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Original Research Article

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

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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 a 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 Buccomaxillofacial 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.*[4] 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	Sex			
	Male		Female	
	n	Frequency	n	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*	Sex			
	Male		Female	
	n	Frequency	n	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[8]

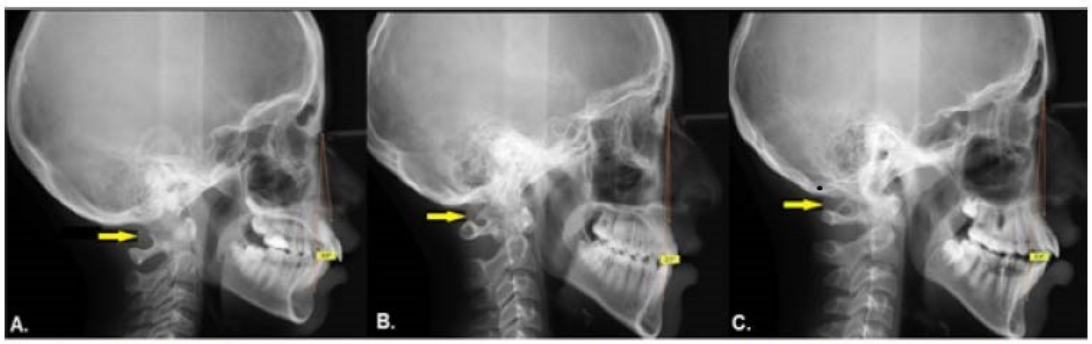

Figure 1. Type of ponticulus posticus.

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		Class II		Class III	
	n	% of total	n	% of total	n	% of total
Absent	212	22.9	402	43.5	28	3.0
Present	96	10.4	177	19.1	10	1.1
Total	308	33.3	579	62.6	38	4.1

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.

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
Erean *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	38.4	226	61.6	142	25.4	416	74.6
Chen *et al.*[5]	2015	Taiwan	12	5.1	235	88	23	9.5	219	90.5
Ere an *et al.*[16]	2015	Korea	129	41.2	184	58.8	128	33.2	257	66.8
Pérez *et al.*[6]	2014	Peru	101	22.1	356	77.9	108	19.3	451	80.7
Bayrakdar *et al.*[3]	2014	Turkey	54	19.5	223	80.5	73	16.1	380	83.9
Chitroda *et al.*[13]	2013	India	154	58	112	42	148	63.2	86	36.8
Schilling *et al.*[10]	2010	Chile	28	10.6	235	89.4	15	8.7	158	91.3
Selby *et al.*[8]	1955	USA	89	69.5	39	30.5	134	75.2	44	245

PP: Ponticulus posticus
Pte.: Present
Percentages found with patients presenting 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].

For age, the presence of PP has been reported in different ethereal groups by Schilling *et al.*, between 10 and 70 years old, finding PP values present from 52% to 99.8% and absent from 0.2% to 47% in ages 11 to 70 years old[10].

In the present study it was also observed that the distribution of the frequency of PP in age groups from 10 to 69 years was higher in the group from 10 to 19 years with 51.4% and from 21 to 30 years with 26.8%, similar to those found by Bayrakdar *et al.*[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.*

where males had a higher frequency of partial PP[15].

Regarding the PP and the skeletal relationship, Gutierrez *et al.*[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.

Table 7. Abstract of the frequency of ponticulus posticus (present and absent) by age groups

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.*[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.*[6]	2014	Peru	5–18	13	87
			>19	24.8	75.2
Bayrakdar *et al.*[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	783
Schilling *et al.*[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.

Table 8. Abstract of the frequency of the ponticulus posticus type according to sex

Authors	Years	Country	Sex							
			Male PP				Female PP			
			Complete	%	Partial	%	Complete	%	Partial	%
Cook	2018	Peru	75	8.1	66	7.1	50	5.4	92	9.9
Gibelli[18]	2015	Italy	8	8.8	10	11	9	6.9	10	7.7
Ere an *et al.*[16]	2015	Turkey	26	8.3	52	16.6	18	4.7	61	15.8
Ercan *et al.*[4]	2015	Turkey	21	8.5	43	17.4	15	5.1	57	19.3
Mudit *et al.*[17]	2014	India	8	2.8	22	7.6	11	3.1	31	8.6
Pérez *et al.*[4]	2014	Peru	53	5	55	5.2	39	3.7	62	5.9

PP: Ponticulus postiticus
Percentages found with patients presenting 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.

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