



Evaluation of the styloid process in a Sri Lankan population using digital panoramic radiographs

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ARTICLE INFO

Keywords:

Styloid process
Digital panoramic tomography
Eagle's syndrome

ABSTRACT

Objective: The objectives of this study were to evaluate the normal radiographic length of the styloid process (SP), prevalence and type of elongation, and angulation of the styloid process in relation to sex and side on digital panoramic radiographs in a Sri Lankan population.

Methods: A total of 100 digital panoramic images selected from the database at the Division of Oral Medicine and Radiology, Faculty of Dental Sciences, University of Peradeniya, Sri Lanka were evaluated for the radiological features of the styloid process. Lengths greater than 30 mm were considered as elongated. Elongated styloid processes were also classified into three types based on Langlais classification (elongated, pseudo-articulated; and segmented).

Results: The mean radiological length of the SP on the right and left side was 25.8 mm ± 7.5 mm and 23.2 mm ± 9.0 mm respectively. The prevalence of elongated styloid process in males and female were 34.9% and 24.6%. The maximum length observed on right and left sides were 43.2 mm and 41 mm respectively. However, the differences between the genders and the sides were statistically not significant ($P = 0.199$). The most frequently observed type of elongation was type I (elongated) according to the Langlais classification.

Conclusion: This study provides valuable knowledge of the anatomical variations of the SP which may help clinicians from various specialties to diagnose the Eagle syndrome.

1. Introduction

The stylohyoid chain (SHC) comprising the styloid process, the stylohyoid ligament, and the lesser cornu and upper half of body of the hyoid bone develops from the Reichert's cartilage of the second pharyngeal arch. The styloid process (SP), a slender, pointed bony outgrowth arising from the inferior surface of the petrous part of temporal bone projects in an antero-inferior direction towards the tonsillar fossa and its apex is located critically between the internal and external carotid arteries. Its distal end gives attachment to three muscles, namely, the stylopharyngeus, stylohyoid and styloglossus, and two ligaments, the stylohyoid and stylomandibular ligaments.¹

The location of the SP is considered clinically significant as it relates to many vital neurovascular structures. The internal jugular vein along with the glossopharyngeal, vagus, accessory and hypoglossal nerves run medial to the SP.^{2,3} The internal carotid artery with the sympathetic

chain is also located medial to the SP.

The average length of the SP has been reported to range from 20 to 30 mm.^{4–6} It is considered elongated when it is longer than 30 mm.^{6–8}

Elongation of SP is an anomaly that may be accompanied by calcification of stylohyoid and stylomandibular ligaments.⁴ An elongated styloid process impinging on the neurovascular structures in the vicinity may trigger an array of symptoms like foreign body sensation in the throat, pain when moving the head, vertigo, dysphagia, otalgia, facial pain, headache, tinnitus and trismus.^{4,8,9} The elongated styloid process along with the assortment of symptoms associated with it referred to as the Eagle's syndrome was first described in 1937 by Eagle, an otorhinolaryngologist.⁴ Clinical examination and radiographs are considered important tools to confirm the diagnosis of elongated SP and Eagle's syndrome. Differential diagnosis of ES includes TMDs, tumors of tongue base, trigeminal and glossopharyngeal neuralgia, migraine, unerupted third molars, myofascial pain, and cervical arthritis.^{5,10} The incidence

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<https://doi.org/10.1016/j.jobcr.2018.10.001>

Received 13 July 2018; Received in revised form 31 July 2018; Accepted 3 October 2018

Available online 04 October 2018

2212-4268/ © 2018 Published by Elsevier B.V. on behalf of Craniofacial Research Foundation.

of ESP has a great variability in populations.^{3,5,9–12} Its occurrence in DPTs varies between 4% and 28%, whereas only 4%–10.3% of that is symptomatic.^{5,6} A study done among the Brazilian population using panoramic images has concluded that 43.89% of the study sample consisted of an elongated styloid process.¹¹ A study on human skulls has shown a styloid process of 70 mm and concluded that a length of more than 41 mm could be considered as an elongated styloid process¹³

Despite its clinical relevance, information available on the morphometry and prevalence of elongation and type or pattern of calcification of the styloid process in the Sri Lankan population is scarce. Limited availability of literature together with marked population variations raises the necessity to evaluate the styloid process morphometrically in the local population. Hence, the present study was undertaken to ascertain the length, prevalence and type of elongation, and angulation of the styloid process in relation to sex and side on digital panoramic radiographs in a Sri Lankan population.

