Orientation of C1-2 Joints in Congenital Atlantoaxial Dislocation

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ABSTRACT

Aim: To study the C1-2 facets in patients with congenital atlantoaxial dislocation and their bearing on the presentation and management.

Materials and methods: Thirty-six patients of congenital AAD were studied in the last 2 years. Twenty-four patients had irreducible AAD (not reducing on traction) and remaining 12 had reducible AAD. Computed tomography (CT) scans were obtained and the C1-2 joints were studied in axial, sagittal and coronal planes. The obliquity of (C1-2) joints was measured using the novel inferior C1 coronal and sagittal angles. The relationship of obliquity of joints, age and reducibility was studied and these were compared with normal subjects. The amount of facet to be drilled was decided by these angles. Direct posterior reduction was attempted by drilling the facets flat in all. Anomalous vertebral arteries (VA) were detected with preoperative CT angiograms and addressed appropriately intraoperatively.

Results: The inferior C1 sagittal and coronal angles were significantly acute in patients with IrAAD as compared to those with RAAD and normal spine. An inferior sagittal angle more than 150º predicted reducibility. More acute the angle, younger was the age of presentation. Relatively acute coronal angles were noticed in patients with telescoping (central or vertical dislocation). Intraoperative reduction could be achieved after drilling the facets nearly flat. Anomalous VA were found in over 70% of the patients with CAAD and were appropriately addressed. The fusion rates were over 90%.

Conclusion: The congenital AAD appears to be a dynamic process, progressing with time. The acuteness of the inferior C1 sagittal facet angles possibly determines the age at presentation and reducibility. Coronal angle determines the telescoping of C2 within C1. Intraoperative reduction through a direct posterior approach can be achieved in patients with IrAAD by drilling the wedge of C1-2 facets to make the joints relatively flat. Comprehensive facetal drilling also increases the fusion rates.

Keywords: Atlantoaxial dislocation, Facets, Orientation, Surgery.

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INTRODUCTION

The stability of a joint is largely determined by the disposition and relationship of facets, though there would be other factors, like ligaments and capsule. The orientation of C1-2 facets in sagittal plane would possibly determine the anterior slip of C1 over C2 and orientation of the same in coronal plane would determine the telescoping of C2 into C1 (vertical slip). Congenital atlantoaxial dislocation (CAAD) has a variable age of presentation. Factors determining this variability remain obscure. The orientation of these facets may not be normal in congenitally deformed joints and this may be the reason for progressive slip and then irreducibility in CAAD. It is not yet clear if we can predict preoperative reduction on traction in these patients. Besides, the orientation would help us plan facet osteotomy to mobilize such deformed joints intraoperatively thereby circumventing the transoral approach completely.

The purpose of this manuscript is to determine the orientation of C1-2 facets and its implication on management in patients with CAAD.

MATERIALS AND METHODS

Thirty-six patients of CAAD (atlantodental interval > 5 mm in children and > 3 mm in adults) and 32 normal cases (age 9 months—45 years) who had normal CT cervical spine done for suspected spinal trauma) presenting to our institute over a period of 2 years, were evaluated. The patient group was further divided into reducible (RAAD) and irreducible (IrAAD) variety based on dynamic (flexion/neutral/extension). JOAS was used for clinical grading of their deficits. X-rays and CT scan of the craniovertebral junction (CVJ). CT CVJ (1 mm section in neutral position) were done in all patients and normal subjects with reconstruction. Parasagittal sections passing through facets of occiput–C1-C2 in neutral position were studied. Inferior C1 sagittal facetal angle was measured in all cases. This was defined as the angle between the line joining anterosuperior and posterior points of the hard palate and the line joining antero-inferior and postero-inferior points of the C1 facet in sagittal section (Fig. 1). Perpendiculars were drawn in case the lines were close to parallel. Angles on both
right and left sides were studied. Similarly, both right and left, coronal inferior C1 facetal angle was measured and was defined as the angle between the line joining the lateral and medial points along the inferior surface of the C1 facet and the line joining the edges of foramen magnum in that coronal section\(^1\) (Fig. 2). Telescoping of C2 into the atlas or occiput (central dislocation) was looked for. This was defined as the presence of C2 body or dens-C2 body junction seen on axial sections passing through the atlas ring or foramen magnum/occipital condyles. Atlantodental interval in all patients was noted. CT angiogram was obtained to discern anomalous vertebral artery. The magnetic resonance imaging (MRI) scan was done in all patients as a part of normal protocol. Data were analyzed using nonparametric tests (Mann-Whitney U-test). Skeletal traction was applied to all patients of IrCAAD and serial X-rays were obtained.

