Imaging Science in Dentistry 2022; 52: 295-302
https://doi.org/10.5624/isd.20220402

A retrospective study of incidental findings occurring in a consecutive case series of lateral cephalograms of 12- to 20-year-old patients referred for routine orthodontic treatment

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ABSTRACT

Purpose: Lateral cephalograms of orthodontic patients may contain incidental findings that could potentially lead to harm.

Materials and Methods: The lateral cephalograms of 1765 consecutive 12- to 20-year-old patients, being considered for routine orthodontic treatment, were retrospectively reviewed. These patients were considered normal, because no abnormalities were found either in their medical history or on their clinical examination.

Results: The overall prevalence of incidental findings was 18.8%, of which 10.3% were ponticulus posticus and 4.2% were bridging of the sella turcica. Although occipital spurs and ponticulus posticus were more prevalent in males, the size of the sella turcicas did not differ between sexes. Of the 1156 patients completing treatment about 2 years later, only one lateral cephalogram displayed progression of the ponticulus posticus in that time.

Conclusion: The prevalence of incidental findings on lateral cephalograms of otherwise normal orthodontic 12- to 20-year-old patients was almost a fifth, of which ponticulus posticus, vertebral fusion, and enlarged parietal foramina were clinically significant. ***(Imaging Sci Dent 2022; 52: 295-302)***

KEY WORDS: Cephalometry; Incidental Findings; Orthodontics

Introduction

Incidental findings are findings discovered secondarily to an investigation made for another purpose. Half of orthodontists reported discovering on lateral cephalograms significant, potentially life-affecting pathologies, such as os odontoideum.[1] Although incidental findings observed on dental panoramic radiographs have been extensively reported and discussed in recent publications,[2] the advent of cone-beam computed tomography (CBCT) has further emphasized the need for the identification of those incidental findings outside the jaws and their appropriate medical management.[3] This need is more pertinent for the even more frequently prescribed lateral cephalograms.

The pretreatment diagnostic record for comprehensive orthodontic treatment should include "radiographic imaging to permit relative evaluation of size, shape, and position of relevant hard, and soft tissue craniofacial structures including dentition and to aid in identification of skeletal anomalies and/or pathology"[4] This is currently performed using large field-of-view (FOV) CBCT scans or conventional lateral cephalograms. Although adults are increasingly driven to seek orthodontic treatment,[5,6] 12- to 20-year-old adolescents remain the core of the average orthodontists' case load. As the projected cancer risk for children was 16 times greater than the risk for adults,[7] lateral cephalograms are still the most widely used cephalometric modality, particularly for patients who do not have craniofacial anomalies, such as cleft lip and palate. Lateral cephalograms are also taken after the completion of the treatment to evaluate treatment outcomes. Lateral cephalograms are also prescribed for children with snoring and nasopharyngeal hypertrophy.[8]

Although lateral cephalograms have been used for decades, few studies have addressed incidental findings on lateral

Received April 2, 2022; Revised April 28, 2022; Accepted May 6, 2022
Published online June 2, 2022
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Table 1. The distribution of the features most frequently found incidentally on lateral cephalograms in the literature

