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ORIGINAL ARTICLE

ASSOCIATION BETWEEN *PONTICULUS POSTICUS* AND SKELETAL MALOCCLUSIONS

Relación del *ponticulus posticus* con patrones de maloclusión esqueletal

Doris Montoya-Gonzales,[1] Eduardo Calle-Velezmoro,[1] Jesica Calle-Morocho,[1,2] Rafael Morales-Vadillo,[1] Janet-Ofelia Guevara-Canales.[1]

1. Facultad de Odontología, Universidad de San Martín de Porres (USMP), Lima, Perú.
2. Centro de Imágenes Dentales, Cañar, Ecuador.

ABSTRACT

Aim: To determine whether there is any association between *Ponticulus posticus* and skeletal patterns in lateral cephalometric radiographs.

Material and Methods: 1313 lateral cephalometric radiographs of patients treated at a Dental Center were studied to evaluate *Ponticulus posticus* presence and degree of ossification, as well as the skeletal malocclusion pattern through the analysis of the intermaxillary relationship.

Results: Ponticulus posticus was present in 20.4% and a higher number of cases with presence of *Ponticulus posticus* was identified in Class II patients, with 53%. According to the Chi-square test for homogeneity, there was no statistically significant difference in presence of *Ponticulus posticus* according to skeletal pattern type (p=0.792), except when presence of *Ponticulus posticus* was classified according to skeletal patterns and according to sex, when frequency was higher in Class II female sex (p=0.032).

Conclusions: There is no relationship between the *Ponticulus posticus* and the different skeletal malocclusion patterns; a statistically significant difference was only found in Class II, where a predominance in the female sex was e vident. No statistically significant association is evident between skeletal malocclusion patterns and the type of ossification.

Keywords: *Ponticulus posticus; Cervical atlas; Malocclusions; Radiography; Cephalometry; Cervical vertebrae*

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Corresponding Author: Doris Montoya Gonzales. Facultad de Odontología, Universidad de San Martín de Porres (USMP), Av. Las Calandrias N° 151 - 291, Santa Anita, Lima, Perú. **Phone:** (+54-35) 14334274 **Email: thais94c@hotmail.com**

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RESUMEN

Objetivo: Determinar si existe relación entre el *Ponticulus posticus* con los patrones de maloclusión esqueletal en teleradiografías laterales.

Material y Métodos: Se estudiaron 1313 teleradiografías laterales de pacientes atendidos en un Centro Odontológico, para evaluar la presencia y grado de osificación del *Ponticulus posticus*; además, de los patrones de maloclusión esqueletal, a través del análisis de la relación intermaxilar.

Resultados: Del total de teleradiografías laterales evaluadas, el *Ponticulus posticus* se presentó en un 20.4%, siendo en pacientes con clase II donde se identificó un mayor número de casos (53%). De acuerdo con la prueba de chi-cuadrado de homogeneidad, no existe diferencia estadísticamente significativa en la presencia del *Ponticulus posticus* de acuerdo con los patrones de maloclusión esqueletal (p=0.792), salvo cuando se subdivide a estos patrones de maloclusión esqueletal según sexo, donde se evidencia una mayor frecuencia en la clase II sexo femenino (p=0.032).

Conclusiones: No existe relación entre el *Ponticulus posticus* y los diferentes patrones de maloclusión esqueletal, solo se encontró diferencia estadísticamente significativa en la clase II, donde se evidenció predominancia en el sexo femenino. No se evidencia una asociación estadísticamente significativa entre los patrones de maloclusión esquelética y el tipo de osificación.

Palabras clave: *Ponticulus posticus; Atlas cervical; Maloclusión; Radiografía; Cefalometría; Vértebras cervicales*

INTRODUCTION

Lateral cephalometric radiography is a standardized and reproducible cranial imaging technique routinely used in orthodontics[1,2] to evaluate the relationships among the teeth, jaws, and the rest of the skull.[3,4] In lateral cephalometric radiographs, the cervical spine area is omitted from cephalometric tracings,[4] although in some cases it is used to evaluate skeletal maturation using the cervical vertebral maturation index to determine growth potential in young patients.[5]

