The Association of Ponticulus Posticus & Elongated Styloid Process with Headaches

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Purpose: The present study was designed to investigate the association of ponticulus posticus (PP) and elongated styloid process (ESP) with headaches.

Methods: Analysis of head and neck cone beam computed tomography samples from the archives of the Department of Oral Radiology was done for the presence of partial or complete PP and ESP length, type, thickness, mediolateral angulation, anterioposterior angulation (horizontal & vertical), lateral or medial curvature. This was followed by personal & telephonic questionnaires to the subjects for the evaluation of the presence of headaches & other associated symptoms.

Results: Among 134 subjects, 62 subjects (46.3%) presented with headache and 72 subjects (53.7%) did not have any headache. On further analysing the total 62 subjects with headache, it was found out that 31 subjects (50.0%) of them had ESP and PP both, 16 subjects (25.8%) had only ESP, and 15 subjects (24.2%) had only PP. A strong association was present between headache and presence of PP & ESP individually and together.

Conclusions: All health care professionals dealing with the head and neck pain disorders should also consider the presence of ESP & PP during diagnosis and treatment.

Key Words: Cone beam computed tomography; Elongated styloid process; Headache; Ponticulus posticus; Surveys and questionnaires

INTRODUCTION

Headaches are highly prevalent and disabling disorders throughout the world but are largely not diagnosed and treated properly. World Health Organisation’s recent research on the leading causes of disabling conditions lists headache as 12th for women and 19th for men worldwide.¹ The fact that the data of the prevalence of headache disorders has been gathered predominantly from the high-income countries leaving vast geographical areas of underdeveloped and developing countries including India leads to a lack of knowledge of the prevalence and burden attributable to headache disorders among such a large population.²

Minority of people with headache disorders are professionally diagnosed, about 50% of people are estimated to be primarily self-treating worldwide.³ The primary headache disorders account for approximately 95% of all headache complaints. Headache also occurs as a typical symptom of a range of other health conditions, called ‘secondary headaches’.⁴

The ponticulus posticus (PP) is a bridge of bone sometimes found on the atlas vertebra surrounding various nervous and vascular structures and is generally regarded as a simple anatomical variant. It can have varied presentations namely complete, incomplete, unilateral or bilateral. The prevalence of PP has been reported to be 5.14%-37.83% in
the western population.\textsuperscript{5} Among Indian population, complete PP was found in 4.3% of the subjects with a male (5.33%) predominance over female (3.76%).\textsuperscript{6} Due to the compression of the structures passing through the foramen, symptoms such as cervical migraine, neurosensory-type hearing loss, neck pain, vertigo, shoulder-arm pain and, vertebrobasilar insufficiency may occur. Severe headache is present in 56%-90% of subjects.\textsuperscript{7}

The stylohyoid complex (SHC) consists of the styloid process (SP), the stylohyoid ligament (SHL) and the lesser horn of the hyoid bone. The SP is a cylindrical, long cartilaginous bone located on the temporal bone with many adjacent nerves and vessels. The normal SP length is approximately 20-30 mm and is considered elongated if either the SP or adjacent SHL ossification shows an overall length in excess of 30 mm.\textsuperscript{8} The compression of the adjacent neural and vascular structures by the elongated styloid process (ESP) leads to the symptoms of headache, dizziness and reversible cerebral ischemia.\textsuperscript{9}

Sekerci et al.\textsuperscript{7} has confirmed a significant correlation between the presence of PP and ESP. In the present study, our aim was to investigate the association of PP & ESP with headaches. To our knowledge, this is the first study in literature investigating this association.

\section*{MATERIALS AND METHODS}

We designed a retrospective study composed of the cone beam computed tomography (CBCT, Carestream 9300; Carestream Health, Rochester, NY, USA) scans of patients who presented to the Department of Oral Medicine and Radiology, M.S. Ramaiah Dental College, Bangalore. All the patients had been referred for diagnosis and treatment planning for different problems involving the maxillofacial region.

