

An Analytical Study of Posterior Atlanto Dental Interval As A Prognosticator in Patients with Bony Craniovertebral Junction Anomalies

DR Shankar¹, Suresh Babu Thirumal²

Abstract

Introduction: The Posterior Atlanto Dental Interval (PADI) is the effective canal diameter, measured from the posterior surface of the Dens to the Posterior arch of the Atlas.

Objective: To study the role of PADI, in producing the symptoms and also the postoperative outcome in patients with bony CranioVertebral Junction anomalies.

Materials and Methods: About 34 patients from March 2016 to Oct 2018 who were operated at Rajiv Gandhi government General Hospital, were prospectively studied. The PADI and the preoperative & Postoperative "Kumar and Kalra Score" (K and K score) was calculated for all patients. The patients were divided into three groups based on the PADI, into 5 mm to 10 mm group, 10 mm to 15 mm group and >15 mm group.

Results: There were 26 male (79.1%) patients and 8 female patients (20.9%) with the mean age of presentation 26.10 years. The PADI was 8.012 mm with range of 5–15 mm. The mean Pre-operative K and K score was 19.52. There were 19 patients with, PADI of 5 mm to 15 mm, 12 patients with PADI of 15 mm to 20 mm and 3 patients with PADI more than 20 mm. The correlation coefficient, between the PADI and the Preoperative & Postoperative "K & K Score" at the time of discharge, 3 months & 6 months postoperative were 0.404, 0.320 and 0.284 respectively.

Conclusions: The correlation between PADI and the Preoperative K and K score, was strongest in patients with PADI of about 5 to 10 mm. The correlation between PADI and the Preoperative K & K score became less stronger, as the follow-up period was increased even though they are significantly related to each other.

Keywords: Posterior Atlanto Dental Interval; Craniovertebral Junction anomalies; Kumar and Kalra Score.

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Introduction

Craniovertebral junction (CVJ) refers to the bony structures in the foramen magnum region which are composed of occipital bone, atlas, and axis which encloses the medulla oblongata, cervicomedullary junction and the upper cervical spinal cord. The

congenital and acquired anomalies can classically produce symptoms by neural compression, vascular compromise and abnormal cerebrospinal fluid (CSF) dynamics.

The Posterior Atlanto Dental Interval (PADI) is the effective canal diameter (ECD) measured between the posterior surface of the odontoid and the anterior most aspect of posterior arch of the atlas (Fig. 1). The PADI implies the space occupied by the cord along with the buffer space for movement of the neck. As the CVJ has a complex anatomy and a poorly understood biomechanics and kinematics, it is not known how important is the PADI in producing the clinical presentation. Our study focusses the role of PADI in producing the clinical manifestations and post surgical outcome in patients with bony CVJ anomalies.

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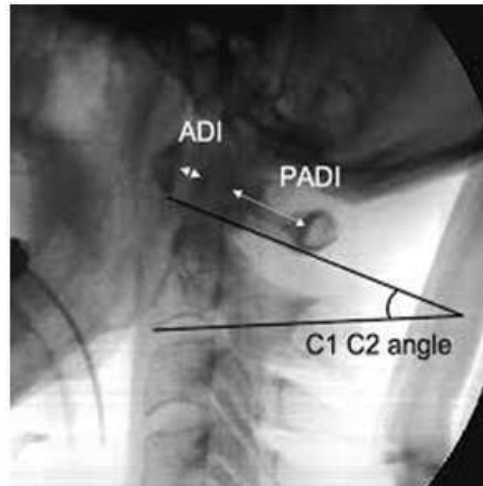


Fig. 1:

Materials and Methods

About 34 patients of Bony Cranio vertebral Junction anomalies, who got admitted at the “Institute of Neurosurgery, Madras Medical College &

Rajiv Gandhi Government Hospital, Chennai 3, were prospectively studied. The patients age, sex distribution and the clinical features were recorded. The clinical examination findings were recorded based on “Kumar and Kalra”(K and K Score) were recorded (Table 1).

Table 1: Kumar and kalra scoring system

Score	1	2	3	4	5
Motor power	Contraction without movement	Movement with gravity	Movement against gravity	Movement against resistance	Normal power
Gait	Wheel chair bound	Restricted mobility	Mobility using aid	Slight disturbance	Normal
Sensory Involvement	Total loss of function	Restricted daily living function	Significant (>25%) but no dysfunction of daily living	Insignificant	No sensory loss
Sphincteric involvement	Retention	Occasional retention	Hesitancy with residual urine	Hesitancy but no residual urine	Normal
Spasticity	Rigid in flexion or extension	Difficult passive movements	Passive movements easy	Slight sncrase	No increase in tone
Respiratory difficulty	Assisted respiration	Dyspnoea at rest	Dyspnoea on mild exertion	Dyspnoea on moderate exertion	Normal

Inclusion Criteria

1. Bony CVJ anomalies (congenital or acquired); and
2. Follow up of atleast six months.

Exclusion Criteria

1. Associated soft tissue anomaly, eg. Chiari malformation, syringomyelia;
2. Follow up of less than six months;
3. Compression over the cord/theal sac at a level in addition to CV junction;
4. Resurgery; and
5. Cord signals changes.

