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Malformations of the Atlas Vertebra Simulating the Jefferson Fracture

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Congenital clefts and aplasias of the atlas vertebra, while rare, are often first encountered in the emergency room setting. Thirty-six patients with atlas malformations and 10 with Jefferson fractures were encountered. Sixteen of the patients with congenital malformations showed bilateral atlantoaxial lateral offset, a finding generally considered to be the result of fracture. The diagnosis of these abnormalities is readily made from plain films by noting their characteristic features. Anomalies produce lateral offset of 1–2 mm. Jefferson fractures produce a greater offset (over 3 mm).

Malformations of the atlas vertebra in gross anatomic specimens are rare [1]. Reports of these malformations simulating the bursting fracture of Jefferson are even less common [2]. We review atlas arch malformations, the bursting fracture of Jefferson, and discuss helpful radiographic signs that may serve to direct attention to the proper diagnosis.

Materials and Methods

We reviewed 36 patients with atlas malformations observed over a 10 year period. The cases were classified into aplasias, either total or partial (fig. 1), and clefts (fissures) of the arches of the atlas vertebra (table 1). Patients with simple posterior midline clefts (rachischisis) were excluded. Interestingly we observed two cases of rachischisis with 1 mm of bilateral atlantoaxial lateral offset. We also evaluated 10 Jefferson fractures encountered during the same period.

Results

Sixteen patients showed aplasia of the posterior arch of the atlas vertebra; nine had total aplasia and seven partial aplasia. One millimeter of bilateral atlantoaxial lateral offset was present in four of nine patients with total aplasia (fig. 2) and in four of seven patients with partial aplasia (fig. 3).

Twenty patients had clefts of the atlas arches; of these, only two had isolated fissures of the anterior arch in the midline and neither patient had atlantoaxial offset. Two of the five patients with clefts through the sulcus of the vertabral artery showed 1 mm of bilateral atlantoaxial lateral offset (fig. 4). In the most common patient group, those with combined clefts of the anterior and posterior arches of the atlas (the latter in the midline), eight patients had 1–2 mm of bilateral atlantoaxial lateral offset (fig. 5).

Discussion

About the seventh week of intrauterine life, ossification begins in the lateral masses of the atlas vertebra and extends dorsally. Several millimeters of cartilage separate the neural arches in the midline posteriorly at birth. During the second

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year of life a separate ossification center for the posterior tubercle of the atlas appears between the neural arches. These neural arches fuse about the third or fourth year of life. While the anterior arch of the atlas is usually cartilaginous at birth, 20% of newborns have an ossification center at that location. Ossification varies with one or more centers appearing during the first year of life. At times, no ossification center arises in the anterior arch but rather the arch forms from ventral extensions of the lateral masses. By the sixth to eighth year of life, fusion of the anterior arch to the lateral masses is completed [3, 4].

Total or partial aplasia of the posterior arch of the atlas are rare; Geipel [1] did not encounter any in 2,749 postmortem specimens of the atlas vertebra. Only about 35 cases were reported before our report [5]. Various types of developmental deficiencies (fig. 1) include: total aplasia, aplasia with persistent posterior tubercle, aplasia with unilateral or bilateral remnant with midline rachischisis, hemiaplasia, and partial hemiaplasia of the posterior arch [3]. In our series of 16 patients, there were nine with total aplasia, four with aplasia with persistent posterior tubercle, and three with hemiaplasia (one of these with a vertebral artery sulcus cleft on the contralateral side).

Clefts of the arches of the atlas are observed more often than aplasias. In the Geipel [1] series of adult atlas specimens, clefts were found in 4% of the posterior arches and in 0.1% of anterior arches. Of these posterior arch clefts, 97% were midline and 3% through the sulcus of the vertebral artery [1].