However, if due attention is paid and normal anatomy is well understood, certain pathologies and/or anatomical variants can be identified, which mostly constitute radiographic findings.[4] One such variant is the *Ponticulus posticus* (PP), also called the sagittal foramen, posterior atlanto foramen,[6] arcuate foramen,[7] variant of Kimmerle's anomaly,[8] superior retroarticular foramen,[9] canalis vertebralis,[10] retroarticular vertebral artery ring,[11] or retroarticular canal.[12]

The most widely accepted term is PP,[13] an anatomical variation in the area of the cervical vertebrae,[14] whose Latin meaning is "small posterior bridge." It is defined as the ossification and/or calcification of the posterior atlanto-occipital ligament[15] and is radiographically classified as either complete (formation of a complete bony ring) or partial (formation of portions of the otherwise incomplete bony ring).[5]

Although cadaver studies are considered the reference method for evaluating the presence of PP,[16] there are case series of clinical studies assessing its prevalence, which varies according to population size, geographical origin, and the influence of quality, diagnostic power, and level of the images.[5] Reported prevalence ranges from 12.6% to 38.3%.[17-20]

This anatomical variant has been associated with several conditions, including diplopia, sensorineural hearing loss, headaches[21,22] and migraines,[21,23] cochlear symptoms (tinnitus and hearing loss),[24] shoulder pain,[25] arm and neck pain, and vertigo.[26] These symptoms may be caused by compression of the vertebral artery as it passes from the transverse foramen of the cervical vertebra to the foramen magnum, producing ischemia of the posterior circulation.[17,27,28]

In addition, it has been associated with Gorlin–Goltz syndrome,[29,30] dental agenesis,[5] an elongated stylohyoid process,[31] and especially with malocclusions.[29,32,33]
Research has sought to determine the relationship between the presence of PP and skeletal malocclusion patterns.[32,34] Some studies[35] suggest that no such relationship exists, whereas others[32] report a positive association. Because of this discrepancy, the objective of the present study was to determine whether there is a relationship between PP and different skeletal malocclusion patterns.

MATERIALS AND METHODS

The study design was observational, analytical, retrospective, and cross-sectional. It was approved by the Research Project Review Committee (Approval No. 012-2019-CRPI/INVE-FO-USMP) and the Research Ethics Committee (Approval No. 002-2019-CEI/INVE-FO-USMP) of the Faculty of Dentistry at Universidad San Martín de Porres, Lima, Peru. All cases were verified to have prior informed consent for radiographic acquisition and for the use of data for academic and research purposes.

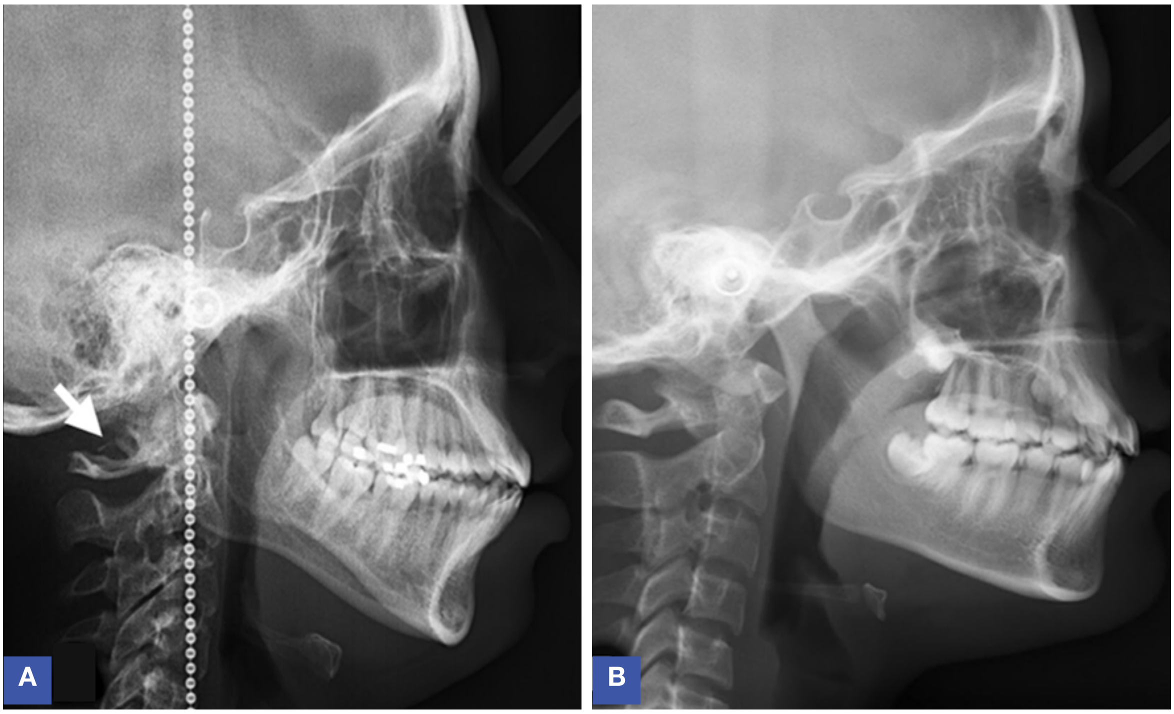
Initially, inter-examiner calibration was performed between the lead researcher and a specialist in oral and maxillofacial radiology with more than five years of ex-perience to collect data on the presence and degree of ossification of PP. In addition, measurements of skeletal malocclusion patterns were calibrated using 16 lateral cephalometric radiographs. Agreement was evaluated using the Kappa statistic and the interclass correlation coefficient; a value of 0.700 was obtained (95% confidence interval: 0.398–1.000), which was considered indicative of good agreement.[36]