Findings	Authors							
	Bisk and Lee[9]	Tetradis and Kantor[10]	Pérez et al.[11]	Adisen and Misirlioglu[12]	Putrino et al.[13]	Hernandez et al.[14]	Najmuddin[15]	Present study
Sample size	513	325	417	1246	350	597	640	1765
Nation	USA	USA	Peru	Turkey	Italy	Columbia	Saudi Arabia	Canada
Male : female	IIG	134 : 191	178 : 239	522 : 724	160 : 190	IIG	320 : 320	800 : 965
Age range, years (mean)	7-27	6-49 (mean: 14.8)	5-53 (mean: 14.9)	10-39 (mean 21.0)	7-21 (mean 12.9)	3-70	15-30	12-20 (mean 14.2)
Sella turcica height, mm (mean)	ING	2.5-12.5 (7.6 ± 1.7)	ING	ING	ING	ING	ING	1.1-12.0 (5.3 ± 1.5)
Sella turcica length, mm (mean)	ING	6.0-17.0 (10.9 ± 1.8)	ING	ING	ING	ING	ING	2.6-15.8 (7.5 ± 1.8)
Sella turcica bridging	ING	11.0%	4.3%	ING	ING	1.4%	ING	4.2%
Large parietal foramen	ING	ING	ING	ING	ING	ING	ING	0.1%
Occipital spur	ING	ING	ING	ING	ING	ING	ING	3.6%
Nasopharyngeal tonsil hyperplasia (adenoids)	1.0%	21.0%	ING	ING	ING	ING	ING	0.0%
Maxillary sinus	1.0%	1.0%	ING	ING	ING	ING	ING	0.0%
Cyst in the jaws	ING	ING	ING	ING	ING	ING	ING	0.0%
Tumor in the jaws	ING	ING	ING	ING	ING	ING	ING	0.0%
Os odontoidium	0.0%	ING	ING	ING	ING	ING	ING	0.0%
Vertebral fusion	0.1%	0.9%	ING	ING	ING	0.4%	ING	0.5%
Ponticulus posticus	0.2%	35.0%	ING	18.8%	16.3%	ING	9.8%	10.3%
Stylohyoid complex	ING	ING	ING	ING	ING	17.6%	ING	0.3%
Calcified carotid artery atheroma	ING	ING	ING	ING	ING	ING	ING	0.0%
Tonsillolith	ING	ING	ING	ING	ING	ING	ING	0.0%
Total	3.5%	IIG	IIG	IIG	IIG	IIG	IIG	18.8%

IIG: inadequate information given, ING: information not given

cephalograms (Table 1).[9-15] The missing data in the literature in Table 1 are represented by *information not given* (ING) or *inadequate information given* (IIG). The present study endeavors to address these deficiencies.

The primary aim of this project was to evaluate the prevalence of incidental findings on digital lateral cephalograms on a consecutive series of patients (12 to 20 years of age) presenting for treatment to a North American graduate orthodontic program. Although the number of incidental findings is extensive,[16] the emphasis in this study is on findings that require further investigation or treatment.

Materials and Methods

This retrospective consecutive case series was awarded research ethical board certificate H20-01235. This study included 12- to 20-year-old patients who were considered for standard or routine orthodontic treatment. They were determined to be appropriate candidates for such treatment based on both a medical history and a clinical examination that did not reveal syndromes or cleft lip or palate. The digital lateral cephalograms were performed using the Planmeca ProMax 2D S3 (Helsinki, Finland).

The incidental findings considered in the present study were those occurring in the 3 zones set out in Figure 1 and presented in Table 2.

The size of the sella turcica on each lateral cephalogram was measured using the Romexis measurement tool (Planmeca ver. 3.8.3.R. of 01/22/2016; Helsinki, Finland) and the Taveras and Wood[17] method. The size of the sella turcica on the 1,765 lateral cephalograms was determined in 2 dimensions: its height and its antero-posterior length.

The patients accepted for orthodontic treatment receive a lateral cephalogram upon completion of treatment. In order to determine whether this 2-year-later lateral cephalogram revealed incidental findings not observable on the pretreatment lateral cephalogram, it was reviewed for the 1,156 patients who received this second lateral cephalogram.

