



## **Ponticulus posticus: Anatomical Variation in Posterior Arch of the Atlas Vertebra Evaluated in Lateral Cephalometric Radiography**

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### **Authors' contributions**

*This work was carried out in collaboration between all authors. Authors ACR, EDJ, RA and FBP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SRC, ARF and STC managed the analyses of the study. Authors ARF, STC and ACR managed the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

**Aims:** To evaluate the prevalence of the *Ponticulus posticus* in a Brazilian sample and discuss about the importance of this anatomical variation in forensic dentistry area.

**Study Design:** Observational and transversal study.

**Place and Duration of Study:** Department of Morphology, Anatomy division, Piracicaba Dental School, University of Campinas-UNICAMP, between June 2014 and December 2015.

**Methodology:** We used 242 lateral cephalometric radiographs of adult individual skulls from both

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sexes (from 18-60 years old). The sample was divided into the following groups: 92 lateral radiographs of males, and 150 lateral radiographs of females. The visual assessment method was performed by the same examiner. Classification form was carried out in three categories in both sexes: Presence of *Ponticulus posticus* with complete ossification; presence of *Ponticulus posticus* with incomplete ossification and absence. Data were performed a descriptive analysis by a decision tree. The sample data were segmented by sex, posteriorly by the presence of *Ponticulus posticus*, and then as complete or incomplete. Also were applied chi square test to analyze the correlation between the presence or absent of the *Ponticulus posticus* in relation about sex and the correlation about the *Ponticulus posticus* is complete or incomplete. The significant level was adjusted to 5%.

**Results:** From the total sample of 242 individuals, 92 (38.02%) were male sex and 150 (61.98%) were female sex. Among the male ones, 19 (7.85%) had shown *Ponticulus posticus* with 10 (4.13%) of them presenting incomplete foramen ossification and the other 9 (3.72%) presenting complete foramen ossification. Concerning the females ones, 34 (14.05%) exhibited this anatomical variation, being 21(8.68%) incomplete and 13 (5.37%). In general, there was no sex influence (chi-square,  $p = 0.8354399$ ) in the presence of *Ponticulus posticus*, indicating that sex is not an influence factor.

**Conclusion:** The presence of this anatomical variation cannot be related to sexual dimorphism.

*Keywords: Anatomy; cervical atlas; sex characteristics; sex dimorphism; Ponticulus posticus.*

## 1. INTRODUCTION

*Ponticulus posticus* is a variation occurring on the Atlas vertebra [1-10]. It is defined as an abnormal small bony bridge [11,12] or an anomalous foramen [13]. This variation is a result of complete or incomplete ossification of the posterior atlanto-occipital membrane along the groove of the vertebral artery, resulting in a foramen, which contains the vertebral artery branch and posterior spinal nerve C1 [14]. If this foramen diameter is reduced it could cause considerable ischemic compression of the vertebral artery with consequent reduction of cerebral blood flow [2].

In the literature, the incidence of the *Ponticulus posticus* has been reported to be between 5.14% and 37.83% in the western population [11,12,15].

The knowledge of the anatomical variations of bony tissue helps us in the analysis of differential characters in individuals who require forensic identification. The forensic analysis is heavily focused on identification of diseased people. Human identification is a major challenge in forensic dentistry practice, for example, especially when the integrity of the body is compromised, such as during mass disasters, wars, explosions, traffic accidents, and assault [16]. The primary aim of forensic anthropology is the reconstruction of an osteobiography, consisting of a set of biological attributes [16].

Previous studies [17-21] confirmed the accuracy of lateral cephalometric radiography. It can be used in the verification of craniofacial anatomical structures to develop discriminant functions.

Atlas vertebra shows greatest variability among the cervical vertebrae [22]. The study of bone anatomical variations tends to be neglected for a forensic dentistry area in human identifications, being described as occasional or even rare. However, the knowledge of the topographical anatomy of the human craniofacial structures and its variations can be crucial to achieving an accurate diagnosis of the individual identity [23]. Knowledge about anatomical variations is also important for anthropology [22,24,25]. Hence, the aim of our study was to evaluate the incidence of the *Ponticulus posticus* in a Brazilian sample and discuss about the importance of this anatomical variation in forensic dentistry area.

