A Retrospective Study of Incidental Findings Occurring in a
Consecutive Case Series of Lateral Cephalograms of Patients
Referred for Orthodontic Treatment

by

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(Craniofacial Science)

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

February 2022

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The following individuals certify that they have read, and recommend to the Faculty of Graduate and Postdoctoral Studies for acceptance, a thesis entitled:

A Retrospective Study of Incidental Findings Occurring in a Consecutive Case Series of Lateral Cephalograms of Patients Referred for Orthodontic Treatment

submitted by Akash Patel in partial fulfillment of the requirements for the degree of Master of Science in Craniofacial Science

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Abstract

Objectives: Lateral Cephalograms (LC) have been used as part of pretreatment records of orthodontic patients for diagnosing and treatment planning. Since LC contains many important anatomical structures, accurate examination of these areas is very important. Incidental findings of clinical significance are believed to be present very commonly on LC and thus orthodontists are more likely to encounter those. The purpose of this study was to find out prevalence of incidental findings in LC taken for orthodontic diagnosis of patients seeking orthodontic treatment at UBC Graduate Orthodontic Clinic.

Methods: A total of 1765 consecutive patients’ pretreatment and follow up LCs were inspected retrospectively. The age was restricted to 12-20 years old at the start of the orthodontic treatment. All the LC were checked within Romexis- image capturing software. Each LC was examined in 3 zones in a systematic way: cranium; neck and cervical spine; and dentofacial complex. Additionally, size of Sella Turcica was also measured in Romexis.

Results: Overall prevalence of incidental findings was 18.8%. Ponticulus Posticus was the most prevalent finding (10.3%) followed by bridging of Sella Turcica (4.2%). Sella turcica height ranged from 1.1-12.0mm and width ranged from 2.6-15.8mm. There is statistically significant association between incidental findings and sex (chi square statistics 16.315 and p<0.05) with males being more likely to present with them.

Conclusions: Incidental findings are prevalent on LC radiographs of orthodontic patients. Thus, careful examination of LC beyond area of orthodontists’ interest is very important. Males are more likely to present with incidental findings than females. As far as the individual anomaly is concerned, only Occipital Spur was more likely to be present in males
than in females. Ponticulus Posticus and Occipital Spur were highest co-occurring incidental findings in the sample. All except on follow up LC revealed no additional prevalence of incidental findings.
Lay Summary

A lateral cephalometric radiograph is 2-dimensional radiograph of the head and partly neck region that is used for orthodontic diagnosis and treatment planning purposed. Although orthodontists are concerned with the jaw bones and teeth and their relationship with each other and to the skull, the LC covered larger areas of skull, neck, cervical spine beyond the jaw bones. These areas on radiographs may contain anatomic abnormalities that may have clinical significance. This project investigated the percentage of occurrence of such incidental findings on LC taken for orthodontic patients. We found that such incidental findings are commonly occurring on LC. Males are more likely to present with these findings than females.
Preface

The primary research question was developed by Dr. David MacDonald (DM) in 2019 at University of British Columbia to check if there are any significant incidental findings in LC taken for the patients seeking orthodontic treatment. Secondary objectives of the research were developed by orthodontic graduate resident, Dr. Akash Patel (AP) with the help of DM and the research committee members Dr. Bingshuang Zou (BZ) and Dr. Edwin Yen (EY).

The LC data was gathered by AP with the help of Peter Hinz, systems administrator at UBC Faculty of Dentistry.

AP collected the data from the lateral cephalograms. Data validation of the subsample was done by AP and DM together.

Statistical analysis was done by AP with the help of Dr. Jolanta Aleksejuniene of UBC faculty of Dentistry.

AP prepared the manuscript followed by content editing by Drs. DM, EY and BZ.

All the data was retrospective, and no human contact was needed for this project. This research was approved by the Research Ethics Board at The University of British Columbia, ethics certificate number H20-01235.
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List of Abbreviations

DPR- Dental Panoramic Radiograph

FFD- Field Focus Distance

FoV- Field of View

IF- Incidental Findings

LC- Lateral Cephalogram

PA- Periapical radiograph

UBC – University of British Columbia
Acknowledgements

My supervisor Dr. David MacDonald for his continuous support and for steering this project in the right direction. His responsiveness has helped immensely for timely completion of this project.

My research committee members, Dr. Edwin Yen and Dr. Bingshuang Zou, for providing valuable constructive feedback and guidance through the course of this project.

Dr. Jolanta Aleksejuniene, for her feedback on statistical calculations of this project.

Dr. Varun Singh, for not only instilling many ideas that are deeply embedded in this project but also for continuous encouragement throughout the graduate program.

Dr. Bernardo Peres for helping to navigate through the protocols of thesis writing, presentation, and defense.
Dedication

This is Dedicated to,

My late brother, Deep for believing in me- You are missed.

My parents for constant support and selfless love.

My wife, Sonam for her sacrifices over the years.

My teachers at different stages of life for their guidance.
Chapter 1: Introduction

The clinical practice guidelines of American Association of Orthodontists (2019) states that 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” Examples of such radiographs can be large field of view CBCT and lateral cephalogram, CBCT being relatively new of the two. Although availability of CBCT is widespread, it’s increased radiation dose especially to children who are more vulnerable to radiation induced side effects makes it not a routine choice for orthodontic records. It’s reserved for patients with severe craniofacial anomalies and cleft lip and palate. Because of that, LC has been the most widely used radiograph in orthodontic patients for pre-treatment diagnosis and treatment planning. LCs are not only taken as part of the pre-treatment records, but also taken after the completion of the treatment to evaluate the outcome of the treatment, and mid-treatment especially if the patient if being prepared for orthognathic surgery. In addition, LC also contains information beyond the maxillofacial complex such as cranium, cervical spine etc. Such vital information can easily be overlooked without proper knowledge of this region.

The existence of incidental findings in the Dental Panoramic Radiographs (DPR) have been extensively reported. However, the existing literature has very little information about the prevalence of incidental findings on LCs. At this point, it is important to review that LC offers several advantages over DPR, although both offer unique value for diagnosis. As discussed earlier, LC covers larger area of head and neck than what DPR covers. In addition, DPR is subject to 10-20% magnification in the vertical plane depending on the unit. It is also subject to distortion in the horizontal plane depending on the patient, operator, and the unit. LC on the
other hand, when set at the standard Film Focus Distance (FFD), should have minimally varying
distortion and magnification (1). This is usually the case for LCs taken for orthodontic purposes
where source to object distance is set constant at 5 feet.

Moffit et al. surveyed 417 orthodontists and concluded that 50% of orthodontists are likely to
discover significant, potentially life affecting pathology, such as os odontoideum, on a LC that
they acquire (2). There are numerous case reports of anomalies found on LCs but very few
studies have systematically investigated the overall prevalence of incidental findings on LC.

