RESEARCH

Prevalence of ponticulus posticus in Indian orthodontic patients

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Objectives: The purpose of this study was to investigate the prevalence of complete ponticulus posticus in Indian orthodontic patients.

Methods: The presence and types of ponticuli posticus were investigated on 858 lateral cephalograms.

Results: Complete ponticulus posticus was found in 4.3% of the subjects studied with a male (5.33%) predominance over female in the population (3.76%).

Conclusions: Ponticulus posticus is not a rare anomaly and the patient must be told of the implications and importance of detecting ponticulus posticus on a lateral cephalogram. This information can prove beneficial for the diagnosis of head and neck symptoms later.

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Introduction

The lateral cephalogram is the most common diagnostic radiograph used in clinical orthodontics. The cervical spine area present in lateral cephalograms is, however, generally omitted in cephalometric tracings. Although the skeletal maturation evaluation¹ using cervical vertebrae and its modified version, cervical vertebrae maturation index² (CVMI), is now commonly used to interpret the growth potential of young patients, inadequate attention is paid to the radiological anatomy of this region with a view to identifying pathology. Significant cervical spine pathology can be detected on the routine lateral cephalogram.³ Since “the eye sees what the mind knows”, one of the aims of this article is to sensitize orthodontists to “see” the cervical spine and be equipped to identify departures from normal anatomy (Figures 1–3). The next step is to be aware of the implications of finding these departures from the normal.

Although the orthodontist is not directly concerned with the management of cervical spine anomalies, he does have an obligation, as a healthcare professional, to take any such findings that may hold importance for the patient to their logical conclusion. Farman and Escobar⁴ described the radiographic appearance of congenital

anomalies of vertebral bodies. Radiographic examination of the cervical spine may reveal a pathological disorder in asymptomatic and symptomatic subjects.

The Latin meaning of ponticulus posticus is “little posterior bridge”, which describes an anomalous malformed bony bridge between the posterior portion of the superior articular process and the posterolateral portion of the superior margin of the posterior arch of the atlas (Figures 4–6). The normal atlas is a ring-like structure consisting of two lateral masses connected by a short anterior arch and a longer posterior arch. It is the widest cervical vertebra, with its anterior arch approximately half as long as the posterior arch. The posterior arch corresponds to the laminae of other vertebrae. On its upper surface is a wide groove for the vertebral artery and the first cervical nerve⁵ (Figure 4). In 1–15% of the population, a bony arch may form thereby converting this groove into a foramen (Figure 4) through which these structures pass.⁵ This bony arch is known as the ponticulus posticus. Many terms have been used in the literature to describe this anomaly, including Kimmerle’s anomaly, foramen sagittale, foramen arcuale or arcuate foramen. The structure is seen clearly on plain films of the craniovertebral junction in the lateral projection, including the lateral cephalogram (Figures 2 and 3).

Ponticulus posticus has become an important anomaly of the atlas as the use of lateral mass screws for the fixation of the atlas in the management of atlantoaxial

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Figure 1 Lateral cephalogram of an orthodontic patient showing normal spine with vertebrae C1–C5

Figure 3 Cervical spine in lateral cephalogram of a patient illustrating the partial ponticulus posticus, an anomalous bony spicule formed from the superior articulating surface of the atlas but not fused to the posterior arch of the atlas

Figure 2 Lateral cephalogram of an orthodontic patient showing cervical spine with complete ponticulus posticus

Figure 4 Cranial view of the atlas vertebra showing the site of formation of ponticulus posticus

Figure 5 CT scan of a patient illustrating the three-dimensional morphology and characterization of complete ponticulus posticus bilaterally

instability has gained popularity.⁶ It is a difficult procedure as the region contains the epidural venous plexus and the greater occipital nerve. Injury to the region can lead to significant bleeding and occipital neuralgia. To avoid such difficulty, surgeons recommend placing screws higher than the classical entry point, starting in the posterior aspect of the posterior arch of atlas.⁷ A broad posterior arch of atlas is the best indication for this modified screw placement. While this may be reasonable for most patients, in patients with a ponticulus posticus, the anomaly has the possibility of being misidentified as the broad posterior arch. Attempts to place the screw in such a misidentified structure can cause injury to the vertebral artery leading to stroke or even death by thrombosis, embolism or arterial dissection. Young *et al*⁶ reported that mistaking the ponticulus posticus for a broad posterior arch of the atlas during C1 lateral mass screw placement could cause injury to the vertebral artery.

