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Evaluating the relation between the elongated styloid process and the ponticulus posticus using cone-beam computed tomography

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Background: *Ponticlus posticus (PP) as a one of the cervical vertebra variations brings about symptoms similar to Eagle syndrome. This study aimed to determine the relationship between elongated styloid process (ESP) and PP in a group of Iranian patients using cone-beam computed tomography (CBCT) images.*
Materials and methods: *The CBCT images of 349 patients (118 males and 231 females; mean age: 32.53 ± 14.143) were involved in this study. The atlas vertebra was investigated for the presence and classification of PP (partial or complete) in sagittal views. Also, the styloid process was evaluated for the presence of ESP in reconstructed panoramic and three-dimensional images. Data were analysed using Mann-Whitney test, Fisher's exact test, and Chi-square test to assess the relationship between the presence of PP and ESP with regard to age and gender.*
Results: *Ponticulus posticus was observed in 24.5% of patients with ESP and 31.98% of patients without ESP. There was no significant relationship between the presence of PP and ESP ($p = 0.198$). Twenty-five patients with ESP showed PP; cases of ESP with either side and opposite side PP were 7.84% and 1.96%, respectively. Cases of bilateral ESP and PP were predominant (14.70%). The mean age of patients with bilateral ESP and PP was higher than others. There was no significant difference between males and females ($p = 0.456$).*
Conclusions: *Considering the prevalence and characteristics of PP in the case and control groups, there was no significant relationship between PP and ESP.* (Folia Morphol 2022; 81, 1: 196–202)

Key words: elongated styloid process, ponticulus posticus, cone-beam computed tomography

INTRODUCTION

The styloid process is a cylindrical projection from the inferior part of the petrous temporal bone, with an average length of 20–30 mm. If ossification of the stylohyoid ligament exceeds 30 mm in length, it is considered to be elongated. The incidence of elongated styloid process (ESP) is controversial. Previous studies have reported incidence rates of 0.09% to 54% in different populations [7, 14, 15, 17, 19]. Eagle syndrome is significant clinical condition due to ESP. It is associated with several complications, such as, dysphagia, recurrent throat pain, foreign body sensation, otalgia, tinnitus, globus sensation, cervical pain, headache, pain on neck rotation, dizzi-

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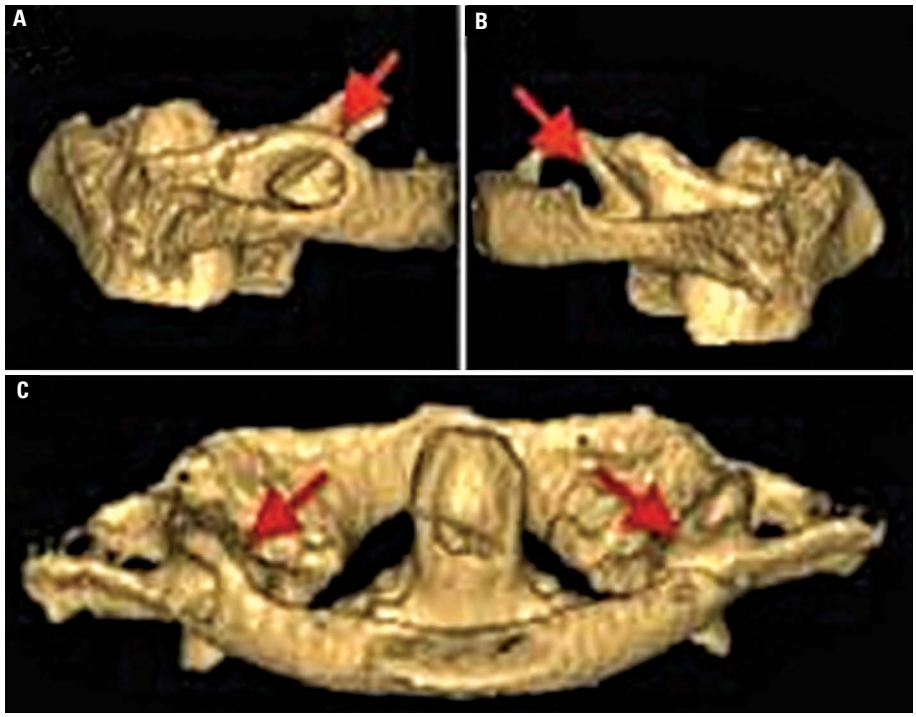