Incidental findings on the LC can be divided into two subgroups: 1) Normal variants and 2)
Anomalies or pathologies with clinical implications. Prevalence, on the other hand, is defined as
“proportion of the population who have a specific characteristic at a given time period” (3), that
specific characteristic in our case is the incidental finding on the LC. Prevalence can be point
prevalence, period prevalence and lifetime prevalence. As the LCs taken during orthodontic
treatment represent the period between pre-treatment and post treatment, measuring the period
prevalence in these cases is more suitable.

1.1 Review of the Current Literature

Bisk et al. investigated LCs of 513 patients in 1976 (4). Their data had 3.5% prevalence of
incidental pathologic/ abnormal findings, the most common being adenoids tissue enlargements.
Their data only had analog LC films.

In 1999, Tetradis et al., examined 540 radiographs, LCs and periapical (PA), of 325 patients (5).
They found total of 431 incidental findings out of which 15 (3.1%) needed further evaluation.
Those findings include vertebral anomalies, cysts and tumors and intracranial calcifications.
Hernandez et al., investigated LCs and DPRs of 783 Columbian patients (6). They concluded 88.12% prevalence of incidental findings which was significantly higher than the previous studies. The reason for such a higher number was inclusion of normal anatomic variants without clinical significance.

1.2 Limitations of Existing Literature

The current prevalence studies of incidental findings on LC have had their limitations as follows:

- Analog films were used instead of digital radiographs: It is now well known that digital LC has some advantages over analog films such as reduced radiation, reduced work time and thus cost savings, capability of image enhancement, compression and archiving, capability of teleradiology and automated cephalometric analysis.
- Prevalence included normal variants into the calculation.
- Small sample size
- Combined multiple types of radiographs (i.e., PA, DRP, LC etc.)

Based on that, it was deemed important for the current project to have included the following: Digital LCs only, have a clear distinction between what’s clinically significant incidental finding and what just a normal anatomic variant without clinical significance.

1.3 Description of Anomalies

The following section serves to provide description of some of the unusual incidental findings (7) (8).

1.3.1 Sella: Bridging

*Description*: Calcification of interclenoidal ligament is termed as bridging of Sella Turcica.
Bridging can be partial or complete.

**Prevalence:** Bridging is prevalent at 1.1-13 per cent in the population (9) (10) (11) (12). It has also been shown to be more prevalent in people with craniofacial anomalies (13) (14) however the specific anomalies were not identified in these studies.

**Clinical significance:** In addition to bridging being more prevalent in people with craniofacial anomalies, bridging is also associated with tooth transposition (15).

![Bridging of sella turcica](image)

**Figure 1: Bridging of sella turcica**

1.3.2 Sella: Size

**Description:** Details of Sella Turcica’s size variations, measurement methods are described in the following sections. Different authors have pointed out different “normal size” range for Sella Turcica based on their findings in their study sample. This is further discussed in the discussion section. Smaller or larger than normal sized Sella Turcica may hint at an associated condition or disease.
Clinical significance: Following is the list of radiographic differential diagnosis of a large Sella Turcica: Rathke’s cleft cyst (16), Nelson’s syndrome, acromegaly, prolactinoma, hypothyroidism, craniopharyngioma, mucocele, Wermer Syndrome (17) (18) (19). Larger or smaller size of Sella can also be a normal anatomic variant. So radiographic appearance should be confirmed with clinical signs and symptoms if any. For example, patients with pituitary disease may present with sign of growth, visual and endocrine disturbance, hair and skin dryness, headache etc. Alkofide et al. concluded that larger Sella size is usually associated with class III subjects and smaller Sella size is associated with class II subjects (11).

Figure 2: Large size sella turcica
1.3.3 Vertebral Fusion

*Description:* Fusion of vertebra could arise due to failure of normal embryological segmentation because of locally decreased blood flow. Fusion of cervical vertebra is more common between C2-C3. One variation of this is atlanto occipital assimilation which happens when the first cervical and last occipital sclerotome fail to segment (20).

*Prevalence:* Vertebral fusion has been reported to be prevalent at the rate of 0.4 to 0.7%. Atlanto occipital assimilation has been reported to be prevalent at 0.75% (21).
Clinical significance: Patients with vertebral fusion are typically asymptomatic. However, symptoms may arise with increasing age or can exaggerate with injuries. In addition, cervical vertebral fusion has been reported to be associated with multiple other conditions or anomalies such as cleft lip and palate (22) (23); craniofacial and other syndromes such as Klippel Feil syndrome (24–27), Apert syndrome (28); and sleep apnea (29).

![Vertebral fusion](image)

**Figure 4: Vertebral fusion**

1.3.4 Os odontoideum

Description: Os odontoideum is the separation of the odontoid ossicle from the rest of odontoid process in axis.

Prevalence: True prevalence of os odontoideum is difficult to diagnose since it’s found incidentally only. However, Perdikakis et al. have estimated its prevalence to be of 70 cases in 10,000 (30).
Clinical Significance: This can result in severe instability of the articulation between Atlas and Axis. This also can be potentially lethal with injuries (31).

1.3.5 Ponticulus Posticus

Description: Ponticulus Posticus is a bony prominence that arises from the posterior arch of atlas. It can partially or completely encircle the vertebral artery.

Prevalence: The prevalence Ponticulus Posticus varies from 1.3-15.9% depending on the study population’s ethnicity one may refer (32). Having said that, there is no gender or ethnicity predilection established so far. It is not an uncommon finding.
Clinical significance: Ponticulus Posticus poses a concern for spine surgeon in cases of lateral mass screw placement is planned (33). It has also been reported that Ponticulus Posticus may also be associated with the following: vertebrobasilar insufficiency, headache and cervical pain syndrome, migraine without aura, onset of acute hearing loss, cervicogenic headache, and chronic tension-type headaches (34,35).

![Figure 6: Ponticulus posticus](image)

1.3.6 Occipital spur

Description: Occipital spur is the enlargement of external occipital protuberance (EOP). The EOP provides insertion site for nuchal ligament (36).

Prevalence: Srivastava et al. found a prevalence of 10% in their retrospective study of human skulls (37) of Indian origin. It is more common in males and thus frequently used for determining gender of the subjects in forensic investigation (38). While in another study it was prevalent at the rate of 41% with 10% having more than 20mm large occipital spur (38). The
population was Australian university students and patients in this study.

*Clinical significance:* Although it is considered normal anatomic variant in most cases, it can be a site for pain and tenderness on lying down (39). Sometimes, the pain from occipital spur can be severe enough to require surgical excision (40).

![Occipital spur](image)

*Figure 7: Occipital spur*

### 1.3.7 Enlarged Parietal foramen

*Description:* Parietal foramina usually are found in 60-70% people and serves as the passage of emissary veins (41). They are also known as “Catlin Marks”. Enlarged parietal foramina, on the other hand, are thought to be autosomal dominant trait (42).