The study population consisted of 1980 lateral cephalometric radiographs obtained from the Radiology Department of patients treated at the Dental Clinic of Universidad de San Martín de Porres between 2017 and 2018. These radiographs were evaluated according to the selection criteria. Inclusion criteria comprised patients aged 7 years and older. Exclusion criteria included lateral cephalometric radiographs in which the craniofacial complex fell outside the established parameters at the time of the imaging; lateral cephalometric radiographs of patients who had undergone orthodontic treatment, dental extraction and/or orthognathic surgery; and patients with jaw pathologies such as tumors or cysts. Consequently, a final sample of 1313 lateral cephalometric radiographs that met the selection criteria was obtained.
Lateral cephalometric radiographs were obtained using a digital Planmeca Pro-Max Dimax 4 Ceph unit (Helsinki, Finland), with a kilovoltage of 80 kV in adults and 70 kV in children, and a milliamperage of 16 mA in adults and 14 mA in children.

The selected lateral cephalometric radiographs underwent two evaluations:
1. To determine the presence or absence of PP through digital identification of this anatomical variant, as well as the type of ossification.

Figure 1

Presence and absence of *Ponticulus posticus* in lateral teleradiographs



A: Presence of *Ponticulus posticus*. **B:** Absence of *Ponticulus posticus*.

2. In lateral cephalometric radiographs in which the presence of PP was identified, Steiner's ANB angle measurement[37] was performed to determine the skeletal malocclusion pattern (from point A to point N, and finally to point B). The tracing was carried out using Romexis 3.0 software (Planmeca), which automatically generated the angular measurement. Angles between 0° and 4° were classified as Class I, values greater than 4° as Class II, and values less than 0° as Class III.

All values obtained from the different statistical tests were considered statistically significant at $p<0.05$. Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) (version 22.0) for Windows (Windows, SPSS Inc., Chicago, Illinois, USA). The non-parametric Pearson chisquare test was applied in this study.

RESULTS

Of the total 1,980 lateral cephalometric radiographs obtained, 1,313 were evaluated, corresponding to the same number of patients who met the selection criteria. The presence of PP was identified in 268 cases (20.4%) (Figure 1).

According to the type of ossification, partial ossification was observed in 117 caSes (43.7%) and complete ossification in 151 cases (56.3%). By sex, 119 cases occurred in male patients (44.4%) and 149 in female patients (55.6%). With respect to age, 232 patients were up to 30 years old (86.6%), while 36 were older than 30 years (13.4%) (Table 1). The relationship between PP and skeletal malocclusion patterns was observed in Class I in 110 cases (41%); Class II in 142 cases (53%); and Class III in 16 cases (6%) (Table 1).