Table 2. The distribution of the features most frequently found incidentally on lateral cephalograms according to sex in the present study

Incidental findings	Potential clinical implications	Male	Female	χ^2	*P*	Total
Cranium and skull Base						
Sella bridging	Dental and craniofacial anomalies	31 (3.9%)	43 (4.5%)	0.37	0.543	74 (4.2%)
Enlarged parietal foramen	Penetrating brain injury, headaches, and seizures	0	2 (0.2%)	Not applicable		2 (0.1%)
Occipital spur	Any head and neck pain	46 (5.8%)	17 (1.8%)	20.21	<0.05	63 (3.6%)
Face and jaws						
Nasopharyngeal tonsil hyperplasia (adenoids)	Apnea, ear and nose infections	0	0	Not applicable		0
Maxillary sinus	Any sinus pathology	0	0	Not applicable		0
Cyst	May need surgery	0	0	Not applicable		0
Tumor	Needs surgery	0	0	Not applicable		0
Spine and neck						
Os odontoidium	Risk of paraplegia	0	0	Not applicable		0
Vertebral fusion	Klippel-Feil syndrome and idiopathic juvenile arthritis	6 (0.8%)	3 (0.3%)	Not applicable		9 (0.5%)
Ponticulus posticus	Head and neck pain, vertigo	98 (12.3%)	83 (8.0%)	6.33	<0.05	181 (10.3%)
Stylohyoid complex	Eagle syndrome	2 (0.3%)	0	Not applicable		2 (0.1%)
Calcified carotid artery atheroma	Stroke, metabolic disease, and calcium disturbance	0	0	Not applicable		0
Tonsillolith	Tonsil abscess, halitosis	0	0	Not applicable		0
	Total	183 (22.9%)	148 (15.3%)	17.30	<0.05	331 (18.8%)

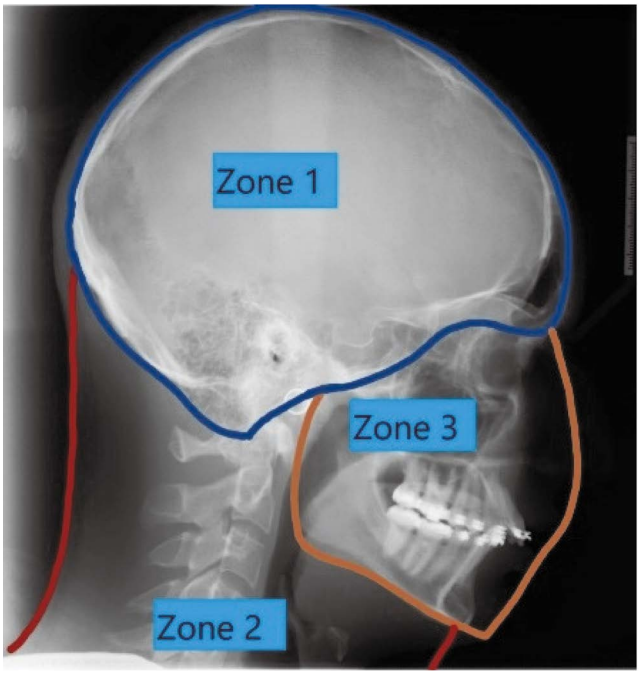

Fig. 1. The 3 zones on lateral cephalograms in the present study. Zone 1: cranium and skull base, zone 2: spine and neck, zone 3: face and jaws zone.

The clinical notes of all patients were reviewed for mention of incidental findings. As dental panoramic radiographs are standard conventional radiography for lesions of the jaws, such as cysts, neoplasms, tonsilloliths, calcified stylohyoid complexes, and mucosal antral pseudocysts these were reviewed in every case to confirm their presence or absence.

The data in this study were categorical, and the Pearson chi-square (χ^2) test (with 1 degree of freedom) was used to determine the significance of differences according to sex within the same category of incidental finding. It was determined that a difference in prevalence was statistically significant when $\chi^2 > 3.84$ ($P < 0.05$; 2-tailed). Whenever the number of cases was inadequate for the χ^2 test, "not applicable" was entered in the tables, meaning that the χ^2 test could not be applied. The calculations were performed using VassarStats.[18]

Results

There were 1,765 patients: 800 males and 965 females. The majority (58%) were self-referred for correction of "crooked" or "sticking out" teeth, a further 4% were self-referred for "cheek-biting" or an inability to bite on the back teeth, and 38% were referred by the patients' general dental practitioners or by the graduate pediatric dentistry program to the graduate orthodontic program to be considered

for orthodontic treatment. The mean age of the sample of patients was 14.2 years, and most of the patients were 12 to 14 years old.