*Prevalence:* Enlarged parietal foramina are usually present 1 in 25,000 people (43). However,
other authors have reported the prevalence to be at 0.2-1 cases in 10,000 people (44) (45).

**Clinical Significance:** Enlarged parietal foramina may be associated with other anomalies such as cleft lip and palate (46). Usually asymptomatic, however, they can make injuries and contact sports prone to skull fracture. People with enlarged parietal foramina are recommended to wear hard helmets/hats while engaging in contact sports (47) such as rugby, American football etc.

![Enlarged parietal foramina](image)

*Figure 8: Enlarged parietal foramina*

### 1.3.8 Others

In addition to the above-mentioned unusual anomalies, the usual but necessarily frequent anomalies that can be found incidentally on LC are calcifications, cysts and tumors of odontogenic and non-odontogenic origin; impacted teeth, various calcifications and enlarged tonsils or adenoids. The prevalence of each is different however collectively, they are not rare.

### 1.4 Objectives and Hypothesis

The primary aim of this project was to evaluate the prevalence of incidental findings on the
digital lateral cephalograms from Feb 24, 2006, to Jan 23, 2020 of orthodontic treatment patients of UBC Faculty of Dentistry.

The secondary objectives of this project were as follows:

1. Analyze the type of incidental findings in relation to sex.
2. Check co-prevalence of different findings.
3. Compare the data with that of existing literature.
4. Compare the prevalence in sequential LCs taken at pre- and post- Treatment.

Null hypothesis was set as follows:

“There is no prevalence of incidental findings on the digital LCs of orthodontic patients of UBC Faculty of Dentistry.”
Chapter 2: Body of Thesis

2.1 Materials and Methods

2.1.1 Ethics approval

Ethics approval was obtained from UBC clinical research ethical board (CREB) on July 20, 2020, before beginning the study. The CREB number was H20-01235.

2.1.2 Methodology

This study was a consecutive case series. Study population was patients seeking orthodontic treatment at UBC Graduate Orthodontic Clinic.

The inclusion criteria for the sample were set as follows:

- age: 12-20 years
- Patient at UBC Graduate Orthodontic Program
- Lateral Cephalometric radiograph taken for orthodontic treatment planning
- Cephalometric radiograph of finished case (No age restrictions)

The exclusion criteria for the sample were set as follows:

- Age above 20 years and below 12 years at the start of the treatment
- Patients with analog LCs, scanned analog LCs, LCs with artifacts that interferes with diagnosis of any of the incidental findings

Only patients with age 12-20 years at the start of orthodontic treatment were included as the investigators feel that it was very important to catch these findings at an early age. Since these
patients may live with these anomalies for the rest of their lives, their management becomes particularly important. This in no way, minimizes the importance of incidental findings in people over 20 years.

After applying the inclusion and exclusion criteria, the initial sample had 1797 patients, 985 females (54.8) and 812 males (45.2). Some of these patients had only pre-treatment LC available. Others had both pre-treatment and posttreatment LC available. The reason for this discrepancy is that not all the patients screened for orthodontic treatment at Graduate Orthodontic Clinic, start orthodontic treatment for reasons such as, not accepting treatment plan, deferral until growth is finished etc. Thus, the initial database had 3004 LC including pre and post treatment LCs.

The machine that UBC uses to acquire LC is Planmeca ProMax 2D S3. It used Charged Coupled Device (CCD) to capture LCs. In CCD technology, the energy of the x-rays is converted into proportional number of electrons which are deposited in the electron wells. These electrons are then transferred to a read-out amplifier in a process called charge coupling which converts the analog signal into digital image. The major disadvantage of the CCD is the large size of sensor which makes it difficult to use for intraoral images. The entire surface area of the sensor is not photosensitive. In fact, some of the sensor area is occupied by electrical components thus increasing the size of the sensor.

Examination of LC was done with Planmeca Romexis (version 3.8.3.R. of 01/22/2016; registered trademark of Planmeca Company, USA) which the image acquisition and storage software that UBC Faculty of Dentistry uses. In addition, it is important to note that UBC strictly adheres to the Image Gently guidelines (48).

Examiner AP performed examination on LC in ascending order from old to new. Blinding was
not required due to it being a prevalence study. Examiner did thorough literature review before commencing the examination to make himself familiar with the appearance of anomalies on LC. LCs were reviewed in Zones as seen in Figure 9.
Figure 9: Zones of reading LC
<table>
<thead>
<tr>
<th>Zone 1: Cranial Base</th>
<th>Zone 2: Neck and Cervical Spine</th>
<th>Zone 3: Dento-facial Complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sella turcica: Size, shape, bridging</td>
<td>• Cervical vertebra: os odontoideum</td>
<td>• Calcifications: parotid duct, Antroliths, Phleboliths</td>
</tr>
<tr>
<td>• Parietal foramina</td>
<td>• Carotid artery calcification: vertically oriented near C4 and C5 usually</td>
<td>• Impacted teeth/ impacted supernumerary</td>
</tr>
<tr>
<td>• Occipital spur</td>
<td>• Stylohyoid ligament calcification</td>
<td>• Wide range of cysts and tumors</td>
</tr>
</tbody>
</table>

*Table 1: Anomalies distributed in each zone of LC*
The examiner had checklist of incidental findings distributed in each zone which served as a guide for examination as seen in Table 1.

While doing the examination of LCs, it was deemed necessary to measure the size of Sella Turcica to remove subjectivity from diagnosing large vs small vs normal Sella. Thus, the size of the Sella Turcica on each LC was measured in Romexis using the inbuilt measurement tool. The measurement method used was described by Taveras and Woods as seen in Fig 10 (18). Two dimensions were measured: largest horizontal measurement (Width) and largest vertical measurement (Height). All the LCs were kept in the same magnification and measurements were made in millimetres allowing up to 1 digit after the decimal point.

**Fig. 4. Taveras’ and Wood’s method for measuring sellar size shown on tracing of patient’s cephalogram. Anteroposterior dimension is 16 mm and depth 17 mm.**

*Figure 10: Method of measuring size of sella turcica; Reproduced from Friedland and Meazzini (1996)*
Subsample of 100 randomly selected radiographs was taken. Randomization was done using computer software. Size of sella turcica was measured again for the subsample after 4 weeks for intra-rater reliability. The same subsample was used for inter-rater reliability measurement between examiner AP and DM.

The same subsample was taken and their DPR and clinical notes were checked to determine true positive of impacted teeth. Later sensitivity and specificity of LC to diagnose impacted teeth were measured using these values.

Examiner AP also checked the clinical notes of all the patients who had positive incidental findings. The purpose was to check whether these incidental findings were noted in the patient’s notes or not.

2.1.3 Statistical Tests

Period prevalence was calculated based on the number of incidental findings found in the sample.

