Assessment of the ponticulus posticus based on the skeletal relationship in strict lateral radiographs

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ABSTRACT

Objective: To evaluate the ponticulus posticus according to the skeletal relationship found in strict lateral radiographs at the Centro Dental Docente of the Universidad Peruana Cayetano Heredia during the period 2015–2017, using the classification according to the degree of mineralization described by Selby and Steiner’s skeletal relationship classification. Material and methods: It was performed on digital strict lateral radiographs using a 20-inch screen using the SIDEXIS XG program, observing the degree of mineralization of the ponticulus posticus: without evidence of the bony spicule over the vertebral artery = absent bridge, when spicule formation and/or calcification was noted or evident in the middle of the bridge or incompletely = partial bridge, when the bony arch was evident finished visualizing = complete bridge and the classification of the skeletal relationship by measuring the ANB angle: Class I = 0 –4°; Class II = >4° and Class III = <0°; the statistical analysis was done with the SPSS V program.22.0 for Windows using the Chi-square tests. Results: Of the 925 digital strict lateral radiographs evaluated, 283 radiographs were found to present ponticulus posticus and the highest frequency was found in the absent type (69.4%), the partial type (17.1%) and the complete type (13.5%). The ponticulus posticus was present in 25.1% of the female and 38.4% of the male. The skeletal relationship associated with ponticulus posticus was present in Class II (19.1%), Class I (10.4%) and Class III (1.1%). Conclusions: The ponticulus posticus is an anatomical variant present in 30.6% of cases. No statistically significant difference was found between the presence of ponticulus posticus and skeletal relationship or sex.

Keywords: Radiography; Ponticulus Posticus; Atlas

1. Introduction

Strict lateral radiographs are used in orthodontics to evaluate development, growth and morphometric relationships of craniofacial and dental structures, and also provide diagnostic information about the upper spine region[1].

Cervical vertebrae exhibit great variability because they are smaller and more delicate than true vertebrae. The first cervical vertebra (C1) is structurally different from all other cervical vertebrae because it has no body and dorsal vertebrae, and according to many authors it is the most variable in humans, with an oblique ligament that is partially calcified or fully calcified, which is an abnormal ossification, arcuate in shape, extending from the lateral mass to the posteromedial border of the vertebral artery (VA) groove, seen in simple radiographs of the skull, however, in lateral projections, usually the mastoid portion of the temporal bone is difficult to make a good observation[2].

The ponticulus posticus (PP) has not received adequate attention in the radiographic anatomy of the cervical spine region and its possible relationship with some pathologies. The potential clinical significance
of PP formation is to date controversial; however, pathologies such as migraine without aura, chronic headaches, vertigo, diplopia and neck pain are attributed to it. Some authors associate it to AV compression, vertebra-basilar insufficiency or AV dissection[3].

For this reason, the purpose of this research was to evaluate the ponticulus posticus (PP) according to the skeletal relationship found in strict lateral digital radiographs (SLDR) at the Centro Dental Docente, Universidad Peruana Cayetano Heredia, during the period 2015–2017.

2. Material and methods

The design of the present study was retrospective, cross-sectional and descriptive. The population was 971 SLDR of the Oral and Maxillofacial Radiology Service, San Isidro branch, Universidad Peruana Cayetano Heredia during the years 2015–2017.

The sample was chosen from the population by convenience (non-probabilistic), and were those that met the selection criteria, leaving 925 SLDR, the procedure was: clear radiographs of patients aged between 8 to 80 years, of both sexes were included. The SLDRs of patients with morphological alterations in the cervical spine, the SLDRs of patients with evident pathologies in the area to be evaluated, the SLDRs of patients with overlapping of the mastoid apophysis over the posterior arch of the atlas (C1) were excluded.