Table 2 displays a total of 331 incidental findings (18.8%), of which 183 (22.9%) were present in males and 148 (15.3%) in females; the predilection for males was very significant. All were found in the cranium and skull base and in the spine and neck, but none in the face and jaws (Fig. 1). The absence of findings in the jaws was confirmed by a review of the accompanying dental panoramic radiographs. The images of the most important and/or most frequent incidental findings are set out in Figures 2-6: sella turcica bridging (Fig. 2), enlarged parietal foramen (Fig. 3), vertebral fusion (Fig. 4A), ponticulus posticus (Figs. 4B and 5) and occipital spur (Fig. 6). The male predilection for ponticulus posticus and occipital spur was significant. None of these incidental findings were documented in the clinical records.

The size of the sella turcica on the 1,765 lateral cephalograms was determined in 2 dimensions: its height and its

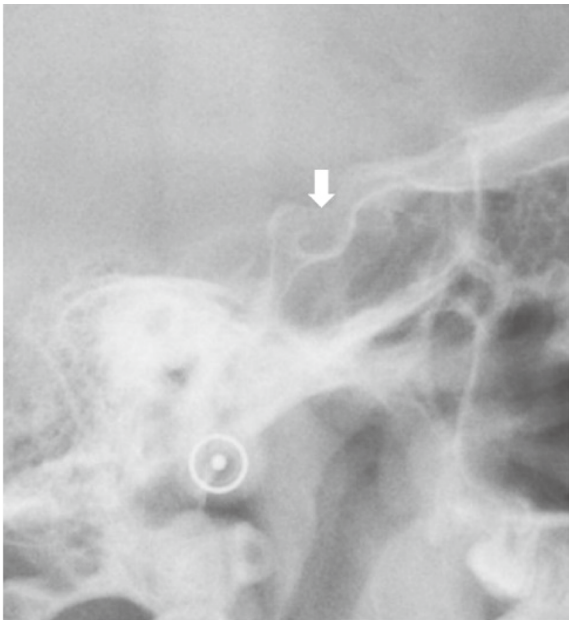

Fig. 2. Cropped lateral cephalogram displays bridging of the sella turcica (white arrow).

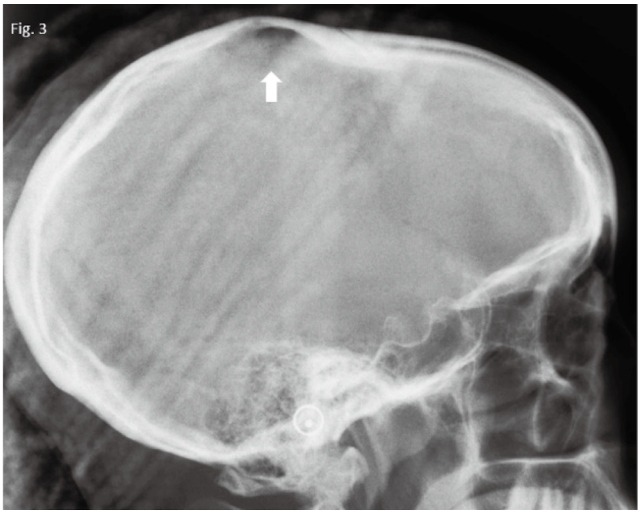

Fig. 3. Lateral cephalogram displays an enlarged parietal foramen (white arrow).