Chi square test was performed to examine the relationship of incidental findings with sex.

Chi square test was also used to determine the percentage of patients that had two anomalies co-prevalent.

Intra-rater reliability of size measurement of Sella Turcica was measured using Interclass Correlation Coefficient (ICC).
2.2 Results

2.2.1 Reasons for seeking orthodontic treatment

Each patient’s screening form was checked to get a general idea for them seek orthodontic treatment. Each patient's chief complaint or reason for seeking orthodontic treatment was grouped in the following categories as shown in Table 2:

<table>
<thead>
<tr>
<th>Crooked Teeth or Teeth Sticking Out</th>
<th>Referred from GDP or UBC Graduate Pediatric Dentistry Department</th>
<th>Others (“I don’t like my teeth”, “Cheek biting”, “Can’t bite on back teeth etc.”)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1011 Patients (58%)</td>
<td>662 Patients (38%)</td>
<td>69 Patients (4%)</td>
</tr>
</tbody>
</table>

*Table 2: Reasons for seeking Orthodontic treatment*

Total of 1742 screening forms were checked. Screening forms for 23 patients couldn’t be found.

2.2.2 Final sample size

Initial sample that was provided by UBC Faculty of Dentistry’s IT department consisted of 1797 patients and 3024 LC. Out of which 32 patients had no usable images upon examination in Romexis. They were either missing images or had images full of artifacts which made examination difficult or had scanned LC films. All of those 32 patients and their LC (total 103) were removed from data. Thus, the final sample consisted of 1765 patients: 800 males and 965 females. Table 3 shows overall age distribution of the sample. Table 4 and 5 show age distribution of males and females respectively.
<table>
<thead>
<tr>
<th>Age</th>
<th>Frequency</th>
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<tbody>
<tr>
<td>12</td>
<td>539</td>
</tr>
<tr>
<td>13</td>
<td>444</td>
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<tr>
<td>14</td>
<td>346</td>
</tr>
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<td>17</td>
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<td>18</td>
<td>48</td>
</tr>
<tr>
<td>19-20</td>
<td>52</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1765</strong></td>
</tr>
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</table>

*Table 3: Age distribution of the sample*
<table>
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<th>Age</th>
<th>Frequency</th>
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<tr>
<td>13</td>
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<td>166</td>
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<td>17</td>
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</tr>
<tr>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>19-20</td>
<td>24</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>800</strong></td>
</tr>
</tbody>
</table>

*Table 4: Age distribution of males*
<table>
<thead>
<tr>
<th>Age</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
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<td>16</td>
<td>50</td>
</tr>
<tr>
<td>17</td>
<td>29</td>
</tr>
<tr>
<td>18</td>
<td>31</td>
</tr>
<tr>
<td>19-20</td>
<td>28</td>
</tr>
<tr>
<td>Total</td>
<td><strong>965</strong></td>
</tr>
</tbody>
</table>

*Table 5: Age distribution of females*
The final number of LC in the sample was 2921, out of which 1765 were pre-treatment and 1156 were follow up LC. The number of pretreatment LCs was higher because not all the patients that are screened for orthodontic treatment start their treatment. Some of the reasons for not starting treatment may include- not agreeing with the presented treatment plan, relocation away from UBC, financial constraints etc.

2.2.3 Final sample size to calculate enlarged parietal foramen prevalence

Since many cephalometric radiographs that were taken from January 2008 had part of calvarium cut off to reduce radiation, those cephs were unusable for diagnosis of enlarged parietal foramen. So, the following number was used to calculate the prevalence of the same.

- Number of patients with cut off calvarium and no other usable images: 31
- LCs with cut off Calvarium: 225
- Subtracting those two from our original sample and data (1765 patients and 2921 lateral cephalometric radiographs) we have the following:
  - Total usable patients (sample size used to calculate enlarged Parietal Foramen) = 1734; 786 Males, 948 Females
  - 2696 usable LCs

The final sample size is shown in the flow chart of Figure 11.
Figure 11: Final sample size
2.2.4 Findings of sequential LC

The sequential radiographs were taken at post treatment for post treatment outcome evaluation and superimposition. The average time between pretreatment and follow up LC was estimated to be 2-2.5 years, the amount of time that needed to finish orthodontic treatment typically. No noticeable difference was detected in the incidental findings of sequential radiographs except the following patient: Chart #106146. This patient had progressive radio opacity (from isolated to fused) in the region of posterior arch of atlas as shown in Figure 11.

![Figure 12: Progressive calcification near posterior arch of atlas](image)

2.2.5 Prevalence of anomalies

Total 331 incidental findings were noted to be present in our entire sample. The overall prevalence of incidental findings thus was calculated 18.8%. Out of 331, 183 (10.4%) were present in males and 148 (8.4%) were present in females. The most prevalent finding was Ponticulus Posticus (n=181). Table 6 shows detailed distribution of each finding.
2.2.6 Results from clinical notes

Clinical notes of the patients who had presence of incidental findings were checked. The purpose was to determine if the clinician or orthodontic resident had observed and noted those findings or not. Total 331 patients had one or more incidental findings present on their LC as noted earlier. Their clinical notes were checked from the day of diagnosis appointment, also known as “meet and greet appointment”. For none of the patients, the incidental findings were mentioned in the clinical notes.
<table>
<thead>
<tr>
<th>Name of the IF</th>
<th>Number of Findings</th>
<th></th>
<th></th>
<th>Prevalence %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Findings In Males</td>
<td>Findings In Females</td>
<td>Total</td>
</tr>
<tr>
<td>Bridging</td>
<td>74</td>
<td>31</td>
<td>43</td>
<td>4.2</td>
</tr>
<tr>
<td>Vert Fusion</td>
<td>9</td>
<td>6</td>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>Os Odontoidium</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Ponticulus Posticus</td>
<td>181</td>
<td>98</td>
<td>83</td>
<td>10.3</td>
</tr>
<tr>
<td>Occipital Spur</td>
<td>63</td>
<td>46</td>
<td>17</td>
<td>3.6</td>
</tr>
<tr>
<td>Enlarged Parietal Foramina</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0.1</td>
</tr>
<tr>
<td>Antrolith</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Tonsilolith</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Carotid artery calcification</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Stylohyoid ligament Calcification</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td>Parotid gland calcification</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Cyst</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Tumour</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>331 (18.8)</td>
<td>183 (10.4)</td>
<td>148 (8.4)</td>
<td>18.8</td>
</tr>
</tbody>
</table>

*Table 6: Prevalence of anomalies*
There was good inter-rater reliability of findings incidental findings between two examiners- AP and DM for the tested subsample of 100 charts. Results of Krippendorff’s alpha are shown in Table 7.