The PP variable whose conceptual and operational definition is: Bone morphological configuration, described as an anatomical variant that connects the retroglenoid tubercle located in the posterior part of the superior articular fossa of the atlas with its posterior arch, which originates from the complete or incomplete ossification of the posterior atlanto-occipital membrane over the groove of the VA resulting in the formation of a gap or foramen containing the VA and the posterior branch of the C1 spinal nerve. The measurement of this variable was determined by evaluating the SLDRs, considering its nominal measurement scale with the following values: no present: when no mineralization is observed in the atlanto-occipital ligament; total: when it forms a complete bony ring of the atlanto-occipital ligament and total mineralization extending from the lateral mass to the posteromedial margin of the vertebral artery groove and partial: when there is linear or amorphous mineralization of the atlanto-occipital ligament and partial mineralization extending from the lateral mass without reaching the posteromedial margin of the vertebral artery groove (Figure 1).

The Skeletal Relation variable whose conceptual and operational definition is the maxillary relationship with the anteroposterior skull base. The measurement of this variable was determined through the evaluation of the SLDR and the measurement of the ANB angle. Its measurement scale was nominal through the following values: Class I: when it presents a normal relationship between the maxilla and the mandible and is limited only to dental malposition. Generally associated with straight or slightly convex profile. Class II: characterized by maxillary skeletal excess or also called maxillary prognathism, upper dentoalveolar excess, mandibular skeletal deficiency or also called mandibular retrognathism and/or lower dentoalveolar deficiency. Associated with convex facial profile. Class III: we found in the same way the same disproportions mentioned in class II, but with the direction of deviation inverted; finding a maxillary retrognathism and/or mandibular prognathism, characterized by a concavity in the facial profile. In addition, the variables age and sex were considered, evaluated through their frequencies.

The observer was previously calibrated with a specialist in oral and maxillofacial radiology (Gold Standard) in the identification of PP types and measurement of the ANB angle in SLDR. To determine that the observer was calibrated, a series of observations were made and compared with the calibrator’s criteria until a Kappa index and interclass correlation coefficient (ICC) greater than 0.80 were present. Permission was requested from the Academic Department of Medicine and Bucco-maxillofacial Surgery.

To select the SLDRs, a formal request was made to the Oral and Maxillofacial Radiology Service of the Dental Teaching Clinic of the Univer-
sidad Peruana Cayetano Heredia to obtain the necessary permissions to access the database of radiographs, during the period 2015–2017. The examiner then proceeded to look at the radiographs and determined which ones met the inclusion criteria for the study, discriminating those that would not be used in the research. For the observation of the SLDRs, a 20-inch Lenovo® brand screen was used in a quiet and semi-dark environment. In addition, the SIDEXIS XG program was used to analyze the SLDRs for the correct diagnosis, using tools such as zoom, brightness and contrast.

Having selected the SLDRs, the SIDEXIS XG program was used and the images were maximized by evaluating the C1 and if they had total or partial mineralization of the PP they were considered for the study group. After that, the “measure angles” tool was accessed through the analysis menu bar. The first cephalometric point of the ANB angle was selected, i.e., point N and the next two cephalometric points A and B determining the type of skeletal relationship in Roman numerals, all data obtained were recorded in an Excel spreadsheet.

The SPSS V.22.0 statistical program for Windows was used. The statistical results had a significance level of \( P \leq 0.05 \). The descriptive statistics of age and types of PP were determined through their frequency distribution and percentages. Analytical statistics were used for the comparison of the variable ponticulus posticus in terms of presence according to sex, age, age group, type-sex and skeletal relationship using the Chi-square test.

The present study used information recorded in the digital databases of the Oral and Maxillofacial Radiology Service of the Salaverry branch of the Teaching Dental Clinic of the Universidad Peruana Cayetano Heredia, in the period 2015–2017, for which the approval of the Institutional Ethics Committee of the Universidad Peruana Cayetano Heredia was obtained. Since this was a database, the owners of the SLDRs were kept anonymous.

### 3. Results

A total of 925 SLDRs from the Oral and Maxillofacial Radiology Service were reviewed, of which 30.6% (283 cases) presented PP and 69.4% (642 cases) did not present PP, the distribution of the frequency of PP according to sex is presented in Table 1.

The frequency distribution of PP type according to sex and classification of Selby et al. is detailed in Table 2 and its frequency distribution according to age in Table 3 (Figure 1).