Majority of our patients had presented at our Out Patient Department (OPD) with myelopathy. as advised. Plain X-ray of the CVJ in lateral neutral, flexion and extension view and in an anterior-posterior view, Open mouth view was done. If on plain X-ray there were findings suggestive of bony CVJ anomalies, then the patient was asked to undergo Computerized Tomography (CT Scan) CVJ with 2 mm cuts with flexion, extension, and neutral view. We have a protocol of having Midsagittal and coronal views and 3-D reconstruction films of the CVJ as well. Based on the radiological investigations, the diagnosis of either mobile/fixed Atlanto-axial dislocation (AAD) with or without Basilar Invagination (BI) was established.

The Associated congenital bony anomalies like occipitalized atlas, Hypoplastic Posterior arch of Atlas, Atlanto Occipital assimilation, Cervical Block Vertebrae etc were identified. At the time of admission, particulars of the patient like name, age, sex, and occupation were noted, and a detailed history including the symptoms and their durations and clinical examination along with K and K scoring was done and recorded.

In patients of fixed Atlanto axial Dislocation (AAD) or Basilar Invagination, traction was applied 24–48 hours prior to surgery. A plain X-ray of the CVJ was done after application of the traction to look for any reducibility of the Atlanto-dental interval (ADI). If there was no reduction of the ADI, a trans-oral decompression and posterior stabilization was planned. However, if there was reduction of the ADI, then only posterior fusion was planned.

The PADI was measured from the posterior surface of the dens to the nearest anterior aspect of posterior arch of Atlas. The PADI was measured on CT CVJ in neutral view. In patients with inflammatory joint disease, e.g. Rheumatoid Arthritis (one patient) and CVJ tuberculosis (one patient), the PADI was calculated from the posterior aspect of the inflammatory soft tissue.

These patients were categorized into three groups based upon the PADI. Group 1 was patients with PADI between 5–10 mm, Group 2 was patients with

PADI between 10–15 mm, and Group 3 was patients with PADI more than 15 mm. The pre-operative and the postoperative clinical status of the patient was assessed by the K and K myelopathic scoring system. The score was recorded in the preoperative period, at the time of discharge, postoperatively, at three and six months follow-up. The correlation between the PADI (group-wise and in total as well) and the pre-operative and the postoperative K and K score was done. The SPSS version 16.0 was used for statistical analysis.

The patients were mobilized as early as possible depending upon the K and K score (usually on the First Postoperative day). A plain X-ray of the CVJ was done in the immediate 1st POD to ensure the adequacy of odontoidectomy and posterior fixation as applicable. The patients were allowed orally (in case of transoral procedure) next day morning. The patients were discharged on the 9th postoperative day and were followed up in OPD. The patients were followed up at one, three, and six months period.

Results

There were 27 male (79.1%) patients and 7 female patients (20.9%) with mean age of presentation 27.10 years with range of 4–59 years. The duration of symptoms in our series varied from 1–120 months with mean of 23.79 months (Table 2).

Table 2: Age and symptoms duration

	Range	Minimum	Maximum	Mean	Standard deviation
Age (years)	55	4	59	27.10	15./069
Duration of symptoms (months)	119	1	120	23.79	26.368

Majority of the patients had motor and sensory symptoms. Spasticity and motor weakness was present in 28 patients (82.1%) and 27 patients (80.6%), respectively. About 80% of patients had sensory symptoms in the form of numbness, paraesthesia.

The sphincter disturbances were seen in about 16 patients (47.8%), Torticollis/restriction of neck movement in about 15 patients (44.8%), and respiratory difficulty in about 15 patients (40.3%) (Table 3).

Table 3: Diagnosis

Diagnosis	No. of Cases	Percentage
Mobile AAD	10	29.9
Fixed AAD	7	20.9
Basilar Invagination with fixed AAD	12	35.8
Odontoid fracture	2	4.5
Os odontoides	2	7.5
Mobile AAD with basilar invagination	1	1.5

The mean preoperative K and K score was 19.27. About, 12 patients had Basilar Invagination with fixed AAD (35.8%), about 7 patients (21%) had only fixed AAD, about 10 (29.9%) had mobile AAD, about 3 patients (7.5%) patients had Os odontoideum, and about 2 (4.5%) had Odontoid Fracture (Table 4).