Table 1

Distribution of *Ponticulus posticus* according to the variables studied

Variables		*Ponticulus posticus* Present n=268	%	Absent n=1045	%	*p*-value
Type of ossification	*Ponticulus posticus* Partial	117	43.7	--	--	
	Ponticulus posticus Complete	151	56.3	--	--	
Sex	Male	119	44.4	443	42.4	0.553
	Female	149	55.6	602	57.6	
Age	Up to 30 years	232	86.6	925	88.5	0.379
	Over 30 years	36	13.4	120	11.5	
Skeletal malocclusion pattern	Class I	110	41	453	43.3	0.792
	Class II	142	53	531	50.8	
	Class III	16	6	61	5.8	

Statistical significance using the Pearson chi-square test (α = 0.05)

Table 2

Analysis of the skeletal malocclusion patterns according to the variables studied

Variables		Skeletal malocclusion pattern Class I n	%	Class II n	%	Class III n	%	*p*-value
Ponticulus posticus	Present *Ponticulus posticus*	110	19.5	142	21.1	16	20.8	0.792
	Absent *Ponticulus posticus*	453	80.5	531	78.9	61	79.2	
Type of ossification	*Ponticulus posticus* Partial	46	41.8	65	45.8	6	37.5	0.720
	Ponticulus posticus Complete	64	58.2	77	54.2	10	62.5	
Sex	Male	56	50.9	53	37.3	10	62.5	0.032
	Female	54	49.1	89	62.7	6	37.5	
Age	Up to 30 years	100	90.9	118	83.1	14	87.5	0.195
	Over 30 years	10	9.1	24	16.9	2	12.5	

Statistical significance using the Pearson chi-square test (α = 0.05)

Skeletal malocclusion patterns according to the presence of PP, type of ossification, and age did not show statistically significant differences (p=0.792, p=0.720, and p=0.195, respectively). However, a statistically significant difference was observed accor-ding to sex (p=0.032), (Table 2).

DISCUSSION

Regarding the presence of PP, an anatomical variant has been associated with several conditions, including dental alterations5 and malocclusions.[31] Some studies, such as those by Falah-Kooshki *et al.*,[20] Nedelcu *et al.*,[18] Giri

et al.,[19] and Bayrakdar *et al.*,[37] reported high prevalences of PP (38.3%, 36.5%, 35.7%, and 34.9%, respectively), which differs from the findings of the present study, where a lower prevalence was observed (20.4%).
This discrepancy may be explained by the imaging modality used: Cone Beam Computed Tomography, employed in those studies, differs from the lateral cephalometric radiographs used in the present study, which are considered the gold standard for determining the presence of PP. Other studies have reported lower prevalences of PP than those observed in the present study, including Adisen *et al.*,[31] (18.8%), Tambawala *et al.*,[17] who reported a prevalence of 15.8% in a sample of 500 patients from India, and Lo Giudice *et al.*,[34] who identified PP in 93 out of 734 cases (12.6%). When compared with cadaveric studies, such as that of Elliott *et al.*,[38] the prevalence of PP was similar to that reported by Adisen *et al.*,[31]

In the present study, the complete form of PP was the most frequent, accounting for 56.3% of cases. This finding contrasts with those reported by Falah-Kooshki *et al.*,[20] who found partial PP to be the most prevalent form (59.8%); by Giri *et al.*,[19] who reported partial ossification in 30.9% of cases and complete ossification in only 4.8%; and by the meta-analysis conducted by Pękala *et al.*,[16] which showed a higher frequency of partial PP (13.6%) compared with complete PP (9.1%). It is noteworthy that this meta-analysis predominantly included studies conducted on cadaveric specimens.

Adisen *et al.*,[31] reported a statistically significant association between the presence of PP and sex (p=0.002), in contrast to the findings of the present study and those of Lo Giudice *et al.*,[34] in which no significant differences in PP prevalence according to sex were observed (p=0.553 and p=0.362, respectively). Conversely, Bayrakdar *et al.*,[37] reported a lower prevalence of PP in females (42.5%), which contrasts with the present study and that of Lombardo *et al.*,[39] where a higher proportion of PP cases was observed among females (55.6% and 63.39%, respectively).

Adisen *et al.*,[31] reported a higher prevalence of PP at a mean age of 20.98±6.95 years (range: 10–39 years), without a statistically significant difference. Similar findings were reported by Falah-Kooshki *et al.*,[20] who observed a mean age of 19.47± 8.37 years (range: 7–64 years). These results are comparable to those of the present study, which found a mean age of 20.01±9.62 years (range: 7–62 years), with no statistically significant difference between individuals younger and older than 30 years (p=0.379). In contrast, Lo Giudice *et al.*,[34] reported a statistically significant difference between age groups, particularly in patients aged 7 to 13 years (p=0.04), within a study population ranging from 1 to 60 years.