## 2. METHODOLOGY

We evaluated 242 digital lateral cephalometric radiography, belongs to Department of Morphology, Anatomy division, Piracicaba Dental School, University of Campinas-UNICAMP.

The sample distribution was determined by sex of the individuals. Therefore, sample was divided into the following groups:

- Group 1: 92 male lateral radiographs.
- Group 2: 150 female lateral radiographs.

Sample selection was based on lateral cephalometric radiographs of the skull which allowed visualization of the posterior arch of the Atlas vertebra. We selected individuals between 18 - 60 years of age, to avoid bone modifications due to aging, growth and development. Dental conditions were not considered. We excluded radiographs where visualization of the posterior arch of the Atlas vertebra was impaired, due to the overlap of the mastoid or occipital process. Individuals who presented birth defects, such as cleft lip and cleft palate, and other conditions or syndromes involving the craniofacial region were excluded from the sample.

For analysis of the *Ponticulus posticus*, one examiner performed visual assessment method in order to minimize errors. Visual method assessment concerns about evaluate the presence of ossification. The examiner searched for whether the structure was radiopaque or not.

According the presence of the *Ponticulus posticus*, the radiographs were classified in three categories:

- a) The presence of *Ponticulus posticus* with complete ossification (Fig. 1A);
- b) The presence of *Ponticulus posticus* with incomplete ossification (Fig. 1B);
- c) None (Fig. 2).

Statistical analyzes were performed in the software R Core Team (R Foundation for Statistical Computing, Vienna, Austria) for

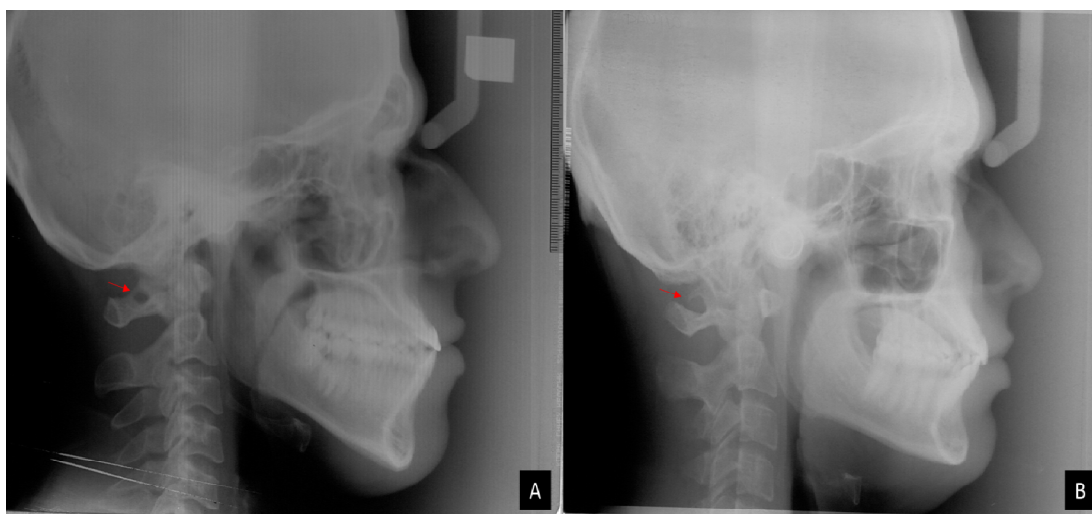
Linux (open source). Data were performed a descriptive analysis by a decision tree (Fig. 3).

The sample data were segmented by sex, posteriorly by the presence of *Ponticulus posticus*, and then as complete or incomplete. Also were applied chi square test to analyze the correlation between the presence or absence of the *Ponticulus posticus* in relation to sex and the correlation about the *Ponticulus posticus* is complete or incomplete. The significant level was adjusted to  $<0.05$ .

### 3. RESULTS

From the total sample of 242 individuals, 92 (38.02%) were male sex and 150 (61.98%) were female sex. Among the male individuals, 19 (7.85%) had shown *Ponticulus posticus* with 10 (4.13%) of them presenting incomplete foramen ossification and the other 9 (3.72%) presenting complete foramen ossification. Concerning the females individuals, 34 (14.05%) exhibited this anatomical variation, being 21(8.68%) incomplete and 13 (5.37%) complete.