CBCT scans were retrieved from the archives and examined for PP and ESP. Exclusion criteria included inadequate picture quality (artifacts, low resolution, patient movement during imaging), patients presenting with congenital and systemic abnormalities involving the craniofacial region. All medical data were obtained from the records. 4500 full skull CBCT scans (field of view 17×13.5 cm) from the archives of Department of Oral Radiology were examined.

1. Evaluation of the Images

The CBCT scans were analysed using a 32-in. Dell liquid crystal display screen with a resolution of 1,280×1,024 pixels. The contrast and brightness of the images were adjusted using the image processing tool in the software to ensure optimal visualization. The images were reconstructed into three-dimensional images and carefully inspected for the presence of PP and ESP. Out of 4500 full skull CBCT scans, 150 scans showing the presence of ESP (≥30 mm) and/or PP were retrieved and analysed. All the CBCT images were evaluated by two observers. To eliminate any error, 100 randomly selected images were re-examined separately by the same two experts 1 month after initial examination. There was complete agreement between the two authors and the two examinations.

1) Evaluation of the PP

The direct visual method of examination under adequate
Illumination was used to analyse whether PP was complete or partial (Fig. 1). Complete type was defined as a clear bony bridge between the superior articular process and the posterior arch of the atlas in 3-D CBCT images. Partial type was considered as a distinct bony spicule extending from the superior articular facet overhanging the dorsal arch (adapted from Sekerci et al.\textsuperscript{7}).

2) Evaluation of the ESP

SP was evaluated on axial, coronal and sagittal planes. SP was analysed for length, type, thickness, mediolateral angulation, anteroposterior angulation (horizontal & vertical), lateral or medial curvature (Fig. 2).

(1) Length: The distance between the base of the SP and the tip of the ossified SHC. If segmental ossification of the stylohyoid ligament was observed, the measurement was made including the non-ossified part in-between (adapted from Ramadan et al.\textsuperscript{10}).

(2) Type: The SHC ossification was evaluated to be continuous or partial (segmented or pseudo articulated) (adapted from Ramadan et al.\textsuperscript{10}).

(3) Thickness: The maximum thickness of SHC ossification (adapted from Ramadan et al.)\textsuperscript{10}.

(4) Mediolateral angulation: Measured by the angle of intersection of the line connecting both bases of the SP and the longitudinal axis SHC on anteroposterior view (adapted from Ramadan et al.\textsuperscript{10}).

(5) Horizontal anteroposterior angulation: A vertical line was passed from the cranial base of the process, which was vertical to Frankfort plane (a line passing horizontally from the superior border of external auditory meatus to the inferior border of the orbital rim). Anterior angulation was measured as the angle between this vertical line on lateral skull X-ray and the body of the process (adapted from

\textbf{Fig. 2.} Elongated styloid process (A) length, (B) type, (C) thickness, (D) mediolateral angulation, (E) anteroposterior angulation (horizontal & vertical), and (F) lateral or medial curvature. MIP, maximum intensity projection; AVG, arteriovenous graft.
Yavuz et al.\(^{(1)}\)).

(6) Vertical anteroposterior angulation: Anteroposterior angle was defined as the vertical line passing from the cranial base of the process, which was vertical to the Frankfort plane (a line passing horizontally from the superior border of the external auditory meatus to the inferior border of the orbital rim) on the lateral view. The angle between this vertical line and the body of the process was measured (adopted from İlgiy et al.\(^{(12)}\)).

(7) Lateral or medial curvature: The angle between the base of the SP and the tip of the SHC at the level of the bending point on skull base views (adopted from Ramadan et al.\(^{(10)}\)).

2. Questionnaire

The analysis was followed by structured close ended questionnaire consisting of 96 entities (adapted from references\(^{(13,14)}\)) to the subjects for the evaluation of the presence of headaches & other associated symptoms. Out of 150 subjects, 134 responded to the questionnaire (personal and telephonic interviews). The questionnaire had good reliability (0.859) by personal and telephonic interviews on assessment with cronbach alpha test.

Informed consent was obtained from all the subjects.

Statistical analysis was conducted using Statistical Package for the Social Sciences (SPSS) 16.0 for Windows (SPSS Inc., Chicago, IL, USA). Data was analysed for these 134 subjects by the Pearson chi-square test. Statistical significance was considered at \(p<0.05\).