The relationship between PP and skeletal malocclusion patterns remains unclear. However, some authors support the hypothesis that, because the cervical vertebrae and the cranial base share a common embryological origin —and because both jaws are related to the cranial base— this may explain the association between cervical vertebral anomalies and skeletal malocclusions. In this context, several studies have reported a higher prevalence of PP in patients with Class II skeletal malocclusion: Lo Giudice *et al.*,[34] reported a prevalence of 14.4%; Falah-Kooshki *et al.*,[20] reported a prevalence of 58.2%, although without statistically significant differences; and Lekavičiūtė *et al.*,[41] found a statistically significant association between PP and Class II malocclusion (*p*=0.042). These findings are consistent with the results of the present study, in which Class II malocclusion was the most prevalent pattern (53%). In contrast, Adisen *et al.*,[31] reported a higher frequency of PP in patients with Angle Class III malocclusion (22.2%), although no statistically significant differences were found among malocclusion types (*p*=0.940). Similarly, Bayrakdar *et al.*,[3] observed a higher prevalence of PP in Class III patients (13.8%), followed by Class II (12.2%) and Class I (10.5%), and reported statistically significant differences among groups with sagittal skeletal anomalies (*p*=0.019).

In the present study, no statistically significant differences were observed in PP prevalence according to skeletal malocclusion pattern (*p*=0.792). The discrepancies between these findings and those of the present study may be attributed to ethnic and geographic differences, as the contrasting results largely derive from studies conducted in Turkish populations.

Oh *et al.*,[42] reported that both the upper cervical spine and the maxillae derive from the notochord and that any alteration in the ossification of the atlas may also be reflected in maxillary morphology. They concluded that the morphology of the upper cervical spine is associated with that of the maxillae, with a stronger relationship observed in skeletal Classes II and III. Putrino *et al.*,[5] further elucidated this possible association by proposing a theory in which the neural crest is described as a pluripotent mesenchyme that serves as the source of various tissue types, including neural, glial, skeletal, connective, pigmentary, and secretory tissues.

Finally, the embryological origin of PP has not yet been fully established. However, Wan *et al.*,[43] suggested that the presence of lamellar patterns within the bone matrix and a cortical structure indicative of endochondral ossification may originate in the dorsal arch. They also proposed that the bony arch may develop as a protective structure for the vertebral artery during head and neck movements.[32] Class III malocclusion has a strong genetic component, as it is largely hereditary.

Most studies involving Class III patients report a higher prevalence of cervical vertebral anomalies, with statistically significant differences when compared with Class II and Class I malocclusions. The findings of the present study should be considered in future research examining the relationship between PP, malocclusions, and the presence of clinical symptoms.

CONCLUSIONS

PP is more prevalent in patients with a Class II skeletal malocclusion pattern; however, no statistically significant association was found, except when the data were classified by sex, in which case a statistically significant higher prevalence was found in female Class II patients. When skeletal malocclusion patterns were compared according to the type of ossification (partial or complete), no statistically significant association was identified. Nevertheless, the identification of PP remains essential due to its potential clinical implications.

CONFLICT OF INTERESTS

The authors have no conflicts of interest.

ETHICS APPROVAL

Approved by the Research Project Review Committee (ACTA No. 012-2019-CRPI/INVE-FO-USMP) and by the Research Ethics Committee (ACTA No. 002-2019-CEI/INVE-FO-USMP) of the Faculty of Dentistry of the University of San Martín de Porres (Facultad de Odontología de la Universidad de San Martín de Porres).

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Jesica Calle-Morocho: Conceptualization, Investigation, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft.

Rafael Morales-Vadillo: Conceptualization, Formal Analysis, Investigation, Methodology, Project administration, Software, Supervision, Writing – review & editing.

Janet-Ofelia Guevara-Canales: Conceptualization, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Writing – review & editing.