Figure 1. Three-dimensional images show ponticulus posticus on extracted atlas vertebra, with one side complete and the other side partial; **A.** Left-side view; **B.** Right-side view; **C.** Rear view.

ness, cerebral ischaemia, and vertigo [7, 11, 20]. Clinicians are conscious about this medical disorder [1]. On the other hand, one of the cervical vertebra variations brings about similar symptoms like Eagle syndrome [3, 12].

The first cervical vertebra of the spine, known as the atlas vertebra, is composed of an anterior and a posterior arch. The posterior arch contains a groove on its superior surface for the vertebral artery and consists of two lateral masses. This cervical vertebra has several variations, including ponticulus posticus (PP). PP is an osseous anomaly of the atlas vertebra, manifesting as a partial or complete calcified bridge. It is located between the lateral masses and over the vertebral groove of the posterior arch of the atlas (Fig. 1) [2]. Exact aetiology of PP is unknown; however, it may be congenital or age-related as a result of degeneration associated with aging [16].

Ponticulus posticus, with a prevalence rate of 1–46%, is not a rare anomaly. In Western countries, its prevalence ranges from 5.1% to 37.8% [8, 12, 16, 21, 24]. In the Iranian population, the frequency of PP has been estimated at 20.6% [10]. PP may be associated with conditions, such as migraine without aura, headache, cervical pain, diplopia, neck pain, shoulder pain, hearing loss, vertebrobasilar insufficiency, visual disorders, speech and swallowing problems, and vertigo [3–6, 8, 9, 16, 21, 24].

Some of these complications are common between PP and ESP, such as headache, cervical pain, speech and swallowing problems, and vertigo [4, 5, 23]. Considering common symptoms, more investigation about any possible relation between ESP and PP can be beneficial.

A previous study established a significant relationship between the presence of PP and ESP and, PP was found in 21.6% of patients [22]. This study only evaluated the frequency of PP in patients with ESP and did not consider patients without ESP. However, there is little evidence to confirm this relationship. Therefore, the present study aimed to evaluate the relationship between ESP and the presence of PP using cone-beam computed tomography (CBCT) images in the case and control groups as well as to assess the effects of gender and age on PP and ESP occurrence.

MATERIALS AND METHODS

This retrospective study surveyed the CBCT images of patients from the archives of the Dental School of Shiraz University of Medical Sciences, Shiraz, Iran. The patients were referred to the Dental School Clinic

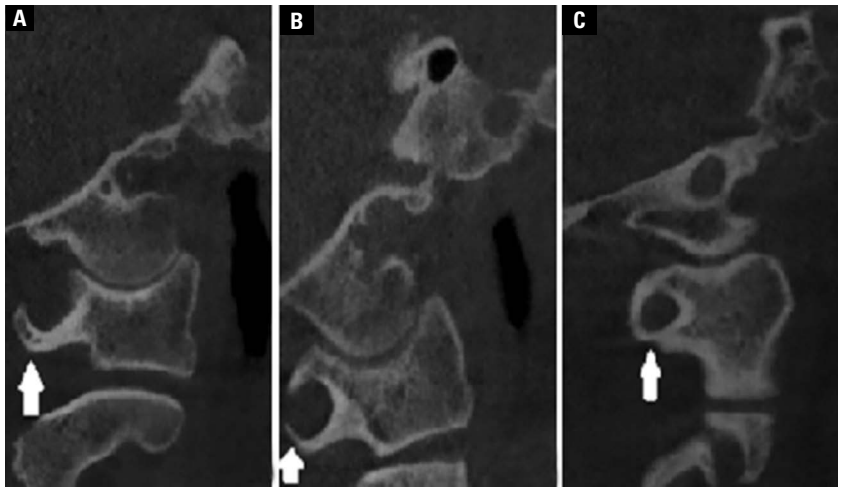

Figure 2. Sagittal cone-beam computed tomography views present; **A.** Without ponticulus posticus (PP); **B.** Partial PP; **C.** Complete PP.