The lateral radiograph of the cervical vertebral column provides several valuable clues to the accurate diagnosis of atlas arch clefts. The anterior arch is normally half-moon-shaped with cortical bone surrounding a medullary cavity; this cortex is absent or indistinct when a cleft is present (fig. 5A). Absence of the arch-canal line, the thin, white, ventrally convex line separating the posterior tubercle of the atlas from the vertebral canal, indicates the presence of a posterior rachischisis. Confirmation of clefts is often made on other views of the atlas vertebra (i.e., basal view of the skull, oblique, frontal views, or tomography of the cervical vertebral column (figs. 5B and 5D). Vertebral artery sulcus clefts may be overlooked on true lateral radiographs of the cervical column; however, they are readily identified on off-lateral views since they are well corticated (fig. 4A).

Fractures of the atlas vertebra account for 6% of cervical vertebral column injuries [6]. One-third of these atlas fractures are the bursting fracture of Jefferson. The injury results from an axial compressive force applied to the vertex of the

TABLE 1: **Malformations of the Atlas Vertebra with and without Bilateral Atlantoaxial Lateral Offset**

Classification	No. Cases (%)		
	With Offset	Without Offset	Totals
Aplasia, posterior arch:			
Total	4 (44)	5 (56)	9
Partial	4 (57)	3 (43)	7
Totals	8	8	16
Clefts (fissures):			
Anterior arch	0	2 (100)	2
Posterior arch	2 (40)	3 (60)	5
Combined	8 (62)	5 (38)	13
Totals	10	10	20

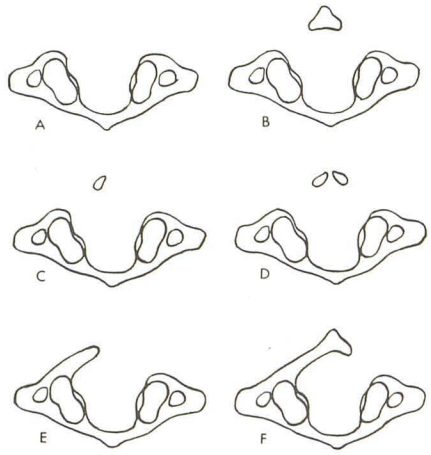

Fig. 1.—Classification of total and partial aplasias of posterior arch of atlas vertebra. **A**, Total aplasia. **B**, Aplasia with persistent posterior tubercle. **C**, Aplasia with paramedian unilateral posterior arch remnant. **D**, Aplasia with paramedian bilateral posterior arch remnant and rachischisis. **E**, Hemiaplasia. **F**, Unilateral posterior arch partial aplasia. (After Von Torklus and Gehle [3].)

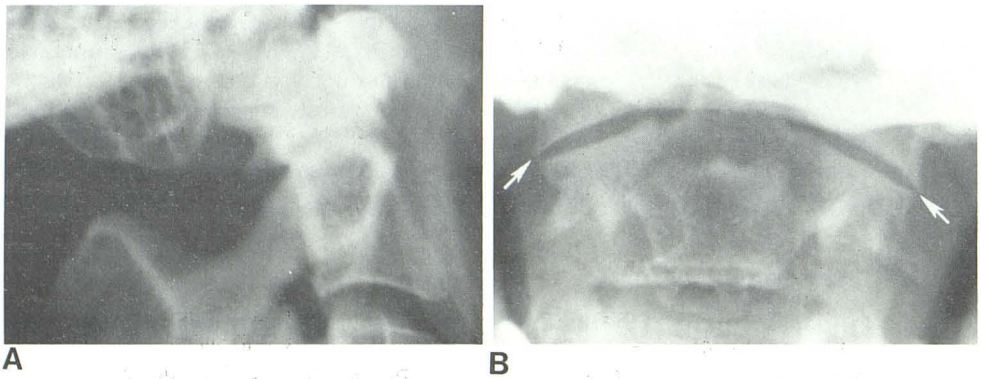

Fig. 2.—Total aplasia of posterior arch of atlas vertebra. **A**, Lateral view. Absence of posterior arch. **B**, Frontal view shows 1 mm of bilateral atlantoaxial lateral offset (*arrows*).