<table>
<thead>
<tr>
<th>Variable 1 (cols 1 &amp; 2)</th>
<th>Percent Agreement</th>
<th>Scott's Pi</th>
<th>Cohen's Kappa</th>
<th>Krippendorff's Alpha (nominal)</th>
<th>N Agreements</th>
<th>N Disagreements</th>
<th>N Cases</th>
<th>N Decisions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>96%</td>
<td>-0.02</td>
<td>-0.02</td>
<td>-0.015</td>
<td>96</td>
<td>4</td>
<td>100</td>
<td>200</td>
</tr>
</tbody>
</table>

*Table 7: Inter-rater reliability*
2.2.7 Prevalence based on sex

The results of chi square test indicates that there was significant difference between males and females for the overall prevalence of incidental findings, with males being more likely to present with an incidental finding. The results are shown in Table 8.

As far as the individual anomaly is concerned, there is no significant difference between males and females for their presence except occipital spur. Occipital spur is more likely to be present in males than in females. The results are shown in Table 9.
Table 8: Sex predilection of incidental findings

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Marginal Row Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>183 (150.03) [7.25]</td>
<td>617 (649.97) [1.67]</td>
<td>800</td>
</tr>
<tr>
<td>Female</td>
<td>148 (180.97) [6.01]</td>
<td>817 (784.03) [1.39]</td>
<td>965</td>
</tr>
<tr>
<td>Marginal Column Totals</td>
<td>331</td>
<td>1434</td>
<td>1765 (Grand Total)</td>
</tr>
</tbody>
</table>

The chi-square statistic is 16.315. The p-value is 0.000054. Significant at $p < .05$.

Table 9: Sex predilection of Occipital Spur

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Marginal Row Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>46 (28.56) [10.66]</td>
<td>754 (771.44) [0.39]</td>
<td>800</td>
</tr>
<tr>
<td>Female</td>
<td>17 (34.44) [8.84]</td>
<td>948 (930.56) [0.33]</td>
<td>965</td>
</tr>
<tr>
<td>Marginal Column Totals</td>
<td>63</td>
<td>1702</td>
<td>1765 (Grand Total)</td>
</tr>
</tbody>
</table>

The chi-square statistic is 20.2137. The p-value is < 0.00001. Significant at $p < .05$. 
2.2.8 Co-prevalence of incidental findings

Chi square 2*2 table was also utilized to derive conclusion about multiple incidental findings existing together in a patient. In 0.6% of the population, ponticulus posticus and occipital spur were present together, making them the highest co-prevalent incidental findings. Table 10 shows full distribution of data.
## Relationship between presence of Anomalies

<table>
<thead>
<tr>
<th>Co-prevalant Anomalies</th>
<th>% of population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ponticulus Posticus and Occipital Spur</td>
<td>0.6</td>
</tr>
<tr>
<td>Sella Bridging and Ponticulus Posticus</td>
<td>0.4</td>
</tr>
<tr>
<td>Sella Bridging and Occipital Spur</td>
<td>0.1</td>
</tr>
<tr>
<td>Sella Bridging and Vert Fusion</td>
<td>0.06</td>
</tr>
<tr>
<td>Ponticulus Posticus and Enalrged Parietal Foramen</td>
<td>0.06</td>
</tr>
<tr>
<td>Vert Fusion and Occipital Spur</td>
<td>0.06</td>
</tr>
<tr>
<td>Ponticulus Posticus and SHL Calcification</td>
<td>0.06</td>
</tr>
</tbody>
</table>

*Table 10: Co-prevalence of incidental findings*
2.2.9 Size of sella turcica

The mean height of sella turcica was 5.3mm (+/-1.5mm) in our sample and the mean width was 7.5mm (+/- 1.8mm). The maximum height and width that found was 12mm and 15.8mm respectively. The minimum height and width that found was 1.1mm and 2.6mm. Table 11 shows this data with respective chart numbers of these patients. Table 12 and 13 demonstrates the same data broken down for males and females respectively.

The intra-rater reliability test of the sella turcica size measurements shows excellent reliability at 95% CI. The results are shown in table 14 and 15.
Sella Size (n=1765)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Value (mm)</th>
<th>Chart#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Height</td>
<td>5.3 (S.D. 1.5)</td>
<td></td>
</tr>
<tr>
<td>Mean Width</td>
<td>7.5 (S.D. 1.8)</td>
<td></td>
</tr>
<tr>
<td>Max Height</td>
<td>12.0</td>
<td>112792</td>
</tr>
<tr>
<td>Max Width</td>
<td>15.8</td>
<td>99981</td>
</tr>
<tr>
<td>Min Height</td>
<td>1.1</td>
<td>105858</td>
</tr>
<tr>
<td>Min Width</td>
<td>2.6</td>
<td>98847</td>
</tr>
</tbody>
</table>

*Table 11: sella turcica sizes of the sample*
Sella Size: Males (n=800)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Value (mm)</th>
<th>Chart#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Height</td>
<td>5.2 (S.D. 1.4)</td>
<td></td>
</tr>
<tr>
<td>Mean Width</td>
<td>7.4 (S.D. 1.8)</td>
<td></td>
</tr>
<tr>
<td>Max Height</td>
<td>9.6</td>
<td>106656</td>
</tr>
<tr>
<td>Max Width</td>
<td>12.6</td>
<td>113025</td>
</tr>
<tr>
<td>Min Height</td>
<td>1.6</td>
<td>78683, 79834</td>
</tr>
<tr>
<td>Min Width</td>
<td>3.0</td>
<td>80074, 81864</td>
</tr>
</tbody>
</table>

*Table 12: sella turcica sizes of males*
Sella Size: Females (n=965)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Value (mm)</th>
<th>Chart#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Height</td>
<td>5.4 (S.D. 1.5)</td>
<td></td>
</tr>
<tr>
<td>Mean Width</td>
<td>7.5 (S.D. 1.9)</td>
<td></td>
</tr>
<tr>
<td>Max Height</td>
<td>12.0</td>
<td>112792</td>
</tr>
<tr>
<td>Max Width</td>
<td>15.8</td>
<td>99981</td>
</tr>
<tr>
<td>Min Height</td>
<td>1.1</td>
<td>105858</td>
</tr>
<tr>
<td>Min Width</td>
<td>2.6</td>
<td>98847</td>
</tr>
</tbody>
</table>

_Table 13: sella turcica sizes of females_
Reliability: Sella Height Measurement

- ICC reliability at 95% CI
- Summary: Excellent Intrarater Reliability

<table>
<thead>
<tr>
<th></th>
<th>Intraclass Correlation</th>
<th>95% Confidence Interval</th>
<th>F Test with True Value 0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
</tr>
<tr>
<td>Single Measures</td>
<td>.995^a</td>
<td>.992</td>
<td>.996</td>
</tr>
<tr>
<td>Average Measures</td>
<td>.997^c</td>
<td>.996</td>
<td>.998</td>
</tr>
</tbody>
</table>

*Table 14: Reliability statistics of sella turcica size measurements*
Reliability: Sella Width Measurement

- ICC reliability at 95% CI
- Summary: Excellent Intra-rater Reliability

Table 15: Reliability statistics of sella turcica size measurements
2.2.10 Impacted teeth and lateral cephalogram

It was suspected that LC may not be a useful tool to diagnose impacted teeth. Thus, the specificity and sensitivity of LC to diagnose impacted teeth was calculated using the formula shown in table 16.