between April 2017 and December 2019 because of different dentofacial problems. Informed contest was taken from patients or their guardians before CBCT examination for probable use in future studies. This study was approved by the Ethics Committee of Shiraz University of Medical Sciences (#IR.SUMS.DENTAl.REC.1399.058). On the other hand, images that could not clearly represent the first cervical vertebra or the apex of styloid process were excluded. Finally, 188 out of 537 images were excluded. In the study group, the CBCT images of 349 patients (118 males and 231 females) were inspected carefully for the presence of PP and ESP.

The CBCT images were acquired using a CBCT system, equipped with a flat panel detector (New Tom VGi, QR srl, Italy). The following parameters were applied for acquiring the images: 110 kVp; total exposure time of 1.8 s; and fields of view of 15 cm × 12 cm and 15 cm × 15 cm. Also, the electrical current (mA) was adjusted automatically for each patient. The subjects were positioned with the Frankfurt plane parallel to the floor. The CBCT images were analysed in NNT version 8.0. For PP assessments, sagittal images were applied. The PP images were categorized as partial or complete, according to their completeness. In the complete type, there was a steady bridge between the lateral mass and the posterior arch, whereas the partial type did not extend fully from the posterior lateral mass to the posterior tubercle (Fig. 2). Images with PP were also categorised as unilateral and bilateral.

To assess styloid process, reconstructed panoramic and three-dimensional images were examined. Styloid process length from where it leaves the tympanic plate of the temporal bone to tip of the process was measured. Styloid process longer than 30 mm was considered to be ESP (Fig. 3). Images with ESP were categorised as unilateral or bilateral. Age and sex were also determined in both groups. The ESP cases were categorised into four groups: group 1 — cases with ESP, but without PP; group 2 — cases with simultaneous ESP and PP on either side; group 3 — cases with bilateral ESP and PP concurrently; and group 4 — cases with ESP and PP on the opposite sides. The

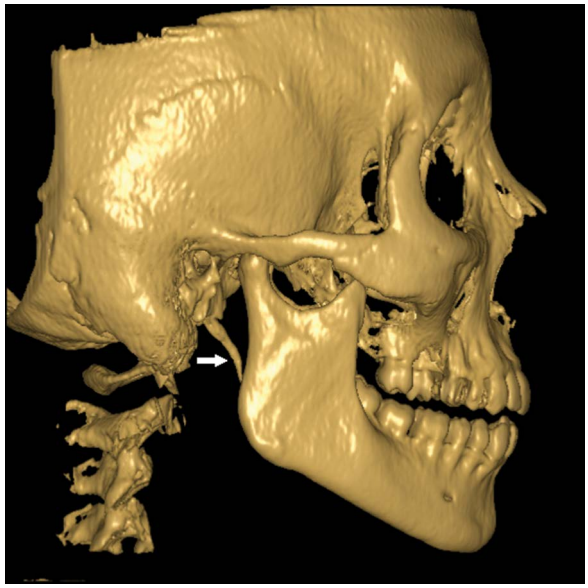

Figure 3. A three-dimensional image of the elongated styloid process in cone-beam computed tomography image.