#### Table 1. Frequency distribution of ponticulus posticus

| Ponticulus posticus | Male | Frequency | Female | Frequency |
|--------------------|------|-----------|--------|-----------|
| Absent             | 226  | 61.6%     | 416    | 74.6%     |
| Present            | 141  | 38.4%     | 142    | 25.4%     |
| Total              | 367  | 100.0%    | 558    | 100.0%    |

#### Table 2. Frequency distribution of ponticulus posticus type according to sex

| Type of Ponticulus posticus* | Male | Frequency | Female | Frequency |
|------------------------------|------|-----------|--------|-----------|
| Absent                       | 226  | 24.4%     | 416    | 45.0%     |
| Complete                     | 75   | 8.1%      | 50     | 5.4%      |
| Partial                      | 66   | 7.1%      | 92     | 9.9%      |
| Total                        | 367  | 39.7%     | 558    | 60.3%     |

* Selby classification

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![Figure 1. Type of ponticulus posticus.](image-url)
Table 3. Frequency distribution of ponticulus posticus type according to age

| Age group       | Ponticulus posticus  |
|-----------------|----------------------|
|                 | Absent               | Complete          | Partial           |
|                 | n                    | Frequency          | n                  | Frequency          | n                  | Frequency          |
| 0 to 9 years old| 16                   | 1.7%               | 5                  | 0.5%               | 8                  | 0.9%               |
| 10 to 19 years old| 326                 | 35.2%              | 65                 | 7.0%               | 84                 | 9.1%               |
| 20 to 29 years old| 179                 | 19.4%              | 35                 | 3.8%               | 34                 | 3.7%               |
| 30 to 39 years old| 71                  | 7.7%               | 15                 | 1.6%               | 20                 | 2.2%               |
| 40 to 49 years old| 34                  | 3.7%               | 4                  | 0.4%               | 7                  | 0.8%               |
| 50 to 59 years old| 13                  | 1.4%               | 0                  | 0.0%               | 1                  | 0.1%               |
| 60 to 69 years old| 3                   | 0.3%               | 1                  | 0.1%               | 4                  | 0.4%               |
| Total           | 642                  | 69.4%              | 125                | 13.5%              | 158                | 17.1%              |

Table 4. Frequency distribution of ponticulus posticus according to skeletal relation

| Ponticulus Posticus | Skeletonized wording | Class I | % of total | n | Class II | % of total | n | Class III | % of total | n |
|---------------------|----------------------|---------|------------|---|---------|------------|---|-----------|------------|---|
| Absent              |                      |         |            |   |         |            |   |           |            |   |
| Present             |                      |         |            |   |         |            |   |           |            |   |
| Total               |                      |         |            |   |         |            |   |           |            |   |

With regard to the frequencies of PP and skeletal relationship, the highest frequency was in class II with 43.5% (402 cases), followed by class I with 22.9% (212 cases) and class III with 3.0% (28 cases), and with regard to present PP and skeletal relationship, the highest frequency was in class II with 19.1% (177 cases), followed by class I with 10.4% (96 cases) and class III with 1.1% (10 cases). There was no significant difference between the skeletal relationship groups (Table 4).

4. Discussion

This study is one of the few worldwide and the first in the country to assess its association with the skeletal relationship in addition to the presence of PP in an attempt to find a possible relationship with malocclusion.

The frequency of PP has been reported by different researchers in countries around the world using various imaging techniques, with a general variation from 7% to 68.4% in Taiwan and India. However, frequency ranges of PP between 11.1% and 19% are presented in several research papers[3,5,6,8–15]. In the present study in the SLDRs a PP frequency of 30.6% was found, this result was higher than the values found in studies carried out in Chile, Turkey and the United Kingdom, however, in India it was present in 68.4% of the cases[6,13,15]. These results could be explained by ethnic or genetic variations, and also by the non-uniformity of the size of the samples studied.

Regarding sex, worldwide studies show different values of frequency of PP, authors such as Chen et al, Chitroda et al. and Selby et al. who indicate that PP occurred more frequently in women[4,6,13], but in the research of Ercan, Pérez, Bayrakdar and Schiling, it was found that there was a greater predominance of PP in men, which coincides with the present research with percentages of 38.4% and 25.1% of PP for both men and women[3,5,7,10] (Table 6), no author consulted in the literature refers to the cause of this finding.