Based on these findings, LC was found to be very sensitive (98.11%) in detecting impacted teeth. However, as suspected, LC was not very specific in diagnosing impacted teeth (55.81%).

### Sensitivity and Specificity of Ceph in detecting Impacted teeth

<table>
<thead>
<tr>
<th>Lateral Ceph Inspection (Test)</th>
<th>DPR and Clinical Notes (DIAGNOSIS/Reference Standard)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present +</td>
</tr>
<tr>
<td>Positive +</td>
<td>True Positive (a): 52</td>
</tr>
<tr>
<td>Negative -</td>
<td>False Negative (c): 1</td>
</tr>
<tr>
<td></td>
<td>Absent -</td>
</tr>
<tr>
<td></td>
<td>False Positive (b): 38</td>
</tr>
<tr>
<td></td>
<td>True Negative (d): 48</td>
</tr>
</tbody>
</table>

\[
\text{SENSITIVITY} = \frac{a}{a + c} = 0.98 \\
\text{SPECIFICITY} = \frac{d}{b + d} = 0.55
\]

Table Source: Dr JA lecture notes

*Table 16: Sensitivity and specificity calculations*
2.3 Discussion

There is very limited existing literature that covers the prevalence of incidental findings on LC. Only 3 studies were found that covers this topic, as mentioned in the literature review section. These studies differ from the methodology that was used in this project. They had different ways of classifying incidental findings. For example, some of them included normal anatomic variants with no clinical significance into the calculation. Study by Bisk et al. was based on LC films (analog) as opposed to digital LCs in this project. Because of these reasons, the prevalence of incidental findings recorded in those studies was different from what the current project reported. The advantages of the methodology used in this project are described in section 2.3.1.

The following table shows the comparison of prevalence of incidental findings of LC between this study and the studies of Bisk et al., Tetradis et al. and Hernandez et al. It is important to note that majority of incidental findings of this project could not be compared to the other studies because 2 out of 3 studies had mixed LC, DPR and PAs as their data and the prevalence on LC alone was not mentioned in their text.
**Table 17: Comparing the prevalence of IF on LC**

Sella turcica has four parts: anterior and posterior parts are called tuberculum sellae and dorsum sellae respectively. Inferior part is sella turcica itself and super portion is diaphragm sellae.

Variation in sella turcica anatomical size could result from enlarged fenestration in the diaphragm sella which can result in the appearance of shrunken or disappeared pituitary gland (49). In the literature, the size of sella turcica on LC can be varied depending on the study one refers to. Tetradis et al. measured the sized of sella turcica on LC and they found that the length ranged from 6-17mm (mean 10.9+-1.8mm) and depth ranged from 2.5-12.5mm (mean 7.6+-1.7mm) (5). Their values are slightly higher than what we found (Mean length 7.8 +/-1.8mm and
mean depth 5.3+/1.5mm). Our values were also lower than what Keats et al. found, which is mean length of 10.6mm and mean depth of 8.1mm (50). The possible variation could be attributed to the sample characteristics such as ethnicity of population, mean age etc. and measurement software’s variation. For example, both Tetradis et al. and Keats et al. had multi-racial sample like this study. However, the methodology used was different. This study had sella turcica measurements done on digital LC while Tetradis et al. used analog films. Keats et al. used skull microsurgical dissection to measure sella size(50). Friedland et al. combined the measurements of multiple studies and concluded that the depth ranges from 4-12mm and the length ranges from 5-16mm (51) however the mean was not specified. Sella bridging was prevalent in 4.2% of the cases in the present sample, with no sex predilection. This falls in the range of prevalence reported in existing literature which is 1.1-13%.

In embryologic development, the posterior pituitary originates from neuroectoderm, and anterior pituitary arises from oral ectoderm. Pituitary fossa originates from hypophyseal cartilage which is derived from cranial neural crest cells. Teeth develop due to interaction between oral epithelium and underlying neural crest cells which have migrated in this region. Several common molecular pathways have been shown to be associated with early development of teeth, pituitary gland and sella turcica (52). Thus, it can be postulated that disorder of one may also present with the disorder of the other. Such an association can hint the orthodontists to early diagnosis of dental problems if a sella turcica abnormality is found on LC. One such association was established by Leonardi at al. where sella turcica bridging was found to be more common when tooth transposition was present (15).

Table 17 displays several anomalies that may be present on DPRs. This table has been reproduced from the textbook of Oral and Maxillofacial Radiology: A Diagnostic Approach (53).
Although clinical examination is the best way to evaluate these anomalies, DPR usually assists in final diagnosis. For example, clinical examination may reveal discrepancies in the number of teeth present in oral cavity however, DPR can confirm where teeth are missing or simply unerupted. In another instance, DPR can hint at abnormal size of teeth however, macrodontia or microdontia can be best evaluated by clinical examination and dental casts due to variations in magnification of DPR from the real. Detection of anomalies on LC can have similar utility. When the size variation of sella turcica is associated with pituitary gland activity; signs and symptoms of hypo or hyperpituitarism can be noted clinically. Hypopituitarism is usually associated with delayed tooth eruption. On the other hand, patients with hyperpituitarism or gigantism usually present with macrodontia.
Table 18: Developmental Lesions of Dental Lamina Origin (Reproduced from Oral and Maxillofacial Radiology: A Diagnostic Approach, 2nd Edition (7))
Cervical vertebral anomalies can be developmental or the results of disturbances later in life. Anomalies such as cervical vertebral fusion, agenesis of odontoid process of C2, and some cases of os odontoideum are thought to be derived from developmental disturbances. Thus, these anomalies are also associated with other syndromes which encompasses anomalies of other anatomical structures that are derived from the same embryonic tissue. For example, association of os odontoideum is associated with Morquio syndrome, achondroplasia, and Down syndrome (54). Similarly vertebral fusion is also associated various syndromes as discussed in the introduction. Os odontoideum can also happen when a previous trauma to the neck resulting in non-union fracture of the odontoid process. In a study by Fielding et al., 17 out of 35 cases had reported previous trauma which happened about 3.5 years before the diagnosis of os odontoideum (55). In the present sample, vertebral fusion was prevalent at 0.5%. No cases of os odontoideum were found in the present sample. True prevalence of these anomalies is difficult establish since these are incidental findings only for people who are asymptomatic.