All patients underwent direct posterior approach. Bilateral C2 root ganglia were cut to get a panoramic view of C1-2 joints. The facets were mobilized using osteotomy. The extent of osteotomy was decided by the inferior C1 sag angle. The posterosuperior wedge of C2 and antero-inferior wedge of C1 was drilled to make the C1-2 joint flat. The height of each wedge to be drilled would be 1/2 \([\sin (180-\text{inf sag C1 angle})-\sin 30] \times \text{anteroposterior length of facet}\). Intraoperative joint manipulation and reduction was then obtained. The anomalous VA, if present was dissected and mobilized such that it was not a hindrance to the C1-2 mobilization and fusion.\(^2,3\)

### RESULTS

The age at presentation was variable. The age group varied between 5 and 60 years (mean of 29.8 ± 18.8) for IrAAD and 6 to 50 years (mean of 29.5 ± 16.0) for RAAD. On traction, 3 patients of IrCAAD showed incomplete reduction. Assimilated arch of atlas and C2-3 fusion was seen in all patients with IrCAAD. In patients with IRAAD, the mean sag inferior C1 facetal angle was 137.4 and 140.2° on the right and left side respectively (Fig. 3) whereas in patients with RAAD, the mean angles were 165.2 and 164.1 on the right and left side. In three patients where reduction could be achieved partly, the mean right and left angles were 157 and 162 respectively. The right and left angles in the normal group were 172.5 and 171.4 respectively. The difference was statistically significant for this angle between IrAAD and the normal group and also the IrAAD and the RAAD group (p < 0.001). The significance was p < 0.05 for that between RAAD and the normal. Also in IrAAD, there was a significant correlation between the age and the inferior sagittal C1 facetal angles. That is, earlier the age of presentation, lesser the inferior
sagittal C1 facetal angle. This correlation was absent in the normal group and those with RAAD.

The mean coronal inferior C1 facetal angles were 148.0 and 143.7° on the right and left sides respectively, for IrAAD (Fig. 4). They were 152.5 and 147.6° on the right and left side respectively, for RAAD. The right and left angles in the normal group were 153.1 and 155.2 respectively. Relatively acute, unilateral coronal angles and bilateral coronal angles were seen in five and two patients respectively with IrAAD. Only two with RAAD, had relatively acute, unilateral coronal angles. Telescoping of C2 within C1 was seen in nine patients of IrAAD and none with RAAD.

There was no relation between the angles and the disability grade and the atlantodental interval.

The inferior sag C1 facetal angle that predicted reducibility in AAD was calculated using ROC curve and was approximately 150° (sensitivity of 100% and specificity of 80%). Patients with inferior sag angle > 150° could be reduced with traction. Anomalous course of VA was noted in 14 patients and could be safeguarded in all (Figs 5 and 6).

With the facetal osteotomies, intraoperative reduction could be achieved in all patients with IrCAAD (Figs 7 and 8). There was no VA injury. Fusion was done using C1 lateral mass and C2 transpedicular screws and using metal spacers or bone grafts as cage fulcrum. Good reduction was achieved in all. JOAS improved in all patients. Fusion rate was over 90%. In two patients, there was redislocation with slipping of spacers and one required reoperation.