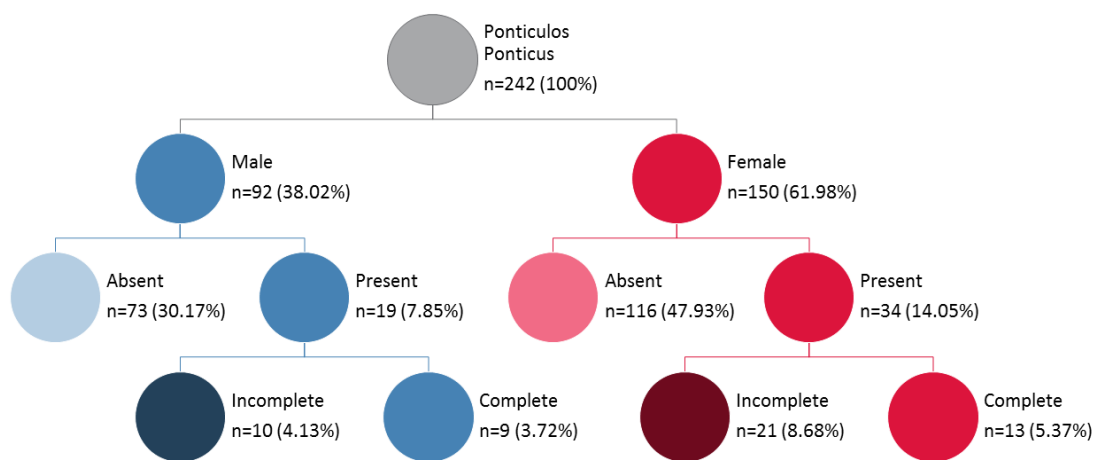
In general, the rate of positive cases of *Ponticulus posticus*, irrespective of sex, was significantly lower (chi-squared,  $P < 0.0001$ ) than negative cases. There was no sex influence (chi-square,  $P = .84$ ) in the presence of *Ponticulus posticus*, indicating that sex is not an



**Fig. 1. A) Lateral cephalometric radiography: The arrow indicates *Ponticulus posticus*  
B) Lateral cephalometric radiography: The arrow indicates the incomplete ossification of the *Ponticulus posticus***



**Fig. 2. Lateral cephalometric radiography: The arrow indicates the absence of the *Ponticulus posticus***



**Fig. 3. Decision tree of sample segmented by sex, absence, complete or incomplete presence of *Ponticulus posticus***

influence factor. In addition, the incidence of incomplete *Ponticulus posticus* did not differ (chi-square,  $P = .72$ ) from complete ones, based on

sex, highlighting the little influence of sex in *Ponticulus posticus* being incomplete or not (Figs. 4 and 5).