Ponticulus posticus has been found to be associated with migraine without aura.⁸ Since the ponticulus posticus is intimately attached to the atlanto-occipital membrane (where the spine and skull meet) and this

membrane, in turn, is attached to the dura mater, small tensions exerted on the dura may result in excruciating head pain of a type experienced in migraine. Several studies have indicated that, in the presence of bony rings of atlas, there is occlusion of the vertebral artery and patients with ponticulus posticus often display symptoms of vertebrobasilar insufficiency such as headache, vertigo and diplopia.⁹ In 1972, Graham and Adams, as described by Eriksen,¹⁰ reported two cases of thrombosis of the vertebrobasilar arterial system in the absence of identifiable arterial disease, but in the presence of ponticulus posticus. White and Panjabi¹¹ pointed out the stretching and kinking effect on the vertebral artery with head rotation. Jackson¹² theorized that adhesions may form between the artery, the first nerve root and bony arch or canal through which they pass.

Considering the growing clinical importance of this entity, we need to understand the morphological features and the prevalence of this anomaly. The cephalogram is a useful screening tool for detection of this.

The prevalence of ponticulus posticus has been reported to be between 5.1% and 37.8% in the

Figure 6 CT scan of a patient illustrating the three-dimensional morphology and characterization of complete ponticulus posticus on left (L) and partial ponticulus posticus on right (R)

Western population.^{6,8,13} Female predominance has been reported in the literature.¹³ We, however, could find only a few reports^{6,14–16} on its prevalence or morphological characteristics in an Asian population. Therefore, we investigated the prevalence and morphological features of ponticulus posticus in an Indian population comprising patients reporting to our institute for orthodontic treatment who were all healthy and free of any systemic or musculoskeletal problems. These patients are more representative of the general population than in other studies, whose samples mostly consisted of symptomatic patients seeking relief of cervical spine problems, since a cause and effect relation of malocclusion to any specific systemic or musculoskeletal problem is not well established.

Exact characterization of ponticulus posticus is possible only by three-dimensional (3D) study as illustrated using a CT scan (Figures 5 and 6).

Materials and methods

The study was carried out at the Division of Orthodontic and Dentofacial Orthopaedics, Department of Dental Surgery, Armed Forces Medical College, Pune, India.

Lateral cephalograms were retrieved from the archives of the division and examined for cervical spine anomalies, in particular ponticulus posticus. Lateral cephalograms with poor visualization of the posterior arch of the atlas due to overlapping of the mastoid process or the occiput were excluded. Patients reporting with congenital anomalies such as cleft lip and palate were not included in the study. Patients with other syndromic conditions involving the craniofacial region were excluded. Lateral cephalograms from 858 patients, comprising 300 males and 558 females, were examined. The average age was 15-years-old (range 8–22 years). The distribution of the sample by age and sex is presented in Table 1.

Each radiograph was carefully inspected for the presence of a ponticulus posticus and whether it was complete or partial. Direct visual method of examination under adequate illumination was used. During initial examination all lateral cephalograms were observed by two of the authors (VS and DC). To eliminate any error 100 randomly selected lateral cephalograms were re-examined separately by the same two authors 1 month after initial examination. There was complete agreement between the two authors and the two examinations. Lateral cephalograms

detected with ponticuli posticus were discussed with the radiologist in the Department of Radiodiagnosis and Imaging (AFMC) to confirm the findings. All the findings were corroborated by the radiologist's report. Complete ponticulus posticus was included in the result as a positive finding. Partial ponticulus was given the benefit of doubt and was not included in the results, although many such cases were observed. The prevalence according to gender was calculated.

Results

Analysis of 858 lateral cephalograms revealed ponticulus posticus in 37 patients, constituting 4.3% of the studied sample. Male predominance was found with a prevalence of 5.33% (16 of 300) and female prevalence of 3.76% (21 of 558).

Table 2 illustrates the prevalence of complete ponticulus posticus as reported in the literature.

Discussion

Considering the grave complications that can arise from overlooking this anomaly in cervical spine surgery and other cervical spine interventions and the ease with which it can be avoided, if identified correctly, we need to emphasize identification of the ponticulus posticus on routine lateral cephalograms.

In the Western population, the prevalence of ponticulus posticus has been reported to be between 5.1% and 37.8%.^{6,8,13} It is a common anatomical variant and is estimated to occur in approximately 3–18% of the population.^{6,8,17–19} Complete ponticulus posticus has been found to be between 2.6% and 14.3% in radiological and between 3.4% and 15% in osteological studies.²⁰ Female predominance has been described more often.¹³ Numerous studies have reported a higher prevalence of cervical spine anomalies in cleft lip and palate patients.^{21,22} The prevalence of complete ponticulus posticus as reported in the literature is summarized in Table 2.