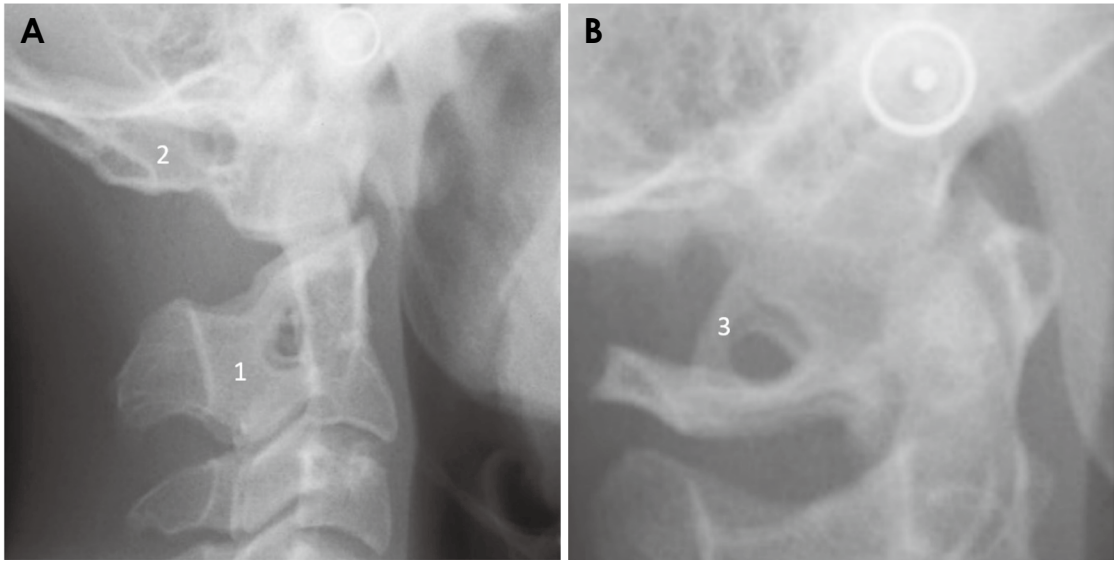

Fig. 4. Cropped lateral cephalogram of a case of fused vertebrae. A. The cephalogram displays both fusion of the laminae of the second and third cervical vertebrae (also known as C2 and C3) (1) and occipitalization of the atlas (2). B. A case of ponticus posticus (3: arcuate foramen) arching over the vertebral artery as it passes over the posterior arch of the atlas.

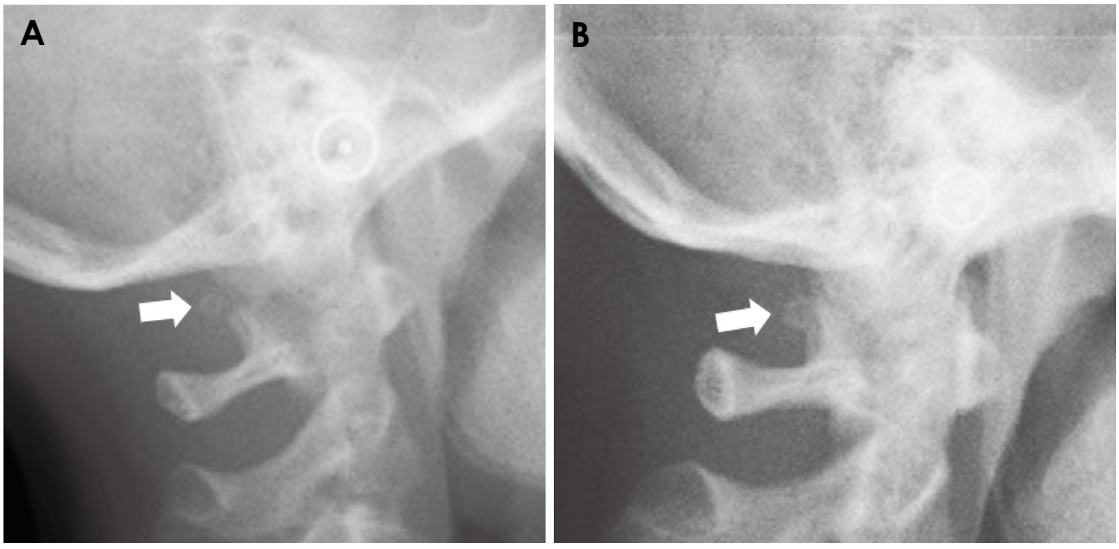

Fig. 5. Lateral cephalograms of the same patient taken 2 years apart at the beginning of treatment (A) and at the completion of treatment (B). They display the development of ponticus posticus (arcuate foramen), and the later image (B) is more developed (white arrows).