Table 1. Classification of the case group regarding elongated styloid process (ESP) and ponticulus posticus (PP)

Groups	Coexistence of ESP and PP	N		Total (%)	Mean age	Standard deviation
		Female	Male			
1	ESP without PP	54	23	77 (75.50%)	34.57	11.684
2	ESP and PP on either side	5	3	8 (7.84%)	34.13	13.622
3	Bilateral ESP and PP	10	5	15 (14.70%)	40.25	12.221
4	ESP and PP on the opposite sides	2	0	2 (1.96%)	31.00	2.828

Table 2. Classification of the control group regarding elongated styloid process (ESP) and ponticulus posticus (PP)

Groups	ESP and PP status	N		Total (%)	Mean age	Standard deviation
		Female	Male			
1	No ESP and no PP	105	63	168 (68.02%)	30.52	15.907
2	No ESP with PP on either side (or bilaterally)	55	24	79 (31.98%)	33.82	12.738

control group was also categorised into two groups: group 1 — no ESP and no PP; and group 2 — no ESP but with PP on either side or both sides.

Statistical analysis

Statistical analysis was performed in SPSS for Windows version 23.0 (SPSS Inc., Chicago, IL, USA). Data were analysed using Mann-Whitney test, Fisher's exact test, and χ^2 test to assess the relationship between the presence of PP and ESP. The relationship between these variables was also assessed with respect to age and gender. The level of statistical significance was set at $p < 0.05$.

RESULTS

The study group consisted of 118 (33.81%) males and 231 (66.19%) females, with the mean age of 32.53 ± 14.143 years (total age range: 3–81 years; age range of males: 5–70 years; and age range of females: 3–81 years). The mean age of patients without ESP was 31.55 years (standard deviation [SD] = = 14.89), while the mean age of patients with ESP was 34.89 years (SD = 11.886).

Out of 349 patients, ESP was observed in 102 (29.2%) patients, including 13 (12.75%) ESPs on the left side, 15 (14.70%) ESPs on the right side, and 74 (72.55%) bilateral ESPs. There was no significant difference regarding the prevalence of ESP between males (31/118; 26.3%) and females (71/231; 30.7%) ($p = 0.456$). Bilateral ESP was detected in 51 (50%) female patients, while unilateral ESP was found in 20 (19.61%) female patients. On the other hand, bilateral ESP was found in 23 (22.55%) male patients, and unilateral ESP was detected in 8 (7.84%) male patients ($p = 0.667$).

As mentioned earlier, the case group was divided into four subgroups (Table 1). Group 1 included cases without PP (n = 77, 75.50%), with the mean age of 34.57 years; this group comprised the majority of cases. Also, 25 patients with ESP showed PP. Cases of bilateral ESP and PP (group 3) were predominant. Group 2 and group 4 included cases of either side and opposite side ESP and PP (n = 10, 9.80%). The results showed that the number of female patients with PP was higher than males (17 vs. 8). The control group was also categorized into two groups (Table 2). The control group with PP (group 2) comprised 79 (31.98%) patients, with the mean age of 33.82 years. The results showed that the number of female patients with PP was higher than males (55 vs. 24).

There was no significant relationship between the presence of PP and ESP ($p = 0.198$). Table 3 presents the analysis of PP and ESP in patients regarding the mean age and gender. The mean age of the patients with ESP and PP was higher than that of the control group. Also, the highest mean age (40.25 ± 12.221 years) was reported in cases of bilateral ESP and PP. Considering gender, there was no significant difference between males and females.

DISCUSSION

Ponticulus posticus is an important anomaly of the atlas vertebra [4, 6, 12]. It is associated with complications that have negative effects on the indi-

Table 3. Analysis of the prevalence of the elongated styloid process (ESP) and ponticulus posticus (PP) considering gender and age

ESP	PP							
	Absent				Present			
	Female	Male	Mean age	Standard deviation	Female	Male	Mean age	Standard deviation
Absent	105	63	30.52	15.907	55	24	33.76	12.256
Present	54	23	34.57	11.684	17	8	35.88	12.686

vidual's quality of life, such as migraine without aura, headache, cervical pain, neck pain, shoulder pain, vertebra-basilar insufficiency, visual disorders, and speech and swallowing problems [3, 4, 6, 8, 9, 12, 16, 24]. The importance of PP is not only because of its clinical effects, but is also related to the insertion of lateral mass screws in this area that is a common treatment for atlas fixation in cases of atlantoaxial instability. If surgeons do not pay particular attention to the presence of PP, they may insert a screw into PP that may result in vertebral artery injuries, fractures, screw weakening, or even death [6, 24].