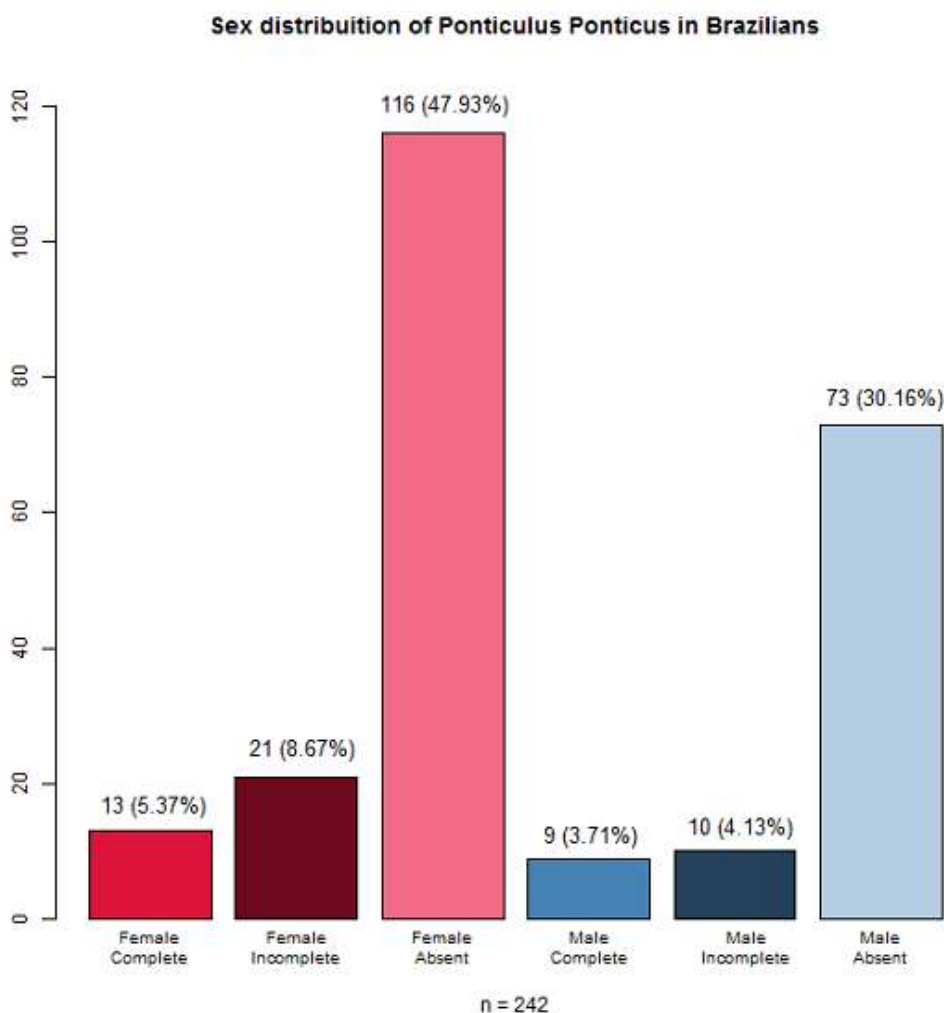
#### 4. DISCUSSION

In dental practice, radiographs are commonly used for diagnostic in maxillo-mandibular structures. Cervical spine can be observed in this type of radiography, but is usually omitted in the cephalometric tracing [6]. *Ponticulus posticus* is an anatomical variation found in Atlas vertebra, and possible to be detected in lateral cephalometric radiographs [11,15,26].

*Ponticulus posticus* incidence in the world population is not well established and only little information exists about its morphology in the literature [9,33]. In the present study, the *Ponticulus posticus* was common in 21.89% of the portion of the assessed Brazilian individuals.

Studies have assessed the incidence of *Ponticulus posticus* in different populations, as shown in Table 1.

In contrast of studies evaluated in Table 1, the results of our study showed that the higher incidence of the *Ponticulus posticus* was incomplete in females. Cederberg et al. [30] evaluated *Ponticulus posticus* presence in 255 radiographs. These authors showed no statistical differences related to sex. In the present study, we evaluated 242 radiographs of Brazilian individuals, which *Ponticulus posticus* was present in 21.89%. Our study showed no sex influence (chi-square,  $P= .84$ ), indicating that sex is not an influence factor.