Pérez et al. found for the ethereal ranges of 5–18 years 13% and 19 years 24.8% of PP present[7]. In this study there were no studies of the skeletal relationship in this age range, however similar results were found in the different types of PP, as well as in the presence or absence of PP, it should be noted that the sample of the study of Pérez et al. was 1,056[7], and the present study was of 925 SLDR.
DSLX: Digital strict lateral X-ray  
CTA: Computed tomography angiography  
LX: Lateral X-ray  
CBCT: Cone-beam computed tomography  
PP: Ponticulus posticus

For Chen et al., their results in age groups between 20 and 60 where the 50 to 59 age groups prevailed with 37.1% and 40 to 49 with 25.7% presence of PP[6].

Bayrakdar et al. found that the variations in frequency for present PP ranged from 14.1% to 21.7% for ages 8 to 81 years[3]. Regarding the type of PP found for the male sex, the percentage of frequency of complete PP ranged from 5% to 8.8% while for partial formation it was from 5.2% to 17.4%, for women they were: complete PP from 3.1% to 6.9% and for partial PP from 5.9% to 19.3%, respectively.

The type of PP according to the age group in the present study showed that the range of 10 to 19 years had 7% of complete PP and partial PP 9.1%, with complete PP in males and partial PP in females, which coincides with the studies carried out by Gibelli, Ercan et al. and Pérez[7,16,17], but different from those found in the research by Mudit et al.

### Table 5. Recent studies of the frequency of ponticulus posticus with different techniques

| Authors         | Years | Country | Total number of patients examined | No. of patients with PP | %     | Imaging technique |
|-----------------|-------|---------|----------------------------------|-------------------------|-------|------------------|
| Cook            | 2018  | Peru    | 925                              | 283                     | 30.6  | DSLX             |
| Vanek et al.    | 2017  | Czech   | 511                              | 73                      | 14.3  | CTA              |
| Adisen et al.   | 2016  | Turkey  | 1,246                            | 234                     | 18.8  | LX               |
| Chen et al.     | 2015  | Taiwan  | 500                              | 35                      | 7     | CBCT             |
| Ere an et al.   | 2015  | Turkey  | 698                              | 257                     | 36.8  | CBCT             |
| Elliot et al.   | 2014  | USA     | 21,789                           | 3,639                   | 16.7  | TC-LX            |
| Mudit et al.    | 2014  | India   | 650                              | 72                      | 11.1  | LX               |
| Pérez et al.    | 2014  | Peru    | 1,056                            | 209                     | 19.8  | LX               |
| Bayrakdar et al. | 2014   | Turkey  | 730                              | 127                     | 17.4  | CBCT             |
| Elgafy et al.   | 2014  | USA     | 100                              | 38                      | 38    | TC               |
| Chitroda et al. | 2013  | India   | 500                              | 342                     | 68.4  | LX               |
| Schilling et al.| 2010  | Chile   | 436                              | 84                      | 19.3  | LX               |
| Wight et al.    | 1999  | UK      | 895                              | 161                     | 18    | LX               |

PP: Ponticulus posticus  
CBCT: Cone-beam computed tomography  
LX: Lateral X-ray  
CTA: Computed tomography angiography  
DSLX: Digital strict lateral X-ray

### Table 6. Recent studies of the frequency of ponticulus posticus (present and absent) according to sex

| Authors          | Years | Country | Sex | Male PP | Female PP |
|------------------|-------|---------|-----|---------|-----------|
|                  |       |         |     | Pte.    | Absent    | Pte. | Absent | %    | %    |
| Cook             | 2018  | Peru    |     | 141    | 226       | 61.6 | 142    | 25.4 | 416  | 74.6 |
| Chen et al.      | 2015  | Taiwan  |     | 12     | 235       | 88   | 23     | 9.5  | 219  | 90.5 |
| Ere an et al.    | 2015  | Korea   |     | 129    | 184       | 58.8 | 128    | 33.2 | 257  | 66.8 |
| Pérez et al.     | 2014  | Peru    |     | 101    | 356       | 77.9 | 108    | 19.3 | 451  | 80.7 |
| Bayrakdar et al. | 2014  | Turkey  |     | 54     | 223       | 80.5 | 73     | 16.1 | 380  | 83.9 |
| Chitroda et al.  | 2013  | India   |     | 154    | 112       | 42   | 148    | 63.2 | 86   | 36.8 |
| Schilling et al. | 2010  | Chile   |     | 28     | 235       | 89.4 | 15     | 8.7  | 158  | 91.3 |
| Selby et al.     | 1955  | USA     |     | 89     | 39        | 30.5 | 134    | 75.2 | 44   | 245  |

PP: Ponticulus posticus  
Pte.: Present  
Percentages found with patients presenting ponticulus posticus.
where males had a higher frequency of partial PP\cite{15}.