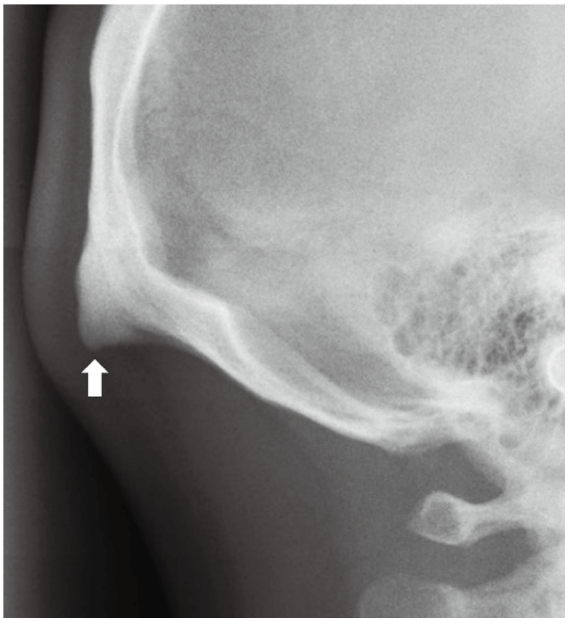

Fig. 6. Cropped lateral cephalogram displays an occipital spur (white arrow).

antero-posterior length. The mean height (range: 1.1-12.0 mm) of the sella turcica was 5.3 ± 1.5 mm in our sample and the mean antero-posterior length (range: 2.6-17.0 mm) was 7.5 ± 1.8 mm. There were no significant differences between males (height: 5.2 ± 1.4 mm, length 7.4 ± 1.8 mm) and females (height: 5.4 ± 1.5 mm, length: 7.5 ± 1.9 mm, for either dimension; $t = 0.813$ for height and $t = 1.14$ for length).

In addition to all 1,765 patients who received a pretreatment lateral cephalogram, 1,156 of them received a second lateral cephalogram upon completion of orthodontic treatment. The average time between the pretreatment and follow-up lateral cephalograms was estimated to be 2 to 2.5 years; the typical amount of time needed to finish orthodontic treatment. No noticeable difference was detected in the incidental findings between these 1,156 pretreatment and posttreatment lateral cephalograms, except for 1 patient (Fig. 5). This patient, with ponticulus posticus, displayed progressive radiopacity in the region of the posterior arch of the atlas (first cervical vertebra).

Discussion

Lateral cephalograms are still recommended for routine prescription by orthodontists,[4] although a substantial study a decade ago revealed that lateral cephalograms assisted in the treatment planning for only 1 out 6 patients.[19] Due to the significantly lower effective dose delivered by a lateral cephalogram and dental panoramic radiograph (47.2 μSv) in comparison to a CBCT scan (107.2 to 249 μSv),[14] lateral cephalograms and dental panoramic radiographs are preferred to CBCT in most routine orthodontic cases in normal patients.

As apparent in Table 1, very few reported consecutive case series on lateral cephalograms have considered incidental findings other than ponticulus posticus. Two out of the 4 reports that considered more than 1 anomaly permit-

ted the total number of incidental findings to be calculated: 3.5% for Bisk and Lee[9] and 18.8% for the present study. Two studies were performed on analog lateral cephalograms over 2 decades ago, whereas 2 other studies (including the present study) were performed on digital lateral cephalograms. Unfortunately, the report of Hernandez et al.,[14] like that of Tetradis and Kantor,[10] did not differentiate between the findings on lateral cephalograms alone and dental panoramic radiographs. Therefore, a total prevalence could not be established for them in Table 1.