Ponticulus posticus has been widely studied in the literature. It is also the most common incidental finding in the current sample as well as in the existing literature. The prevalence in the present sample was 10.3% with no gender predilection. Adisen et al. had the largest sample of LC in the literature so far. On a 1246 LC examined, they found ponticulus posticus to be prevalent at 18.8% with males more likely to have it. However, it is important to note that their sample comprised of Turkish population only (56). The existing literature presents with contradictory findings as far as gender predilection of ponticulus posticus is concerned. Putrino et al. and Sharma et al. reported male predominance for this anomaly while Gupta et al. found female predominance (57) (58) (59). Giri et al. reported no statistically significant gender predilection for ponticulus posticus (60). It is important to note that there are wide variations
even in the studies that investigated the same population. The study population of Gupta et al., Giri et al. and Sharma et al. was Indian, however their reported gender predominance was different.

In the current sample, occipital spur was prevalent at 3.6% with males more likely to present with one. The existing literature has higher prevalence ranging from 10-41% with male predilection. The differences may be due to differences in sample population. Shahar et al. also reported that not only that the males are likely to present with occipital spur but also the average size of occipital spur was larger in males than in females (38). This is helpful in forensic examination for gender identification. Occipital spur can be divided into 3 types as shown in Table 17 (61). Type I was more common in women and Type III was more common in men (61).

Enlarged parietal foramina was found in 0.1% of the sample which is similar to existing literature with equal gender predilection (41) (42). On LC, this presents as well-defined radiolucency of varying size. It is usually bilateral but it’s occasional unilateral presence may add confusion in clinical diagnosis. Enlargement is also usually wider mesio-laterally than antero-posteriorly. Although asymptomatic, some published reports have suggested their co-prevalence with craniofacial dysostosis, mental retardation and chromosomal deletion (25) (62).

Table 19: Types of occipital spur

- Type I: Smooth or flat type
- Type II: Crest type
- Type III: Spine type
Patients are also more prone to skull fractures thus it is advised to wear hard helmets while engaging in contact sports such as rugby (41).

Unlike the study by Bisk et al., this project could not find any LCs with enlarged tonsils. Bisk et al. had 0.99% of their sample with large adenoids. Their sample had the age range of 7-27 years. They did not show the relationship of this findings with age. It can be assumed that larger age range in their sample could have attributed to this additional finding. Tonsils, as with other lymphoid tissue, are large in pre and early adolescent children. Thus, regardless of the findings of the current project, practitioners should look out for enlarged tonsils in LCs.

As far as incidental findings and sex is concerned, this study found that males were more likely to present with incidental findings on LC. In the existing literature, only Hernandez et al. has investigated the sex differences of incidental findings. Contrary to this study, they found no significant difference between males and females. Knowing the sexual predilection can be useful information for forensic studies and for knowing the inheritance patterns for certain familiar disorders. For example, Taurodontism is more prevalent in females due to X chromosomal aneuploidy. This is also associated with several other X-linked syndromes, such as Klinefelter Syndrome (63) (64).

Existing literature has not shown the relationship between age and incidental findings. The age range of the present sample was comparatively smaller, 12-20 years. Some of the incidental findings are very rare. Thus, statistical relationship between age and incidental findings would be very difficult to establish. However, the cause of origin, as discussed in the literature review section, may give some clue about the relationship of age and incidental findings. Anomalies which are present due to embryological disturbance and genetics can typically be present even in
younger people. However, it will be difficult to establish when they become visible on radiographs unless the population in different age groups is exposed to unnecessary radiation to seek this information. Examples of such anomalies can be vertebral fusion, enlarged parietal foramen. Anomalies which have environmental causes such as trauma, may be present at age. Such Os odontoideum, as discussed earlier was associated with trauma within 3 years before its discovery.

Calcifications, cysts and tumors are typically found in more adult population. This also means that if the sample age of this study was increased to include people above 20 years of age, it would probably show prevalence of more anomalies. However, just like impacted teeth, cysts and tumors are best viewed on DPRs. Thus the prevalence studies of DPR can provide useful and rather more accurate information on the prevalence of cysts, tumors and calcifications that may be missing from this project due to the age range of 12-20 years of this sample.

Existing prevalence studies has no information on co-prevalence of incidental findings presenting together. In the current project, this relationship was examined. Dental anomalies are usually found co-occurring (65) which triggers the clinician to look for more anomalies when one anomaly is present. For example, ectopic permanent canines usually present with small or missing permanent maxillary lateral incisors, missing permanent mandibular 2nd premolars. It was the aim of this project to examine if similar could be concluded or not for incidental findings. It was found that anomalies that most commonly occur together were ponticulus posticus and occipital spur. However, the results were not statistically significant. Dental anomalies happen together because of associated genetic component of such anomalies and because of the common origin of the teeth and surrounding structure. In case of incidental findings of the LC, it can be assumed, based on the current findings, that co-prevalence of them
is unlikely unless it is associated with syndromes. This could be attributed to the diverse cause of incidental findings and more widespread distribution of associated structures which may not have a common origin.

Presence of incidental findings on LC doesn’t always mean presence of clinical signs and symptoms. However, having knowledge of these incidental findings directs the clinician to ask right kind of questions to the patient for investigation and refer onward for further evaluation when needed. Some authors have also cautioned against relying on LC alone for checking incidental findings especially in cases of cervical vertebra. Patcas et al. concluded that one LC alone has high incidence of false positive findings when it showed the cervical vertebral fusion. Thus, multiple LC or CBCT is more suitable when in doubt (66). They concluded that based on their study of comparing LC, multidetector CT and CBCT images of 4 cadaver heads. Yochum et al. also concluded that some normal anatomic variants of C2-C3 joint can appear as fused on LC, which the author called “pseudo fusion” (67). This may not be very compelling evidence, thus the clinical significance of incidental findings on LC should not be undermined.

On the other hand, many of the incidental findings discussed in the project, such as vertebral fusion and bridging of sella turcica, are frequently associated with various syndromes. In those cases, the direct clinical implications from incidental findings may not be much of the value however the associated syndromic symptoms may need further management. Thus, a thorough knowledge of co-existing conditions is of paramount importance.

Existing studies in the literature have examined only the initial LCs. In this project, initial and subsequent LCs were examined whenever available. 65.49% of patients of this sample had subsequent LCs taken. Subsequent LCs are usually taken for post treatment evaluation.
Subsequent LC for the remaining patients was not available because they may not have started their treatment. Not all the patients who are screened in graduate orthodontics department, start their treatment for reasons such as rejecting the provided treatment choices, cost associated with treatment especially for orthognathic surgery patients, and treatment start only after completion of growth. The aim was to examine any difference and potentially follow the development of incidental findings on LC. Only one such case was found where subsequent LC differed from initial LC. This patient had progressive calcification at the posterior arch of atlas, what we believe would be leading to future ponticulus posticus. Based on these results, it is safe to assume that subsequent radiographs are unlikely to produce different outcome especially when taken after a short interval of approximately 2 years which was the case here.