The mean PADI was 9.027 mm with range of 5–16 mm. About one patient had Rheumatoid Arthritis, and one patient had CVJ Tuberculosis (was on anti-tubercular therapy for 6 months). Radiologically, about 13 patients had occipitalized atlas, and out of these 13 patients, about 5 patients had partially Occipitalized Atlas (Table 5).

Table 4: Surgical procedures done

Surgical procedures	No. of cases
C1-C2 fixation	14
Occipito cervical fusion	3
Transoral odontoidectomy with C1-C2 fixation	9
Transoral odontoidectomy with occipito cervical fusion	8

Table 5: Complications

Complications	No. of patients	Percentage
Wound dehiscence	3	7.46
Oral wound	2	5.97
Posterior wound	1	1.49
Csf leak	2	2.98
Meningitis	1	1.49
Death	1	1.49

Out of these 26 patients, about six patients had associated C2–C3 fusion. Five patients had only C2–C3 fusion, one patient had bifid C2, one patient had clival segmentation defect, one had hypoplastic C1 arch, and one patient had combination of C2–C3 and C5–C6 fusion, two patients had C3–C4 fusion, eleven patients had cord intensity changes at the CVJ.

Preoperatively, skull traction was applied in about 22 patients (65.7%). About 14 (41.18%) patients underwent C1C2 Posterior fixation. Occipitocervical fusion alone was done in about 3 (8.82%) patients. The combined Trans Oral Odontoidectomy and C1 Lateral mass & C2 Pedicle screw fixation was done in about nine (26.47%) patients. Transoral Odontoidectomy with Occipito

cervical Fusion was done in about eight (23.52%) patients.

About twenty nine (88.06%) patients had improved significantly in their symptoms, postoperatively, whereas four (11.76%) patients had no improvement and one (2.94%) patient got expired during the post-operative period.

About three patients had postoperative wound dehiscence (7.46%). About two patients (2.98%) developed postoperative CSF leak, two patients (2.98%) had developed Oral wound. One patient (1.49%) developed meningitis in the Postoperative period. One patient (1.46%) died on the 4th Postoperative period due to Aspiration Pneumonitis (Table 6).

Table 6: Correlation between padi and K & K score

	Mean K and K score	Correlation coefficient	p-value
Preoperative	19.27	0.404	0.001
At the time of discharge	22.87	0.320	0.008
3 Months follow up	23.33	0.302	0.013
6 Months follow up	23.46	0.284	0.020

The mean postoperative “K and K score” at the time of discharge, three months and six months follow-up were 21.87, 23.33, and 23.46 respectively. These patients had showed significant improvement in the initial postoperative period

and with the passage of time the improvement stabilized as seen by only minimal change in the mean of the post-operative K and K score, at three months and six months (Table 7).

Table 7: Mean K and K score

Padi	Preoperative	At discharge	3 Months follow up	6 Months follow up
5-10 mm	18.81	21.09	22.89	23.01
10-15 mm	19.46	22.22	23.53	23.66
>15 mm	19.54	22.32	23.57	23.71

The correlation coefficients between the PADI and the preoperative and the postoperative K and K score at the time of discharge, three months and six months follow up were 0.44 0.320, and 0.284 respectively.

The PADI and the preoperative K & K Score was significantly related to each other indicating that the PADI plays a major role in determining the severity of the presentation.

The strength of correlation between the PADI and the post-operative scores reduced as the follow-up increased indicating that the PADI is more strongly

related to the postoperative improvement in the early postoperative period and with passage of time the PADI might play a lesser, though significantly important, role in governing the postoperative improvement.

There were 39 patients who had an ECD between 5 mm to 10 mm, 24 patients with ECD between 10 mm to 15 mm, and 4 patients with ECD more than 15 mm. The mean preoperative K and K score and mean K and K score at the time of discharge, at three months and six months follow up were critically analysed (Table 8).

Table 8: Correlation between padi and K & K score

Padi	Pre-op	p-value	At discharge	p-value	Post-op (3 months)	p-value	Post-op (6 months)	p-Value
5-10	0.421	0.002	0.341	0.008	0.303	0.012	0.297	0.019
10-15	0.401	0.007	0.311	0.014	0.296	0.022	0.278	0.029
>15	0.357	0.012	0.291	0.023	0.257	0.025	0.234	0.028

The PADI was significantly correlated with the preoperative score indicating that the PADI played an important role in determining the preoperative K and K score. The amount of correlation had significantly got reduced as the follow up was increased.

The PADI and the pre-operative K and K score were most significantly and strongly related to each other in patients with PADI between 5-10 mm. With increasing PADI, i.e. in group of patients with PADI between 10-15 mm and >15 mm, the strength and significance of correlation between the PADI and the preoperative K and K score got reduced (though it still remained significant).