Regarding the PP and the skeletal relationship, Gutierrez et al.\cite{18} shows 680 lateral skull radiographs of the Orthodontic Specialty of the Autonomous University of Nayarit taken from 2010 to 2015 where they found that in the class I population 8.3% presented PP, in the class III population 13.04% presented PP and in the class II population it was the highest percentage with 36.2%; values similar to those found in our research which shows the highest percentage of PP present with class II malocclusion with 19.1%.

The variations found when comparing the PP frequency values in each of the objectives with those reported by the different researchers mentioned indicate that they are possibly due to the size of the sample, the difference in the ages sampled, the type of daily life (diet, patients’ diseases, etc.) and the ethnic and genetic traits of the city population of heterogeneous origin that we had in the present study.

It can now be seen that it is difficult to establish a guideline for the relationship between different research efforts in PP, because the research interests and variables of analysis and conduct vary in different countries. However, based on the present work, it could be proposed for the future to estimate, for example, a Peruvian population in order of age, sex, origin (native or mestizo) in order to establish uniform criteria that will allow for a more in-depth study of PP.

| Authors         | Year | Country | Ponticulus posticus Group or age | Present % | Absent % |
|-----------------|------|---------|---------------------------------|-----------|----------|
| Cook            | 2018 | Peru    | 0–9                             | 1.4       | 1.7      |
|                 |      |         | 10–19                           | 16.1      | 35.2     |
|                 |      |         | 20–29                           | 7.5       | 19.4     |
|                 |      |         | 30–39                           | 3.8       | 7.7      |
|                 |      |         | 40–49                           | 1.2       | 3.7      |
|                 |      |         | 50–59                           | 0.1       | 1.4      |
|                 |      |         | >60                             | 0.5       | 0.3      |
| Chen et al.\cite{5} | 2015 | Taiwan  | 20–29                           | 22.8      | 12.3     |
|                 |      |         | 30–39                           | 5.7       | 10.5     |
|                 |      |         | 40–49                           | 25.7      | 21.9     |
|                 |      |         | 50–59                           | 37.1      | 29.9     |
|                 |      |         | >60                             | 8.5       | 25.4     |
| Pérez et al.\cite{6} | 2014 | Peru    | 5–18                            | 13        | 87       |
|                 |      |         | >19                             | 24.8      | 75.2     |
| Bayrakdar et al.\cite{3} | 2014 | Turkey  | 8–18                            | 14.1      | 85.9     |
|                 |      |         | 19–28                           | 17.7      | 82.3     |
|                 |      |         | 29–38                           | 173       | 82.7     |
|                 |      |         | 39–48                           | 19.6      | 80.4     |
|                 |      |         | 49–81                           | 21.7      | 78.3     |
| Schilling et al.\cite{10} | 2010 | Chile   | 0–10                            | 86.9      | 13.1     |
|                 |      |         | 11–20                           | 52.8      | 47.2     |
|                 |      |         | 21–30                           | 80.1      | 19.9     |
|                 |      |         | 31–40                           | 93.8      | 6.2      |
|                 |      |         | 41–50                           | 98.4      | 1.6      |
|                 |      |         | 51–60                           | 99.5      | 0.5      |
|                 |      |         | 61–70                           | 99.8      | 0.2      |

PP: Ponticulus posticus.
Percentages found with patients with ponticulus posticus.
5. Conclusions

PP is an anatomical variant that was present in 30.6% of the cases. No significant differences were found between age groups or skeletal relationship. Regarding sex, no significant statistical differences were found with respect to the type of PP, but there were differences in terms of the presence and absence of PP, being higher in males.