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ORCID

Doris Montoya-Gonzales
0000-0003-2616-3767
Eduardo Calle-Velezmoro
0000-0003-3479-4294
Jesica Calle-Morocho
0000-0002-7789-8715
Rafael Morales-Vadillo
0000-0002-7835-6408
Janet-Ofelia Guevara-Canales
0000-0002-7040-8269

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REFERENCES

1. Di Venere D, Laforgia A, Lorusso P, Capodiferro S, Corsalini M. Ectopic Eruption of the First Permanent Molar in the Maxilla: Cephalometric Features of 13 Pediatric Patients. Appl Sci. 2021;11:7869.
2. Ghodasra R, Brizuela M. Orthodontics, Cephalometric Analysis. 2023 Jul 17. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025. PMID: 37603663.
3. Bayrakdar IS, Miloglu O, Altun O, Gumussoy I, Durna D, Yilmaz AB. Cone beam computed tomography imaging of ponticulus posticus: prevalence, characteristics, and a review of the literature. Oral Surg Oral Med Oral Pathol Oral Radiol. 2014;118(6):e210-9. https://doi.org/10.1016/j.oooo.2014.09.014
4. Mortezai O, Rahimi H, Tofangchiha M, Radfar S, Ranjbaran M, Pagnoni F, Reda R, Testarelli L. Relationship of the Morphology and Size of Sella Turcica with Dental Anomalies and Skeletal Malocclusions. Diagnostics. 2023;13(19):3088. https://doi.org/10.3390/diagnostics13193088. PMID: 37835831; PMCID: PMC10573052.
5. Putrino A, Leonardi RM, Barbato E, Galluccio G. The Association between Ponticulus Posticus and Dental Agenesis: A Retrospective Study. Open Dent J. 2018;12:510-9. https://doi.org/10.2174/1874210601812010510
6. Loth-Niemerycz J. Badania anatomiczne i antropologiczne nad kanalem wyrostkow poprzecznych (Canalis transversarius) kregow szyowych czlowieka i malp. Pr Tow Nauk Warsz. 1916;III:1-92.
7. Stubbs DM. The Arcuate Foramen. Variability in Distribution Related to Race and Sex. Spine. 1992; 17(12):1502-04.
8. Kimmerle A. Mitteilung über einen eigenartigen Befund am Atlas. Rontgenpraxis. 1930;2:479-80.
9. Brocher JE. Die Occipito-Cervical-Gegend: Eine diagnostisch-pathologische Studie. Stuttgart: Thieme; 1955.
10. Wolf-Heidegger G. Atlas der systematischen Anatomie des Menschen. Vol. 1. 2. Aufl. Basel: Karger; 1961.
11. Lamberty BGH, Zivanovic S. The retro-articular vertebral artery ring of the atlas and its significance. Acta Anat. 1973;85(1):113-22.
12. Mitchell J. The incidence and dimensions of the retroarticular canal of the atlas vertebra. Acta Anat (Basel). 1998;163(2):113-20. https://doi.org/10.1159/000046490
13. Schilling J, Schilling A, Galdames IS. Ponticulus posticus on the posterior arch of atlas, prevalence analysis in asymptomatic patients. Int J Morphol. 2010; 28(1):317-22.
14. Di Venere D, Laforgia A, Azzollini D, Barile G, De Giacomo A, Inchingolo AD, Rapone B, Capodiferro S, Kazakova R, Corsalini M. Calcification of the Atlanto-Occipital Ligament (Ponticulus Posticus) in Orthodontic Patients: A Retrospective Study. Healthcare (Basel). 2022;10(7):1234. https://doi.org/10.3390/healthcare10071234. PMID: 35885761; PMCID: PMC9319085.
15. Mudit G, Srinivas K, Satheesha R. Retrospective analysis of ponticulus posticus in Indian orthodontic patients-a lateral cephalometric study. Ethiop J Health Sci. 2014;24(4):285-90. https://doi.org/10.4314/ejhs.v24i4.2. PMID: 25489191; PMCID: PMC4248026.
16. Pękala PA, Henry BM, Pękala JR, Hsieh WC, Vikse J, Sanna B, Walocha JA, Tubbs SR, Tomaszewski KA. Prevalence of foramen arcuale and its clinical significance: A meta-analysis of 55,985 subjects: PS095. Porto Biomed J. 2017;2(5):190. https://doi.org/10.1016/j.pbj.2017.07.036. Epub 2017 Sep 1. PMID: 32258648; PMCID: PMC6806871.
17. Tambawala SS, Karjodkar FR, Sansare K, Motghare D, Mishra I, Gaikwad S, Dora AC. Prevalence of Ponticulus Posticus on Lateral Cephalometric Radiographs, its Association with Cervicogenic Headache and a Review of Literature. World Neurosurg. 2017 Jul;103:566-575. https://doi.org/10.1016/j.wneu.2017.04.030. Epub 2017 Apr 17. PMID: 28427978.
18. Nedelcu AH, Hutanu A, Nedelcu I, Partene Vicoleanu S, Statescu G, Gavril L, Haliciu AM, Ursaru M, Tarniceriu CC. The Prevalence and Morphology-Wise Demographic Distribution of Ponticulus Posticus on CT Scans-A Retrospective Observational Study. Medicina (Kaunas). 2023; 59(4):650. https://doi.org/10.3390/medicina59040650. PMID: 37109607; PMCID: PMC101469 98.
19. Giri J, Pokharel PR, Gyawali R. How common is ponticulus posticus on lateral cephalograms? BMC Res Notes. 2017;10(1):172. https://doi.org/10.1186/s13104-017-2494-z
20. Falah-Kooshki S, Nikkerdar N, Imani MM, Faraji R, Golshah A. Correlation of Ponticulus Posticus with Dentofacial Skeletal Patterns. Contemp Clin Dent. 2022;13(1):35-39. https://doi.org/10.4103/ccd.ccd_621_20

