AUTHORS CONTRIBUTIONS

| Sr.# | Author's Full Name | Intellectual Contribution to Paper in Terms of: |
|---|---|---|
| 1. | Usman Ahmad Kamboh | 1. Study design, methodology and paper writing. |
| 2. | Mehwish Manzoor, & Muhammad Usama Saleem | 3. Data collection and calculations. |
| 3. | Adeel Rauf | 4. Analysis of data and interpretation of results. |
| 4. | Mehreen Mehboob, & Sana Jamal | 5. Literature review and referencing. |
| 5. | Manzoor Ahmad | 6. Editing and quality insurer. |