Not one of the previous studies, had gone back to check the clinical notes of the orthodontists to see whether the findings were reported by the orthodontist or not. In this project, the clinical notes were reviewed. An alternative of this method would be do a survey of orthodontists sampling their awareness of incidental findings on LC. However, a survey like this can introduce bias in the method: when we ask orthodontists to find out anomalies on LC, they may record anomalies more actively than normal. Results from the clinical notes show that these incidental findings were not recording to the clinical notes. It is expected from any clinician that they would do follow up exam on incidental findings and refer for further tests and evaluation when needed. The result of this study shows that further training about the incidental findings of LC should be incorporated in the graduate programs. In the present project, the focus was on clinically significant incidental findings only. However, it has been pointed out that it is equally important to possess knowledge of insignificant normal variants. This avoids unnecessary follow-up and associated cost, harm from additional radiation (5) (8).
In one study done by MacDonald-Jankowski D.S., it was noted that significant amount of untreated dental disease was still present in dental panoramic tomograms of 1000 casual patients, even though the overall dental health of the population had undoubtedly improved in the interim (68). This study was performed nearly 20 years after the first such study at the same institution. It is interesting that there still seems to be a lot of unrecorded potentially clinically significant pathologies on radiographs, regardless of the type. It is possible that these findings could have been noticed and dismissed as not relevant to the patients’ treatment at that time. It can also be argued that as our knowledge about radiological findings of anomalies improves, we tend to be more receptive of noticing incidental findings in retrospective studies that may have been noted but not recorded, especially in case of incidental findings of LC. Since the orthodontic practices of today see more patients of all age groups than before, more people are and will be radiographed for orthodontic treatment. Thus, care should be taken to not increase the burden of undetected incidental findings. Incorporating and regularly updating the knowledge of incidental findings in dental school and grad school curriculum may reduce the burden. Incidental findings that have not been recorded have medicolegal implications and potentially expose the dentists or orthodontists to lawsuits for negligence.

Although it should not come as a surprise, we also concluded that LCs are not very specific in detecting impacted teeth. Thus, DPRs are taken for that purpose and LCs are not. The reason for that is the presence of superimposing structures on the LC’s 2-dimensional representation of the patient’s 3-dimensional head may make the diagnosis difficult. Also, the current sample had most patients in late mixed to early permanent dentition thus, the erupting teeth sometimes give false appearance of impacted teeth. Lastly, mesio-angular path of eruption of permanent 2nd mandibular molars can also falsely appear as impacted tooth. Thus, for detection of this and
other hidden pathologies in the jaws, DPR is a more useful tool then LC. Nevertheless, the LC’s display of the whole head and upper neck compels the examiners to not only review it but also record the findings.

2.3.1 Strengths

This project has many strengths when compared to previous studies. In previous studies, the authors examined LC of patients seeking orthodontic treatment retrospectively but there was not report of them going back to the clinical notes of those patients to determine whether these incidental findings were reported by the diagnosing orthodontist during the exam. In this project, examiner (AP) went back to the clinical notes of each patient who had positive incidental findings to check if those were recorded or not in the clinical notes. It was found that these findings had not been entered to the notes which emphasizes that it is critical that orthodontic trainees are aware of these findings and their importance.

Second strength of this project was the heterogeneity of the sample. UBC being in Vancouver should have one of the most ethnically diverse patient population since Vancouver is one the most ethnically diverse cities in the world (69). Thus, the sample is representative of a multiethnic urban Canadian community.

In addition, this study had the largest sample of consecutive patients for whom a LC had been taken, of all the existing literature.

Some of the existing studies had included normal variants in the prevalence of incidental findings which significantly increased the prevalence of incidental findings however not all those findings were clinically significant. In this project, the distinction between normal variant and clinically significant incidental finding was clearly made based on existing literature, thereby
excluding the normal variants from prevalence data.

Moreover, this project examined incidental findings on digital LC which is more relevant to today’s orthodontic practices who have either widely adopted digital radiography or are in the transition. The advantages of digital radiography have been discussed in earlier sections.

2.3.2 Limitations

Although the current project had many strengths, it inevitably had some weaknesses. The sample that we used was retrospective. The project mostly focused on prevalence calculation of incidental findings, thus it had minimal impact from the sample being retrospective.

In the present study, the size of sella turcica was measured in “x” and “y” axis. However, sella turcica being a 3D structure, the measurements in this study will not be accurately reflecting the actual size of the structure due to missing “z” axis measurement. Thus, it is possible to overestimate the clinical significance of certain anomalies visible on LC. Moreover, a large sella turcica does not necessarily mean hyperfunction of pituitary gland. It should trigger the examiner to seek supplemental information via existing sign and symptoms, clinical examination etc. before reaching final diagnosis.

LC has a lot of superimposing structures. Inevitably, there is a chance that some of the anomalies may not have been recorded in the present study due to multiple superimposing structures on LC. Thus, under-recording of incidental findings is certainly possible in the present study.

2.3.3 Future directions

This study has made some good revelations. Just like the existing literatures, this study confirms that the presence of clinically significant incidental findings is not very uncommon on LC. In
addition, without proper training, the clinicians can fail to record these findings on LC. As the French philosopher Henri Bergson and Canadian novelist Robertson Davies have quoted “The eye sees only what the mind is prepared to comprehend” (70). It is thus recommended that; a useful checklist of the anomalies/ incidental findings can be prepared from the data presented in this study. Such a checklist if taught in dental school, can be useful for systematic examination of LC, not just in orthodontics but anywhere else as well where LC are taken for diagnosis. Artificial intelligence and machine learning will be the new direction to aid in detecting any abnormalities/ pathologies on LCs, which may reduce the cost, time, the need for human knowledge, and the number of human errors and increase the quality of life among orthodontic patients. The data from this study can also be used in future to see if there is any relationship exists between incidental findings and the class of malocclusion. The final skeletal diagnosis of the patients who had incidental findings (n=331) in this study can be found in the clinical notes. This data can be used to determine that relationship. Alkofide et al., seeking a similar answer, concluded that large sella turcica size is usually associated with class III malocclusion and small sella turcica is usually associated with class II malocclusion (11).
Chapter 3: Conclusion

Our results suggest the following:

- Incidental findings are prevalent on LC radiographs taken for orthodontic diagnosis and treatment planning. Thus, careful examination of LC beyond area of orthodontic interest is very important.
- Males are more likely to present with incidental findings than females.
- Occipital spur was the only finding that was more likely to be present in males than in females. All other incidental findings had no significant difference between males and females.
- Ponticulus posticus and occipital spur were highest co-occurring incidental findings in the sample.
- Follow up LC had no significant additional prevalence of incidental findings than pretreatment LC.
References