A study by Kim *et al*¹⁸ in a Korean population is a retrospective review of 3D CT scan images and radiographs. CT scan images of 225 consecutive patients over 18 years of age were taken at a teaching hospital. They were referred by orthopaedic surgeons or neurosurgeons for evaluation of cervical spine problems. Digital lateral cephalometric radiographs of 315 consecutive patients over the age of 18 were taken in the department of dentistry of the same hospital for evaluation of dental conditions, facial patterns and jaw relationships, regardless of the presence or absence of any cervical symptoms or headaches. The average age was 28 years (range 18–69 years).

CT results revealed complete ponticulus posticus in less than 1% of cases (0.9%) on the left side, and a

Table 1 Distribution of sample as per age and sex

	n	Age in years	Complete ponticulus posticus	
			n	%
Male	300	8–22	16	5.33
Female	558	8–22	21	3.76
Total	858	8–22	37	4.3

Table 2 Prevalence of complete ponticulus posticus as reported in literature

<i>Authors</i>	<i>Year</i>	<i>Material and methods</i>	<i>Prevalence (%)</i>	<i>Male (%)</i>	<i>Female (%)</i>
Kendrick and Biggs ²⁴	1963	Lateral cephalographs — 353	15.8	—	—
Lambarty and Zivanovic ⁹	1973	Anatomical specimen	15	—	—
		Radiographs	7.5		
Takaaki et al ¹⁵	1979	Radiographs — 307	4.89	7.7	2.2
Sweat and Crowe ¹⁹	1987	Radiographs — 1000	13	—	—
Stubbs ¹³	1992	Lateral spine radiographs — 1000	13	—	—
Mitchell ²⁵	1998	Atlas vertebrae — 1354	9.8	—	—
Wight et al ⁸	1999	Lateral spine radiographs — 895	18	—	—
Hasan et al ¹⁴	2001	Atlas vertebrae — 350	3.42	—	—
Unur et al ²⁰	2004	Lateral spine radiographs — 351	5.1	4.6	5.3
Cakmak et al ²⁶	2005	Atlas vertebrae — 60	11.7		
		Lateral spine radiographs — 416	7.2	4.55	8.45
Kim et al ¹⁸	2007	Lateral cephalograms — 315	4	(16)*	(13)*
		CT scans — 225	0.9		
Cederberg et al ²³	2008	Lateral cephalographs — 255	11	—	—
Simsek and Yigitkanli ¹⁶	2008	Dry atlas vertebrae — 158	3.8	—	—
Present study	2009	Lateral cephalographs — 858	4.3	5.33	3.76

*Total prevalence of complete and partial ponticulus posticus

—, Insignificant or no details

combination of complete and partial (23%), with highest prevalence on the left (23%), followed by bilateral (18%) and right (17%). This distinction of right, left and bilateral is, however, not possible in a lateral cephalogram study. Moreover, all patients, called for CT examination were symptomatic. The lateral cephalogram study revealed an overall prevalence of 14%, comprising 4% complete and 10% incomplete. This finding is in good agreement with our figure of 4.3% for complete ponticulus posticus. There was no significant difference in the prevalence between men (37 out of 146, 25%; complete and partial) and women (21 out of 79, 27%; complete and partial) in their study. No statistically significant gender difference was found in our sample. However, a small male predominance (5.3% in males compared with 3.76% in females) was noted.

In a radiological (not a cephalometric) survey of 307 Japanese patients carried out in the orthopaedic department of Kinki University, Japan, Takaaki et al¹⁵ found ponticulus posticus in 9.1% (28 of 307), complete in 15 cases (4.89%), incomplete in 9 (2.93%) cases and calcification type in others with male predominance (12.5%) over females (5.1%). The prevalence of complete ponticulus posticus was found to be 7% (12 of 171) in males and 2.2% (3 of 136) in females. Age was not a factor regarding incidence. It must be emphasized again that all these were symptomatic patients and hence prevalence findings may not represent the population distribution in our patients, who were free of any symptoms related to cervical spine problems or any systemic problem. Male predominance correlates with our study, however, gender difference is quite significant in Takaaki et al's study¹⁵. They also observed that in patients with at least one narrow disc space the possible occurrence of ponticulus posticus was greater. No correlation was found with other cervical anomalies such as block

vertebrae. This aspect was not looked into in our study and needs further investigation to be commented upon.

Hasan et al¹⁴ carried out an anatomical study on macerated atlas vertebrae and routine cadaveric dissections analysing a north Indian population. The study reported posterolateral tunnel in 1.14% and posterior and lateral ponticuli in 6.57% and 2% of vertebrae, respectively.