According to the literature, PP is a significant and common radiographic finding in the nevoid basal cell carcinoma syndrome [13]. Moreover, some studies have shown an association between PP and Barré-Lieou syndrome; however, there is little evidence to confirm this relationship [9]. Some complications, such as headache, cervical pain, speech disorders, and swallowing problems, are common between PP and ESP. However, only one previous study considered the presence of PP in patients with ESP [22]. In the present study, CBCT images were analysed to determine the relationship between the presence of PP and ESP. Based on the results, the case group with ESP included 77 (75.50%) patients without PP, 5 (4.90%) patients with PP on the left side, 3 (2.94%) patients with PP on the right side, 15 (14.70%) patients with bilateral ESP and PP, and 2 (1.96%) patients with opposite-side PP. Based on the results, the number of patients with bilateral ESP and PP was higher than that of patients with ESP and PP on one side. In the current study, in the control group (n = 247). 168 (68.02%) patients showed no PP, 11 (4.45%) patients showed PP on the left side, 8 (3.24%) patients showed PP on the right side, and 60 (24.29%) patients had bilateral PP. Overall, PP was not found in the majority of patients in the control group.

There was no significant relationship between the presence of ESP and PP with regard to laterality ($p = 0.198$).

The only 1 study investigated the relationship between PP and ESP and reported a significant association between the presence of PP and ESP [22]. Unlike our study, Sekerci et al. [22] did not include a control group to evaluate the presence of PP in patients without ESP. The mean age of the case group in the present study and the study by Sekerci et al. [22] was almost similar. The present study showed that the majority of patients in the case group had bilateral ESP, which is consistent with the results reported by Sekerci et al. [22] However, the prevalence of PP in their study (39.3%) was higher than the present study (29.8%). It should be noted that the current research and the mentioned study used CBCT images for the evaluation of patients [22]. Therefore, the discrepancy between the results can be related to different ethnicities of the study groups.

Moreover, the incidence rate of ESP in the study by Sekerci et al. [22] was estimated at 21.5%, which is close to the present study (29.2%). Based on our results, although the number of female patients was higher than that of male patients in the groups, the relationship between gender and PP was not significant ($p = 0.460$). In line with the present findings, previous studies did not report a significant relationship between PP and gender [2, 10, 16, 18, 24], whereas Sekerci et al. [22] reported a higher number of male patients than females.

In the current study, the mean age of the patients with ESP and PP was higher than that of the control group. But there was no significant difference between case and control groups. The highest mean age (40.25 ± 12.221 years) was reported in cases of bilateral ESP and PP. There was a significant correlation between the grade of PP completeness and age; in other words, with increasing age, partial PP on the right side tended to become more complete. Some studies have shown that the prevalence of PP increases with age, while some studies found no significant relationship between PP and age [18, 21]. Therefore, further longitudinal research may better

represent this relationship. Overall, the prevalence of PP alone (29.8%) is somehow similar to the prevalence of isolated ESP (29.2%). Although these structures were not rare in the study population, their coexistence was not confirmed.

CONCLUSIONS

The prevalence and characteristics of PP and ESP were evaluated in an Iranian population to assess the relationship between the presence of PP and ESP using CBCT images. According to the results, no significant relationship was found between PP and ESP. The mean age of patients with bilateral ESP and PP was higher than others. Also, a higher prevalence of PP was reported among female patients in both case and control groups.

This study was a retrospective study that did not examine the patients, and there was no information about the patients' symptoms. Therefore, it is recommended to investigate the clinical status of these patients in future studies. Also, further assessment of different racial and ethnic groups can provide us with more reliable results.

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Conflict of interest: None declared

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