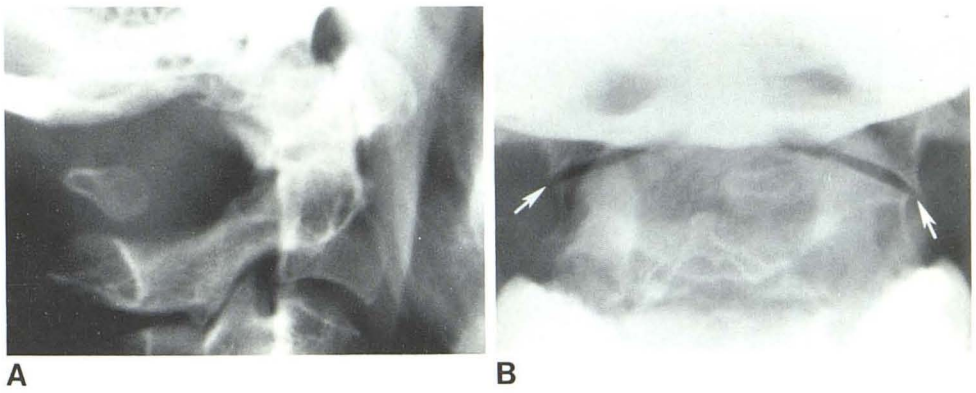

Fig. 3.—Partial aplasia of posterior arch of atlas vertebra. **A**, Lateral view. Aplasia with paramedian unilateral posterior arch remnant on left. **B**, Frontal view shows 1 mm bilateral atlantoaxial lateral offset (*arrows*).

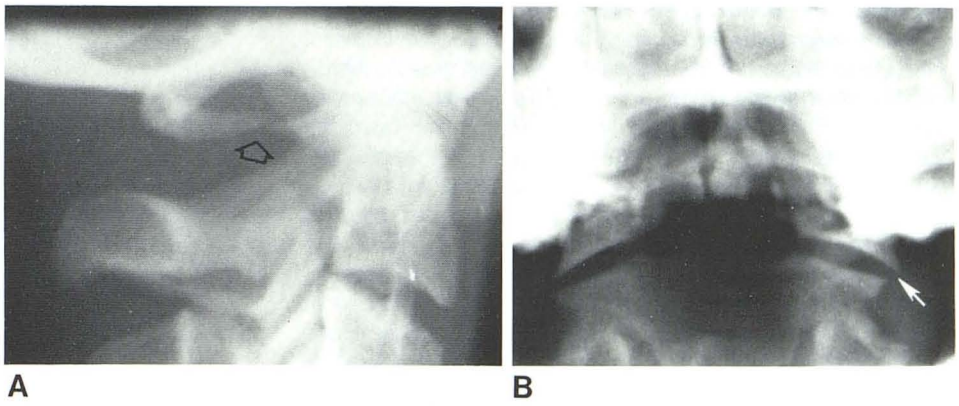

Fig. 4.—Cleft through sulcus of vertebral artery. **A**, Off-lateral view shows cleft (fissure) (*arrow*). **B**, Frontal view shows 2 mm of left lateral atlantoaxial offset (*arrow*).