RESULTS

The study group comprised 134 subjects including 86 males (64.2%) and 48 females (35.8%) with an age range of 15 to 86 years. Out of 134 subjects, 114 had the presence of ESP (102 bilateral & 12 unilateral ESP) and 48 had PP (27 bilateral & 21 unilateral PP). Further among these 134 subjects, 86 had only ESP, 20 had only PP and 28 had PP with ESP.

Among 134 subjects, 62 subjects (46.3%) presented with headache and 72 subjects (53.7%) did not have any headache. Out of 114 ESP subjects, 47 subjects (41.2%) presented with headache and 67 subjects (58.8%) did not. Among 48 subjects with PP, 46 subjects (95.8%) had headache and 2 subjects (4.2%) did not. The \(p\)-value was 0.001, thus suggesting a positive association between headache and PP & ESP individually.

On analysing the individual ESP parameters, there was no association between headache and length, type, thickness, mediolateral angulation, anterioposterior angulation (horizontal & vertical), lateral or medial curvature (Tables 1-3).

On further analysing the total 62 subjects with headache, it was found out that 31 subjects (50.0%) of them had ESP and PP both, 16 subjects (25.8%) had only ESP, and 15 subjects (24.2%) had only PP. The \(p\)-value of 0.009 suggested a strong association between headache and presence of PP & ESP together (Table 4).

DISCUSSION

Ponticulus posticus also known as Kimmerle’s variant, foramen retroarticulare superior, canalis vertebralis, retroarticular vertebral artery ring, retroarticular canal and retrocondylar vertebral artery ring. Conflicting theories have been put forward by various authors for the origin of this anomaly. The theories suggested congenital characteristic; genetic trait; ossification due to ageing; external mechanical factors; acquired ossification of ligaments induced by the pulsation of the vertebral artery or activation of existing special osteogenetic potency in the region of the craniovertebral junction. These ponticuli in extreme cases compromise the calibre of the vertebral artery. Ercegovac and Davidovic\(^{(27)}\) alleviated the symptoms of vertebrobasilar insufficiency by surgical removal of the bony ring in 8 cases thus confirming their predisposition to a peripheral compression syndrome. Finale et al.\(^{(18)}\) reported a case of drop attacks on head rotation and hyperextension in an adolescent having PP.

Wight et al.\(^{(19)}\) investigated the relationship of PP and headache symptoms, a significant association was found between PP and migraine without aura. PP is intimately attached to the atlanto-occipital membrane which is further attached to the dura. Thus any mechanical dysfunction at the atlanto-occipital joint could result in traction on the dura, initiating the onset of unilateral headache prevalent in migraine. The treatment modalities available for PP include...
surgical and spinal manipulative therapy (SMT) to the craniovertebral articulation.

The ESP and its clinical symptoms were first described by Eagle. Therefore, it is also known as Eagle’s syndrome (ES).  

The incidence of the ESP ranges between 1.4% and 54% in the literature, whereas incidence of the ES (1%-5%) is much lower. Steinmann anticipated diverse theories to explain the ossification of SHC. These were theory of reactive hyperplasia, reactive metaplasia and anatomic variance. Langlais et al. have classified the radiographic appearance of elongated and mineralized stylohyoid ligaments based on the types of elongation and the pattern of calcification.

Two types of syndrome were described by Eagle. ‘Classic styloid syndrome’ characterized by dysphagia, odynophagia, increased salivation and a sensation of a foreign body in the pharynx, sometimes accompanied by vocal changes. Second type ‘stylocarotid syndrome’ caused by the SHC exerting pressure on the internal and external carotid arteries thus stimulating the sympathetic nerve plexus around the vessels causing orbital pain, parietal headache, vision disturbance and syncopal attacks. Chuang et al. reported