As a sex predilection has already been identified for other disorders, such as taurodontism, which is more prevalent in normal adolescent females in addition to those with X-chromosomal aneuploidy,[20,21] sex predilections for other features were sought in this study. Although it was found that males were more likely to present with incidental findings on lateral cephalograms, both overall and for specific incidental findings such as occipital spurs and ponticulus posticus, this did not extend to the size of the sella turcica as presented on lateral cephalograms.

The sella turcica is the most obvious extragnathic structure on lateral cephalograms, sited almost centrally within the head. Tetradis and Kantor[10] reported that the length and height of the sella turcica were significantly larger than those of the present study ($t = 54.46$ and $t = 29.41$, respectively). Although both the study of Tetradis and Kantor[10] and this study included multi-ethnic North American communities, both studies varied markedly with regard to other incidental findings, such sella turcica bridging, nasopharyngeal tonsil hyperplasia, and posticulus posticus; this suggests that both communities were quite different.

Sella turcica bridging (Fig. 2) was prevalent in 4.2% of the cases in the present sample, again with no sex predilection. This rate of 4.2% falls within the range of prevalence reported in existing literature which is 1.4%-11%, as displayed in Table 1. Although sella turcica bridging is frequently associated with syndromes, its global overall prevalence as an incidental finding in the general population in non-syndromic cases was higher than previously thought.[22] An association exists between dental abnormalities and sella turcica bridging;[23] almost 50% of children with malocclusion have sella turcica abnormalities. Assessment of the sella turcica is recommended during cephalometric analysis.[24]

Enlarged parietal foramina (Fig. 3) were found in 0.1% of the sample, reflecting a higher frequency than the reported prevalence of 1/15,000 to 1/50,000.[25] Although most patients with enlarged parietal foramina are asymptomatic, some have "experienced violent headaches, vomiting, and intense pain on application of mild pressure to the unprotected cerebral cortex."[25] "Most people with enlarged parietal foramina present in an autosomal dominant fashion with high, but incomplete penetrance."[25] Although the risk for penetrating brain injury is small, the anxiety it provokes can be lessened by informing parents, teachers, and the affected child how to avoid potential brain-injuring activities.[26]

By the time the child has reached 8 to 10 years of age, the cervical spine has achieved the same dimensions as it will have in adulthood.[27] The second vertebra of the cervical spine (axis) has the most complex development of all vertebrae,[27] resulting in its prominence with regards to os odontoideum and vertebral fusion. Os odontoideum is defined as "an independent ossicle of variable size with smooth circumferential cortical margins separated from the axis."[28] Although the absence of os odontoideum in the present study and in that of Bisk and Lee[9] suggests that they are unlikely in normal orthodontic case series, it has been associated with Down and Crouzon syndromes and a history of trauma.[29]

The reported prevalence of vertebral fusion varies from 0.1%[9] to 0.9% (Table 1),[10] with the present study in between, at 0.5%. Fusion of the second and third cervical vertebrae is the most frequent site for such fusions (Fig. 4A).[31] These fusions may occur due to a locally decreased blood supply in the third to eighth week of intrauterine life.[30] While such cases could be due to idiopathic cervical fusion, consideration should be given to the possibility of Klippel-Feil syndrome.[31] Nevertheless, Figure 3 in the study of Nouri et al.[31] displays a case of idiopathic cervical fusion with similar laminar fusion to that in the present Figure 4A. The patient presented by Nouri et al. also had degenerative cervical myelopathy.[31] Arthritic changes in the cervical spine suggestive of idiopathic juvenile arthritis should be evaluated on lateral cephalograms.[32] Figure 4A also displays occipitalization of the atlas (synostosis between the atlas and occipital bone), which was also reported by Tetradis and Kantor.[10] This has been reported to occur in about 1.0% of cases[33] and is often associated with congenital defects of the vertebrae, including syndromes such as Klippel-Feil syndrome.[33] It becomes symptomatic in the second decade, generally after minor trauma. The symptoms are limited neck motion, peripheral nerve irritation, anesthesia, and weakness.[33] Fusion of the second to third cervical vertebrae may coexist with occipitalization (Fig. 4A).[33]