Conflict of interest

The author declares no conflict of interest.

References

1. Capeloza L. Diagnóstico en ortodoncia (Spanish) [Diagnosis in orthodontics]. Maringá: Dental Press; 2005.
2. Testut L, Laterjet A. Compendio de anatomía descriptiva (Spanish) [Compendium of descriptive anatomy]. Barcelona: Salvat; 2013.
3. Bayrakdar IS, Miloglu O, Altun O, et al. Cone beam computed tomography imaging of ponticulus posticus: Prevalence, characteristics, and a review of the literature. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology 2014; 118(6): e210–e219.
4. Selby S, Garn SM, Kanareff V. The incidence and familial nature of a bony bridge on the first cervical vertebra. American Journal of Physical Anthropology 1955; 13(1): 129–141.
5. Sekerci AE, Soylu E, Arikan MP, et al. Is there a relationship between the presence of ponticulus posticus and elongated styloid process? Clinical Imaging 2015; 39(2): 220–224.
6. Chen C, Chen Y, Wang C. Prevalence of ponticuli posticus among patients referred for dental examinations by cone-beam CT. The Spine Journal 2015; 15(6): 1270–1276.
7. Pérez JE, Chávez AK, Ponce D. Frequency of ponticulus posticus in lateral cephalometric radiography of peruvian patients. International Journal of Morphology 2014; 32(1): 54–60.
8. Vanek P, Bradáč O, De Lacy P, et al. Vertebral artery and osseous anomalies characteristic at the cranio-cervical junction diagnosed by CT and 3D CT angiography in normal Czech population: Analysis of 511 consecutive patients. Neurosurgical Review 2017; 40(3): 369–376. doi: 10.1007/s10143-016-0784-x.
9. Wight S, Osborne N, Breen AC. Incidence of ponticulus posterior of the atlas in migraine and cervicogenic headache. Journal of Manipulative and Physiological Therapeutics 1999; 22(1): 15–20.
10. Schilling J, Schilling A, Galdames IS. Ponticulus posticus on the posterior arch of atlas, prevalence analysis in asymptomatic patients. International Journal of Morphology 2010; 28(1): 317–322.
11. Elliott RE, Tanweer O. The prevalence of the ponticulus posticus (arcuate foramen) and its importance in the Goel-Harms procedure: Meta-analysis and review of the literature. World Neurosurgery 2014; 82(1–2): e335–e343.
12. Elgafy H, Pompo F, Vela R, et al. Ipsilateral arcuate foramen and high-riding vertebral artery: Implication on C1–C2 instrumentation. The Spine Journal 2014; 14(7): 1351–1355.
13. Chitroda PK, Katti G, Baba IA, et al. Ponticulus posticus on the posterior arch of atlas, prevalence analysis in symptomatic and asymptomatic patients of gulbarga population. Journal of Clinical and Diagnostic Research 2013; 7(12): 3044–3047.
14. Adisen MZ, Misriioglu M. Prevalence of ponticulus posticus among patients with different dental malocclusions by digital lateral cephalogram: A comparative study. Surgical and Radiologic Anatomy 2017; 39(3): 293–297.
15. Mudit G, Srinivas K, Sateesha R. Retrospective analysis of ponticulus posticus in Indian orthodontic patients—A lateral cephalometric study. Ethiopian Journal of Health Sciences 2014; 24(4): 285–290.
16. Sekerci AE, Soylu E, Arikan MP, et al. Prevalence and morphologic characteristics of ponticulus posticus: Analysis using cone-beam computed tomography. Journal of Chiropractic Medicine 2015; 14(3): 153–161.
17. Gibelli D, Cappella A, Cerutti E, et al. Prevalence of ponticulus posticus in a Northern Italian orthodontic population: A lateral cephalometric study. Surgical and Radiologic Anatomy 2016; 38(3): 309–312.
doi: 10.1007/s00276-015-1554-0.

18. Gutiérrez M, Gutiérrez J, Gutiérrez J. Ponticus Posticus en las maloclusiones esquéleticas (Spanish) [Ponticus Posticus in eschletic malocclusions]. Revista Tame 2016; 5(13): 473–476.