Discussion

The CVJ anatomy consists of various neural structures like the cervico-medullary region, the cerebellum, fourth ventricle, and the lower cranial and upper cervical nerves and also includes important vessels like vertebral and posterior inferior cerebellar artery.¹ Any lesion in this region can therefore produce clinical symptomatology by compression of any of the neural structure or

vascular compromise and abnormal CSF dynamics.

The PADI is the effective canal diameter is measured from the posterior surface of the dens to the nearest anterior most aspect of posterior arch of atlas.² The PADI implies the space which is occupied by the buffer space (which can be compromised without producing any signs or symptoms) and the cord itself. If there is any breach in the “Safe zone of Steel”, then there is likelihood of production of signs and symptoms of cervico-medullary compression. It appears logically that any compromise in the PADI would lead to the production of the symptoms and more severe the compression more severe would be the symptoms.³

The bony CVJ anomalies commonly encountered are mobile and fixed AAD, basilar invagination, Os odontoideum, and fracture Odontoid.⁴ Although pathologies of bony CVJ anomalies may vary, their presentations are more or less similar.

In our study, the PADI and the preoperative score was significantly related to each other indicating that the PADI plays a major role in determining the severity of the presentation.⁵

The relation was strongest in the group where the PADI was between 5 and 10 mm, and in the

remaining two groups the association was not as strong (though it was significantly related to the pre-operative K and K score.⁶

The correlation between the PADI and the preoperative K and K score although was significant, but there appears to be other factors which might play an important role in determining the preoperative K and K score (reflecting the severity of the symptoms), especially if the PADI is on the higher side.

Symptoms duration might be one of the factors apart from PADI, which might govern the severity of the symptoms. Interestingly, there were few patients in our study who had short duration of history but had a low K and K score (without any history of trauma) and vice versa.

In a study by Dickman *et al.* they found that after Transoral odontoidectomy in patients with congenital bone malformations and pre-existing fusions or assimilations of the joints had only 50% risk of instability compared to patients with <90% rate of instability in patients with rheumatoid arthritis. Other factors might be history of repeated trauma to the head-neck region (leading to mono/para/quadruparesis), associated diseases like rheumatoid arthritis, genetics (folate metabolism abnormalities) etc.

In our study, we found that the strength of correlation between the PADI and the postoperative scores got reduced as the follow up increased indicating that the PADI is more strongly related to the postoperative improvement in the early postoperative period and with passage of time the PADI might play a lesser, though significantly important, role in governing the postoperative improvement. In the early post-operative period, the compression over the thecal sac was relieved (increased PADI) and that would lead to improvement in the symptoms. With increasing follow up, the relation between the PADI and the K and K score got reduced, though it was significantly positive. With increasing follow up, other factors might play an important role in determining the outcome.⁷

In a study conducted by Dickman *et al.* they found that immediately after fixation by cable techniques the motion at C1-C2 in all directions was controlled only 20%-50% depending upon the technique used. Therefore, by postfusion absolute immobilization is not achieved and so with passage of time, this difference in the ability to immobilize might explain the reduced significance of association between the ECD and the improvement.⁸

In two patients with similar preoperative PADI

and postoperative decompression, they might have different immobilization and as proper immobilization is necessary for fusion they might have some differences in their outcomes. Fusion also depends upon the nutritional status of the patient.⁹ For immobilization, we advice Philadelphia collar to all out patients in the postoperative period. As patients might have differences in compliance, they might have different fusion rates and this might be another factor explaining the reduced significance of PADI.

The PADI appears to be related significantly to the preoperative severity of the symptoms and is also significantly related to the postoperative improvement. The relation between the PADI and the preoperative severity was maximum in the group of patients with PADI between 5 and 10 mm. As the follow up period was increased, the strength of the relation got reduced but was still significantly positive.¹⁰

Limitations

To properly establish the role of PADI in determining the preoperative neurological status and its effect on post-operative K and K Score, a larger sample size would be needed.

Moreover, in our study, although we have used the K and K scoring system, which includes respiratory component, but in our study, no objective assessment of respiratory function was done by pulmonary function tests (PFT).

As respiration is apparently an important factor in assessing the postoperative morbidity, it would be advisable to include PFT in future studies on the significance of PADI.

Conclusion

The PADI implies the space occupied by the cord along with the buffer space. Any reduction in the PADI is likely to cause neurological deterioration.

Based on our study, we could be able to identify that the PADI is significantly related to the pre-operative clinical status of the patient.

This correlation was strongest in the group of patients with PADI of about 5-10 mm. It was also observed that as the follow-up period increased, the correlation between the PADI and the post-operative score became weaker, though their significant correlation exists, because of the other confounding factors other than PADI, that govern their post-operative outcome.

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