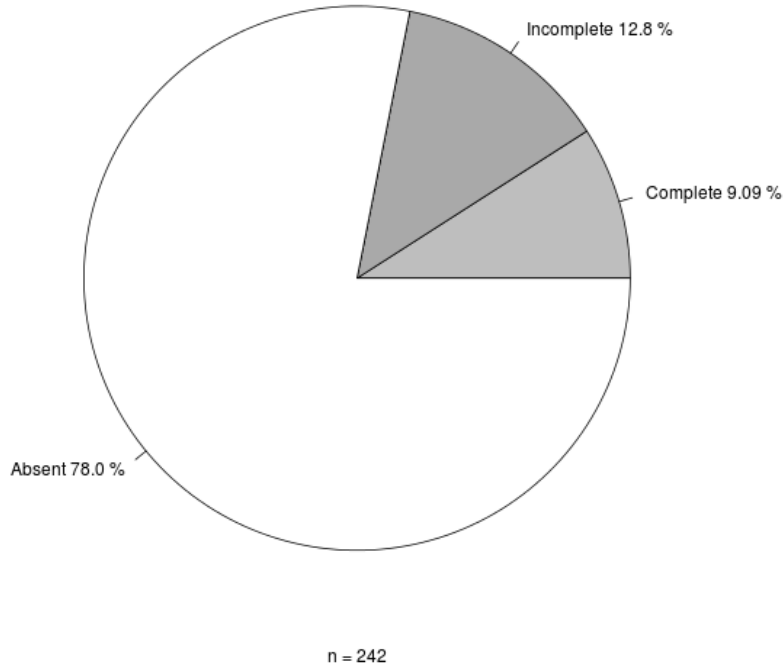


**Fig. 4. Sex distribution of *Ponticulus ponticus* in Brazilians**

**Table 1. *Ponticulus posticus* incidence in the literature**

Reference	Review source	Total prevalence	Study type	Population	Age	Female prevalence	Male prevalence
Wight, et al. 1999 [9]	895 Lateral cervical spine x-ray	161	Prospective study	Scotland	42	86	75
Bezerra, et al. 2001 [2]	Male cadaver	-	Case report	Brazilian	-	-	-
Young, et al. 2005 [10]	464 neck radiographics	72	Retrospective study	USA	NA	NA	NA
Kim et al. 2007 [15]	225 CT and 312 lateral cephalometric	58 in CT 44 in cephalometric	Retrospective study	Korean	45 in CT 28 in cephalometric	21 in CT 25 in cephalometric	37 in CT 19 in cephalometric
Krishnamurthy, et al. 2007 [27]	1044 Dry human atlas	144	NA	India	NA	NA	NA
Simsek et al. 2008 [7]	158 dry macerated atlas	15	NA	Turkey	NA	NA	NA
Cho, 2009 [12]	200 CT and plain radiographics	31	Retrospective study	Korea	45 mean	14 in 100	17 in 100
Karau, et al.. 2010 [28]	204 sides in skeletons	29 sides	NA	Kenya	NA	NA	NA
Kuhta, et al. 2010 [26]	304 lateral cervical spine radiographics	112	NA	USA	NA	NA	NA
Koutsouraki, et al. 2010 [14]	Female patient	1	Case report	Greece	18	-	-
Schilling et al, 2010 [5]	436 Digital lateral cephalometric	84	Cross sectional	Chile	18,44	46	38
Sharma, et al. 2010 [6]	858 Lateral cephalometric	37*	NA	India	15	21	16
Travan, et al. 2011 [8]	Female skeleton	1	Case report	Central Europe	12-14	-	-
Chitroda, et al. 2013 [11]	500 digital lateral cephalography	302	NA	Karnataka region, India	5-70	158	144

Reference	Review source	Total prevalence	Study type	Population	Age	Female prevalence	Male prevalence
Bayrakdar, et al. 2014 [1]	Considered only complete <i>Ponticulus posticus</i>	127 (17.4%)	Cohort	Turkey	8-81	73	54
Elgafy, et al. 2014 [29]	100 CT	14	Retrospective study	Italy	47.1 mean	5	9
Mudit, et al. 2014 [3]	650 Lateral cephalometric	72	NA	Karnataka region, India	20 mean	42	30
Pérez, et al. 2014 [30]	1056 Lateral cephalometric	209	NA	Peru	14.05 mean	NA	NA
Sabir, et al. 2014 [4]	200 Lateral cephalometric and CBCT	58	NA	India	NA	NA	NA
Chen, et al. 2015 [31]	500 CBCT	35	Retrospective study	Taiwan	44.8 mean	23	12
Sekerçi, et al. 2015 [32]	542 CBCT	213	Retrospective study	Turkey	32.7	108	105



**Fig. 5. Distribution of *Ponticulus posticus* in sample**

In general, literature and results of this study showed that the *Ponticulus posticus* incidence does not depend on sex. This bone formation is due to congenital origin [6].

In the sample evaluated, our study showed that the *Ponticulus posticus* incidence cannot be related to the sexual dimorphism. Therefore, there was no sex influence in the presence of *Ponticulus posticus*, indicating that sex is not an influencing factor. Therefore, *Ponticulus posticus* cannot be used as a differential character in sex determination and thus does not contribute in human identification analysis of dental documents, such as radiographs. However, in the literature this anatomical variation was found with a clinical importance as one of the headache etiologies.

## 5. CONCLUSION

The present study concludes that the incidence of incomplete and complete *Ponticulus posticus* did not differ. But more important, *Ponticulus posticus* is an anatomical variation that cannot be related to sexual dimorphism.

## CONSENT

All authors declare that 'written informed consent was obtained from the patient (or other approved

parties) for publication of this paper and accompanying images'.

## ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee (Committee for Ethics of Research of the State University of Campinas - Protocol number CEP- FOP- UNICAMP-014/2014) and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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