2. Materials and methods

A total of 100 panoramic images (43 male and 57 female) were selected from the database. The images selected were from patients in the age range of 20 and 30 years, referred to our unit for routine clinical investigations as part of their dental treatment, who showed no history of trauma or no known history of craniofacial anomalies and craniofacial surgery, and had no clinical evidence of Eagle's syndrome. The patients who had undergone orthodontic treatment and patients having incomplete clinical records were excluded from the study. Clearance was obtained from the Faculty Ethics Review Committee and written consent had been obtained from all the participants for using the data for study purposes prior to image acquisition.

All digital DPTs used in the study have been taken using the Vatech CBCT scanner (Vatech Corporation, South Korea) under standard settings with minimal radiation exposure using the ALARA principle. Images had been stored and converted into DICOM file format using the acquisition software integrated to the machine. All digital images were examined on a 24-inch LCD screen in a dark room using the standard software. Contrast and brightness of the images were adjusted using the image processing tool in the software to ensure optimal visualization. Measurements were obtained using the EzDent software.

The age, gender, length of the SP, type of elongation and the medial angulation of the styloid process were recorded. The angular and linear measurements were obtained using the EzDent software measurement tools with precision values of 0.1° and 0.1 mm, respectively. The types and the pattern of elongation were determined for both right and left styloid process based on the classification proposed by Langlais et al.¹⁴

Measurements of the styloid process were taken as follows.

1. The complete length of the styloid process was measured on the frontal side of the styloid process by a line joining its originating point from the tympanic plate to the tip of the process, regardless of whether the styloid process was segmented.^{6,11} The styloid process that measured > 30 mm was considered as elongated, and the one not exceeding 30 mm was regarded as normal.
2. Elongated styloid processes were categorized according to the classification proposed by Langlais et al.¹⁴ based on radiologic features: type I as elongated, type II as pseudo articulated and type III as segmented. The radiographic presentation of type I, is seen as an uninterrupted integrity of the stylohyoid complex regardless of its length. In type II, the styloid process is apparently joined to the mineralized stylomandibular or stylohyoid ligament by a single pseudo articulation (Fig. 1A). Type III comprises either short or long non-continuous portions of the styloid complex or interrupted segments of mineralized styloid ligament (Fig. 1B).
3. The measurement of the medial angulation of the styloid process was carried out by first drawing, a horizontal line across the hard palate, parallel to it, second, a line perpendicular to the horizontal

line passing through tip of the styloid process, and a third line along the styloid process from the base of the skull to the tip of the styloid process and the angle between the perpendicular line (second line) and the styloid process (third line) was measured.¹⁵

3. Statistical analysis

All measurements were recorded by a single investigator. To assess intra-examiner reliability, 30 cases were randomly selected, and all measurements were repeated. These measurements were made after a reasonable time interval. The two sets of measurements were then compared with paired t-tests. Results were expressed as means and standard deviations (SDs) and the differences between the left and right side and males and females were analyzed using the Statistical Package for Social Sciences (SPSS). Students' t-test was used for the analysis and a significance level of 0.05 was considered for comparisons.

4. Results

The intra-examiner reliability was high, since the paired t tests indicated no significant differences ($P > 0.05$) between the two sets of measurements. DPTs belonging to one hundred patients (185 styloid process in 43 males and 57 females) within the age range of 20–30 years (mean ages were 24.7 years for males, 25.4 years for females, and 25.1 years for the total sample) were assessed. Fifteen styloid processes which were not clearly visualized on the selected DPTs were excluded from the analysis.

4.1. Length and angulation of styloid process

Descriptive statistics including means and standard deviations generated for all variables of the styloid process on the right and left sides separately for males and females and for the total sample are presented in Table 1. The mean values of measurements of length were higher in males than those of the females. The mean values of medial angulation were greater in females than those in males. However, the results of the Student's t-test demonstrated the differences to be non significant ($P = 0.271$).

4.2. The incidence of elongated styloid process

The occurrence of elongated styloid process is presented in Table 2. A total of 29 (29%) individuals had elongated styloid processes. Out of the 57 females 14 (24.6%) showed elongated styloid processes and out of this 14 cases 10 cases were observed to have unilateral elongation. Fifteen male individuals (34.9%) presented with elongated styloid process and the occurrence of an elongated process either in males or females was not statistically significant ($P = 0.199$). In the total sample only 11 (11%) individuals demonstrated bilateral elongations of the styloid process.

4.3. Type of elongation (Table 3)

The most common type of elongation observed within the study group was type 1 (55%), that is elongation as a single unit. The prevalence of type II was 40%, however, the type III or the non continuous portions of the styloid complex or the segmented type was observed only in two cases (5%) and interestingly both these SPs were present in males.