21. Mokhtari N, Ashtari F, Razavi M, Ghaffari R. Prevalence and characteristics of ponticulus posticus and its association with cervicogenic headache and migraine: A lateral cephalometric study. J Res Med Sci. 2022;27:61. https://doi.org/10.4103/jrms.jrms_384_21
22. Macrì M, Perrella G, Varvara G, Murmura G, Traini T, Rendina F, Festa F. Assessments of Prevalence of Ponticulus Posticus, Atlas Posterior Arch Deficiency, Sella Turcica Bridging, Maxillary Canine Impaction, and Associations Among Them in 500 CBCTs of Italian Orthodontic Patients. Front. Dent. Med. 2021; 2:708169. https://doi.org/10.3389/fdmed.2021.708169
23. Tripodi D, Tieri M, Demartis P, Però G, Marzo G, D'Ercole S. Ponticulus posticus: clinical and CBCT analysis in a young Italian population. Eur J Paediatr Dent. 2019;20(3):219-223. https://doi.org/10.23804/ejpd.2019.20.03.10
24. Polat E, Orhan K. Examination of Incidental Intra-cranial and Extra-cranial Head and Neck Calcifications Using Cone-beam Computed Tomography. J Stomatol. 2022; 75:222-30. https://doi.org/10.5114/jos.2022.122108
25. Evirgen Ş, Yüksel HT, Yüksel G, Kaki B, Kamburoğlu K. Assessment of intravertebral pneumatocysts, degenerative joint disease, and ponticulus posticus in the cervical spine through cone beam computed tomography examination. Oral Surg Oral Med Oral Pathol Oral Radiol. 2020;129(5):531-538. https://doi.org/10.1016/j.oooo.2019.10.002.
26. Gul E, Atik I. Does ponticulus posticus affect vertebral artery diameter. Surg Radiol Anat. 2024. https://doi.org/10.1007/s00276-024-034-30-w
27. Sabir H, Kumbhare S, Rout P. Evaluation of ponticulus posticus on digital lateral cephalograms and cone beam computed tomography in patients with migraine and healthy individuals: a comparative study. Oral Surg Oral Med Oral Pathol Oral Radiol. 2014;118(3):348-54. https://doi.org/10.1016/j.oooo.2014.04.016
28. Leonardi R, Santarelli A, Barbato E, Ciavarella D, Bolouri S, Härle F, Palazzo G, Lo Muzio L. Atlanto-occipital ligament calcification: a novel sign in nevoid basal cell carcinoma syndrome. Anticancer Res. 2010;30(10):4265-7. PMID: 21036751.
29. Friedrich RE. Ponticulus posticus is a frequent radiographic finding on lateral cephalograms in nevoid basal cell carcinoma syndrome (Gorlin-Goltz syndrome). Anticancer Res. 2014; 34(12):7395-9. PMID: 25503179.
30. Sekerci AE, Soylu E, Arikan MP, Aglarci OS. Is there a relationship between the presence of ponticulus posticus and elongated styloid process? Clin Imaging. 2015;39(2):220-4. https://doi.org/10.1016/j.clinimag.2014.11.016
31. Adisen MZ, Misirlioglu M. Prevalence of ponticulus posticus among patients with different dental malocclusions by digital lateral cephalogram: a comparative study. Surg Radiol Anat. 2017;39(3):293-7. https://doi.org/10.1007/s00276-016-1728-4
32. Giudice AL, Brewer I, Leonardi R, Roberts N, Bagnato G. Pain threshold and temporomandibular function in systemic sclerosis: comparison with psoriatic arthritis. Clin Rheumatol. 2018;37(7):1861-7. https://doi.org/10.1007/s10067-018-4028-z
33. Go G, Hwang SH, Park IS, Park H. Rotational Vertebral Artery Compression: Bow Hunter's Syndrome. J Korean Neurosurg Soc. 2013; 54(3):243-245. https://doi.org/10.3340/jkns.20 13.543.243
34. Lo Giudice A, Caccianiga G, Crimi S, Cavallini C, Leonardi R. Frequency and type of ponticulus posticus in a longitudinal sample of nonorthodontically treated patients: relationship with gender, age, skeletal maturity, and skeletal malocclusion. Oral Surg Oral Med Oral Pathol Oral Radiol. 2018;126(3):291-7. https://doi.org/10.1016/j.oooo.2018.05.001
35. Cicchetti DV. Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment instruments in psychology. Psychol Assess. 1994;6(4):284-90.
36. Hassan MM, Alfaifi WH, Qaysi AM, Alfaifi AA, AlGhafli ZM, Mattoo KA, Daghriri SM, Hawthan LM, Daghriri RM, Moafa AA, Al Moaleem MM. Comparative Evaluation of Digital Cephalometric Tracing Applications on Mobile Devices and Manual Tracing. Med Sci Monit. 2024 Jun 23;30:e944628. https://doi.org/10.12659/MSM.944628. PMID: 38909276; PMCID: PMC1 130 5110.
37. Bayrakdar IŞ, Miloğlu Ö, Yeşiltepe S, Yılmaz AB. Ponticulus posticus in a cohort of orthodontic children and adolescent patients with different sagittal skeletal anomalies: a comparative cone beam com-puted tomography investigation. Folia Morphol (Warsz). 2018;77(1):65-71. https://doi.org/10.5603/FM.a2017.0075. Epub 2017 Aug 23. PMID: 28832088.
38. 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 Neurosurg. 2014;82(1-2):e335-43. https://doi.org/10.1016/j.wneu.2013.09.014