DISCUSSION

Thus, C1-2 is extremely mobile but structurally weak and is located between two relatively fixed points, the OC1 and C2-3 joints. Presence of a bony anomaly in the region of atlantoaxial joint has a significant influence on its stability. It is reasonable to expect additional stress on the C1-2 joint in case of assimilated arch of atlas further accentuated by the presence of C2-3 fusion, as evident in 60% of the cases of assimilated atlas. This was noted in 80% of our patients. Nonetheless patients with CAAD become symptomatic at different age. Initially a delicate balance is struck between the mobile articulation and the adjacent spinal cord and motion is maintained without neurologic compromise. The relationship must be altered before symptoms develop.
The facets of the IrAAD were oriented craniocaudally (posteroanteriorly) in the sagittal plane as compared to RAAD and normal patients. The younger patients with IrAAD had more vertical (acute) inferior sagittal C1 facetal angle as compared to the older patients with IrAAD. IrAAD appears to be a dynamic process and the dislocation aggravates with time. IrAADs are also possibly reducible to begin with. In these patients, C1-2 facets are oriented craniocaudally in the sagittal plane (posteroanteriorly). The C1 along with the head slips anteriorly over the C2 due to this vertical orientation. As the center of gravity of head shifts anteriorly, the lordosis of the cervical spine increases to compensate for it. This further increases the anterior slip of C1 over the C2. There would be a time when it cannot be reduced on simple extension and later even with traction. The ligaments and the capsule too become fibrotic in this dislocated position. Meanwhile, the resultant increased anterior angulation at craniovertebral junction accentuates the compression of odontoid and C2 body at the cervicomedullary junction, giving rise to symptoms. More acute (craniocaudal) the inferior sagittal C1 facetal angle, earlier would be the presentation and stage of irreducibility. This explains the variable age of presentation. Besides, the degenerative changes of aging cause lower cervical articulation to become more rigid. This gradual restriction of motion below places an increased demand on the ligaments and capsular structure of C1-2 joint instability in an already vertical joint.

The genesis of congenital RAAD was thought to be different. The inferior sag C1 facetal angles in RAAD is slightly acute as compared to the normal patients. So, in the presence of lax ligaments or due to congenital absence of transverse ligament or due to short peg-like
Fig. 8: Preoperative and postoperative CT images of patient with severe vertical and anteroposterior CAAD in whom direct posterior reduction could be achieved after facetectomy. Note the angle drilled to near normal in postoperative image as compared to the deformed C1-2 joint seen in preoperative image.

odontoid or os-odontoidenum, there may be dislocation of C1-2 facet. As the facetal angle is relatively flat, it comes back to normal position on extension. Thus, it appears that RAAD and IrAAD may be part of the same spectrum.

In normal subjects, the inferior sag C1 facetal angle does not change much with age. Of our 32 normal subjects, there were 10 children with age ranging from 9 months to 7 years. In these 10 children, this angle was always > 172º.

In the coronal plane, the vertical orientation of the facets decides the telescoping of C2 into C1 and basilar invagination. Akin to the anterior slip, the vertical orientation of the facet in the coronal plane causes cranial slip of C2 into C1. A new craniometric index namely vertical atlantoaxial index, based on mid sagittal section of CT CVJ has been described. However, in that series, the acuity of these angles has not been measured. In our series, at least one coronal angle was acute in patients with IrAAD and was statistically significant when compared to those with RAAD and the normal group. We found gross asymmetry in the coronal angles of the C1 facet in patients with IrAAD and this explains why the telescoping of C2 was deviated to one side.

The management of IrAAD traditionally has been application of preoperative traction followed by transoral decompression and then posterior fusion. Traction improves the preoperative neurological status in many patients and may in fact reduce certain so called IrAAD. The transoral procedure is not without complications. Management of basilar invagination through the posterior approach alone with distraction of C1-2 joints and fixation has been described. The IrAAD with the BI is reduced on distraction and then fixed with spacers alone. The use of spacers is essential if posterior approach alone is used because without them the AAD (anteroposterior dislocation) would reduce but the vertical slip and vertical mobility would persist.

We were able to achieve intraoperative reduction in all patients with IrAAD (Figs 7 and 8). The preoperative reduction and stabilization through posterior approach alone using spacers and articular screws poses a technical difficulty in patients with hypoplastic facet or with
more acute sagittal angles. The IrCAAD appears to be a dynamic process, progressing with time. The facet orientation in appears to be a major deciding factor for the age of presentation. All patients with IrAAD, irrespective of age, merit an attempt at closed reduction, which if successful, avoids transoral procedure.

REFERENCES