Similarly, Simsek and Yigitkanli¹⁶ in an anatomical observation of 158 isolated anatomical specimens of dry C1 vertebrae in the Turkish population found complete osseous bridging in 3.8% of specimens and partial bridging in 5.6%.

A study on cadavers, however, cannot be representative of the general population since every human cadaver cannot be assessed, and access in such studies is limited by availability. The present study is more representative of the general population since access to all ages of the population was easy and treatment was sought electively. Although the results of the study by Simsek and Yigitkanli¹⁶ are more or less in consonance with our results, parallels are hard to draw for the reasons mentioned.

Wight et al⁸ reported a prevalence of 18% for ponticulus posticus in 895 patients who visited the chiropractic clinic for the first time and whose condition required radiographic examination. This high prevalence can be attributed to the systemic condition of the patients reporting for treatment; all patients were symptomatic and were seeking treatment for conditions such as cervicogenic headache, neck pain, Barré-Lieou syndrome, photophobia and migraine.

Cederberg et al²³ studied arcuate foramen in 255 subjects using lateral cephalographs. Ponticulus posticus partial and complete was found in 11% of the cases. No gender difference was reported and congenital origin of the anomaly was cited.

Lambarty and Zivanovic⁹ reported the prevalence of complete ponticulus posticus as 15% in their osteological specimens and 7.5% in radiographic analysis.

Kendrick and Biggs²⁴ studied the lateral cephalometric radiographs of 353 young Caucasian orthodontic patients aged 6–17 years for the presence of ponticulus posticus of the first cervical vertebra. Of these, 15.8% showed “some degree” of a ponticulus posticus with no apparent sex predilection (14.6% males and 16.9% females). The youngest female with ponticulus posticus was 6 years 7 months and the youngest male was 6 years 4 months. This proves again that higher age is not a criterion for formation of ponticulus.

Mitchell²⁵ studied 1354 atlas vertebrae of South African white and black adults aged between 20 and 80 years for the incidence and dimensions of the retroarticular canal. Nearly 10% of the specimens had complete arcuate foramina. The incidence did not increase with age and was lower in white adults compared with black adults; with white males having the lowest, and white and black females alike having the highest incidence. This is higher than found in our study and may be due to racial difference.

Sweat and Crowe,¹⁹ in a study to evaluate the nature of origin, formation and significance of ponticulus posticus, used various methods, including videofluoroscopic tape recordings of the cervical range of motion, with patients demonstrating a ponticulus posticus, cervical and central nervous system dissection. Their study of 5 dry specimens and 1000 lateral cervical X-ray films taken between 1952 and 1984 at an upper cervical chiropractic practice showed ponticulus posticus in 18.9%, with complete ponticulus posticus in 13% of their sample. Lamellar patterns within bone matrix and an obvious cortex indicating endochondral ossification support the embryonic origin from the dorsal arch of proatlas. It is similar to the foramen of the first cervical nerve commonly seen in most vertebrates, most notably quadrupeds; this supports a genetic, rather than acquired, origin.

The high prevalence in this study may be because patients were seeking treatment for some cervical spine-

related ailments. Although this study establishes the origin and significance of ponticulus posticus, it cannot be considered to be representative of the general population.

No significant correlation was found with age in our study. This study also has the largest sample size among routine orthodontic patient studies. We did not include the partial ponticuli because the spicules were not large, although they might have been a mild form of partial ponticulus posticus. Importantly, in these patients, the lateral portion of the posterior arch tended to be thin and low while the thickness of the posterior portion tended to look normal (Figure 4). If this morphological feature is visible on radiographs, care must be taken when inserting screws in the posterior arch, as a vertebral artery injury, fracture or weakening could occur. The wide variation in shape and size of ponticulus mentioned in the literature is not discernible in lateral cephalograms and a CT scan is needed for that purpose. This wide variation in shape, size and location of the ponticuli seems to be natural, considering that they are a normal occurrence in quadrupeds and act as an additional extension for the attachment of the posterior atlanto-occipital membrane.

In conclusion, the finding of ponticulus posticus can be of great importance for patients, in whom these anomalies assume clinical significance during management of cervical spine surgical intervention, especially those requiring screw placements in the lateral mass region of atlas. As indicated by this study, it is a not an uncommon anomaly in the Indian population. Thus, care must be taken to account for it on lateral cephalograms of orthodontic patients. If any such anomaly is detected or suspected, it must be documented in the patient's health record and specialist consultation must be sought. A CT scan can be used to substantiate the size and morphology of the ponticulus, if required. Apart from this surgical aspect, it may assume significance in certain cases of headache and migraine. The cephalogram must thus be looked upon as a baseline screening tool for detecting anomalies and pathology in the cervical spine region.

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