39. Lombardo C, Roggio F, Caltabiano R, Maugeri G, D'Amico GA, Lo Giudice A, Musumeci G, Loreto C. Ponticulus posticus and skeletal malocclusion: A pilot study in a Southern Italian pre-orthodontic court. Open Med (Wars). 2024;19(1):20240965. https://doi.org/10.1515/med-2024-0965. PMID: 39 015295; PMCID: PMC11249640.
40. Buyuk SK, Sekerci AE, Benkli YA, Ekizer A. A survey of ponticulus posticus: Radiological analysis of atlas in an orthodontic population based on cone-beam computed tomography. Niger J Clin Pract. 2017;20(1):106-110. https://doi.org/10.4103/1119-3077.178916. PMID: 27958256.
41. Lekavičiūtė R, Šopagienė D, Razukevičius D, Trakinienė G, Lopatienė K. The Relationship Between Orthodontic Malocclusion and Morphological Features of Sella Turcica Bridging and Ponticulus Posticus. Medicina. 2024;60(11):1853. https://doi.org/10.3390/medicina60111853
42. Oh E, Ahn SJ, Sonnesen L. Ethnic differences in craniofacial and upper spine morphology between European and Asian children with skeletal Class III malocclusion. Am J Orthod Dentofacial Orthop. 2019;156(4):502-511. https://doi.org/10.1016/j.ajodo.2018.10.024. PMID: 315 82 122.
43. Wan Z, Shen SG, Gui H, Zhang P, Shen S. Evaluation of the postoperative stability of a counter-clockwise rotation technique for skeletal class II patients by using a novel three-dimensional position-posture method. Sci Rep. 2019;9(1):13196. https://doi.org/10.1038/s41598-019-49335-2. PMID: 31519983; PMCID: PMC6744461.