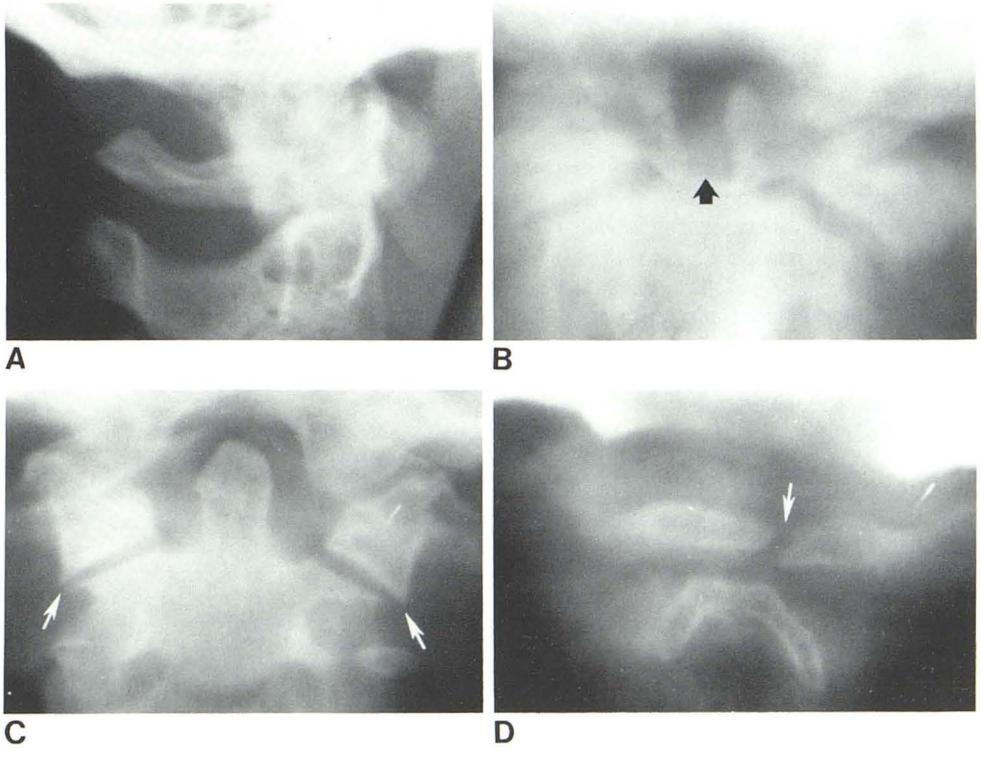

Fig. 5.—Combined clefts of anterior and posterior arches of atlas vertebra. **A**, Lateral view. Rachischisis evidenced by absence of arch-canal line posteriorly and absent cortical line anteriorly. **B–D**, Frontal tomograms show anterior arch cleft (**B**, *arrow*), bilateral atlantoaxial lateral offset (**C**, *arrows*), and posterior arch cleft (**D**, *arrow*).

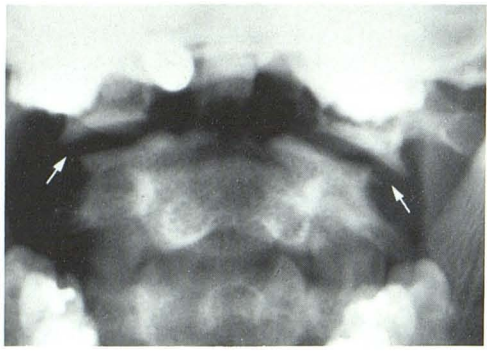

Fig. 6.—Bursting fracture of Jefferson. Bilateral atlantoaxial lateral offset of greater than 2 mm (*arrows*).

skull with the head and neck held rigidly erect [6]. The classic radiographic findings are bilateral atlantoaxial lateral offset of 3–9 mm (fig. 6). Lateral mass offset greater than 7 mm indicates probable rupture of the transverse ligament of the atlas with resulting instability [7]. These arch fractures usually occur near the lateral masses and therefore may not be observed on routine cervical column radiographs [6]. Conventional or computed tomography is often required for diagnosis.

Nontraumatic causes of lateral displacement of the atlas vertebra relative to the axis (C2) have been considered in the literature [8]. In anatomic specimens, Braakman and Penning [9] were able to produce a variety of atlantoaxial offsets on frontal films. All of these are theoretically possible in living patients. Such physiologic atlantoaxial offsets are caused by abduction and rotation of the head. Therefore, the reader is cautioned to always observe the orientation of the atlas to the axis to assure accurate interpretation. In the absence of rotation of the atlantoaxial segment only two conditions may be regarded as normal: (1) no offset or (2) unidirectional or bilateral lateral offset of 1–2 mm. This has been our experience as well; we have not encountered these offsets in a normal cervical vertebral column.

Editor's Note.

For another article on pseudospread of the atlas simulating Jefferson fracture, please see the article by Suss et al. in this issue.

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