Ponticulus posticus (also known as arcuate foramen or atlanto-occipital ligament calcification) is the bony bridge of the atlas (first cervical vertebra) arching over the horizontal part of the third segment of the vertebral artery (Fig. 4B).[34] It has been associated with migraine-like headaches (with-

out an aura), neck pain, and vertigo.[12,34] It was also the most common incidental finding in the present study, as well as in the literature (Table 1). Figure 5 displays the development of a case of ponticulus posticus over the 2 years of orthodontic treatment.

In the present study, occipital spur, also called enlarged external occipital protuberance (Fig. 6),[35] was prevalent (3.6%), although this finding has hitherto not been reported in such young patients.[35] The clinical importance of the enlarged external occipital protuberance arises from its potential to cause migraine or other primary headache disorders.[35]

Lymphoid tissue in the head and neck is represented by nodal (lymph nodes) and extranodal (Waldeyer's ring of tonsils) origins.[36] The 2 tonsils that present on lateral cephalograms are the nasopharyngeal and palatine tonsils when tonsilloliths are present. No enlarged (hyperplastic) nasopharyngeal tonsils (also known as adenoids) were reported in this study of 12- to 20-year-old patients, whereas Bisk and Lee[9] determined that 1.0% of their patients had large adenoids. This may reflect their study's age range that extended into the first decade of life, as these are more prevalent between 6 and 12 years of age. A systematic review of lateral cephalograms indicated that lateral cephalograms are diagnostically accurate for enlarged (hyperplastic) nasopharyngeal tonsils and posterior upper airway obstruction.[37] Furthermore, although the airway development continues until about the 12th year of age, orthodontic treatment, such as functional appliances, may improve the fundamental and essential functions of the respiratory system.[38]

No published report in Table 1 evaluated the presence of palatine tonsilloliths. Although they were not present in the present study, they were reported in 13.4% of all dental panoramic radiographs in a recent report.[39] In that report, however, they were only present in 2.7% of all 10-to-19-year olds.[39]

Calcification of the stylohyoid complex, if present, should be as readily observable on lateral cephalograms as it is on dental panoramic radiographs.[40]

Although no published report in Table 1 evaluated the presence of calcified carotid artery atheromas, Hernandez et al.[14] reported intracranial vascular calcification in 10 cases. It is likely that these occurred in the older end of their age spectrum of 3 to 70 years.[14] Furthermore, it is likely that calcified carotid artery atheromas, if present, were not overlooked and unrecorded, at least in most of the cases of the present study, as the potential importance of their presence has been widely known for the last 2 decades.[41]

The most obvious and frequent lesions in the maxillary sinuses are mucosal antral pseudocysts. These have been reported on dental panoramic radiographs in a number of communities and vary markedly between them. Reported case series of Hong Kong Chinese,[42] Londoners (UK),[43] and Canadians[2] were substantially among adults in whom the development of the maxillary sinuses would have been well established. As most of the 12- to 20-year-old patients were in the age range of 12-14 years in this study, this might not yet be the case for the patients analyzed herein.

The prevalence of incidental findings on lateral cephalograms of otherwise normal orthodontic patients 12 to 20 years of age was almost a fifth of all cases. Some of these incidental findings were clinically significant, such as ponticulus posticus, vertebral fusion, and enlarged parietal foramina. Therefore, the skull and cervical spine regions on the lateral cephalograms should be carefully reviewed for anomalies during cephalometric analysis.

Conflicts of Interest: None

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