| Table 1. Association of headache with ESP length, thickness, mediolateral angulation, anterioposterior angulation (horizontal & vertical), lateral or medial curvature |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| ESP parameter   | Headache        | Mean            | Std. deviation  | Std. error mean |
| Right ESP length (mm) | Present | 37.58 | 13.99 | 2.04 | 0.33 |
|                 | Absent          | 38.83 | 15.60 | 1.85 |
| Left ESP length (mm) | Present | 35.97 | 13.51 | 1.99 |
|                 | Absent          | 38.70 | 15.44 | 1.83 |
| Right ESP thickness (mm) | Present | 3.79 | 1.43 | 0.20 |
|                 | Absent          | 4.11 | 1.27 | 0.15 |
| Left ESP thickness (mm) | Present | 4.04 | 1.88 | 0.27 |
|                 | Absent          | 4.07 | 1.27 | 0.15 |
| Right ESP ant vertical angle (°) | Present | 30.87 | 7.10 | 1.03 |
|                 | Absent          | 31.54 | 7.58 | 0.89 |
| Right ESP ant horizontal angle (°) | Present | 62.60 | 5.67 | 0.83 |
|                 | Absent          | 61.70 | 6.02 | 0.71 |
| Left ESP ant vertical angle (°) | Present | 31.14 | 6.76 | 0.98 |
|                 | Absent          | 31.19 | 7.35 | 0.87 |
| Left ESP ant horizontal angle (°) | Present | 62.65 | 6.14 | 0.90 |
|                 | Absent          | 62.40 | 5.95 | 0.70 |
| Right ESP medial angle (°) | Present | 66.51 | 5.22 | 0.76 |
|                 | Absent          | 65.63 | 5.27 | 0.62 |
| Left ESP medial angle (°) | Present | 69.06 | 4.54 | 0.66 |
|                 | Absent          | 66.92 | 8.93 | 1.06 |

ESP, elongated styloid process; Std., standard.

| Table 2. Association of headache with left ESP type |
|-----------------|-----------------|-----------------|-----------------|
| Headache        | Continuous | Partial | Total |
| Absent          | 32          | 35        | 67   |
| Present         | 28          | 19        | 47   |
| Total           | 60          | 54        | 114  |

ESP, elongated styloid process. p-value=1.5.

| Table 3. Association of headache with right ESP type |
|-----------------|-----------------|-----------------|-----------------|
| Headache        | Continuous | Partial | Total |
| Absent          | 27          | 40        | 67   |
| Present         | 26          | 21        | 47   |
| Total           | 53          | 61        | 114  |

ESP, elongated styloid process. p-value=1.2.

| Table 4. Association of 62 headache subjects with PP & ESP |
|-----------------|-----------------|-----------------|-----------------|
| ESP             | Present | PP         | Total |
| Absent          | 0       | 15         | 15   |
| Present         | 16      | 31         | 47   |
| Total           | 16      | 46         | 62   |

PP, ponticulus posticus; ESP, elongated styloid process. p-value=0.009.
a case of left hemispheric ischemia within 15 seconds of turning head to the left which was completely reversible on returning the head to the neutral position. The findings were correlated with computed tomography angiography and surgery. Öztunç et al.²⁶ analysed the SP among 208 patients with orofacial pain and concluded that patients suffering from orofacial pain, who also had elongated SP, had increased rate of corresponding neurological complaints compared with non-elongated ones.

The treatment of ES is primarily surgical through an intraoral or extraoral approach.²⁹ Nonsurgical treatments include reassurance, non-steroidal anti-inflammatory medications, analgesics, anticonvulsants, antidepressants, and local infiltrations with steroids or anesthetic agents. Patients who fail to get relief from medical therapy may benefit from surgical removal of the elongated portion of the SP.²⁹

In conclusion, headache is one of the most common disorders worldwide causing substantial levels of disability and lost productivity through missed workdays. Health care for headache needs to be improved by education. According to our study, there is a positive association of headache with PP & ESP. Therefore, ESP & PP could be major etiologic factors responsible for headaches and should be taken into consideration while diagnosing and managing headache disorders. The clinicians, radiologists, surgeons, dentists and chiropractors, should be aware of these anatomical variations and their various clinical features. We recommend further research to determine the type of headaches associated with ESP and PP.

**CONFLICT OF INTEREST**

No potential conflict of interest relevant to this article was reported.

**REFERENCES**