5. Discussion

The length of the styloid process (SP) varies from individual to individual, and population to population. In 1937, Eagle, an otorhinolaryngologist documented that the average length of the styloid process ranges between 25 mm and 30 mm and when it is over 30 mm it is

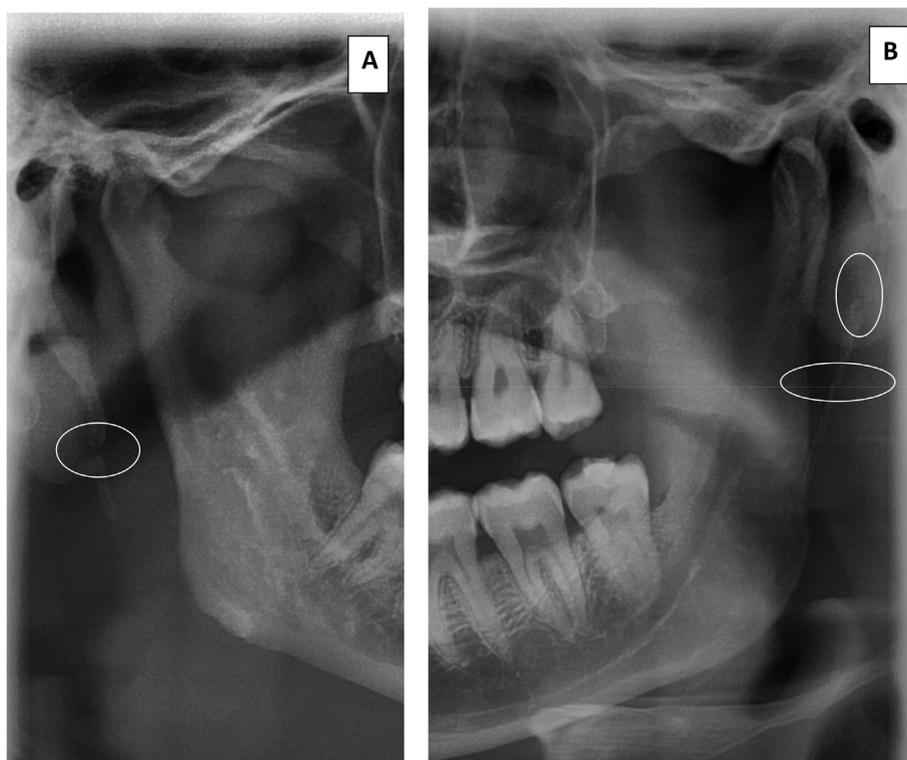


Fig. 1. Cropped panoramic views demonstrating classification based on radiologic features by Langlais et al (1986)¹⁴ (A) type II, pseudo articulated and (B) type III, segmented.

considered as an elongated styloid process causing the stylohyoid syndrome or the Eagle syndrome.⁴

A variety of approaches are available to determine the dimensions of SP and diagnose Eagle syndrome: panoramic radiographs, lateral views of the neck, posterior-anterior view of skull, orthopantomographs, and computed tomography.⁶ Even though Cone Beam Computed Tomography¹⁶ has been used as a method in identifying it, its limited availability, radiation and cost reduced routine use. Besides, numerous studies on dimensions of SP are based on measurements of dry skulls or cadavers. The use of panoramic radiographs is often the preferred method of choice for diagnosis of an elongated styloid process. It is a simple technique of routine use giving an overview of dentomaxillofacial complex.¹⁷ As in previous studies^{6,8,17} we utilized panoramic radiographs to analyze the styloid process in a Sri Lankan population. However, precautions must be taken when conducting and analyzing the images, taking care to stabilize the degree of distortion inherent to the technique and equipment. This criterion is very important, since the measurements are in millimeters and numerical changes observed can mean different statistical results.

Numerous studies have been conducted to determine the length of SP in different population groups. Balcioglu et al.⁸ analyzing the measurements of styloid processes using panoramic radiographs in a Turkish population reported that the mean length of SP in males and

females on the right and left sides to be 25.78 ± 5.68 mm; 22.69 ± 3.68 mm, 25.80 ± 5.75 mm; and 22.75 ± 3.65 mm, respectively. Natsis et al.¹⁰ measuring 262 styloid processes of dry skulls in a Greek population reported that the lengths of right-sided styloid processes ranged from 6.4 to 70.2 mm and left-sided styloid processes from 5.2 to 69.0 mm. Vadgaonkar et al.³ observed that the mean length of the styloid process was 17.8 ± 9.3 mm and 18.2 ± 5.6 mm for the right and left sides, respectively in dry skulls of a south Indian population. In females, the mean length of the SP was 25.3 ± 4.9 mm and 25.8 ± 4.4 mm and 24.8 ± 5.5 mm on the right and left side, respectively whereas in males the corresponding values of the SP was 27.4 ± 5.9 mm and 28.4 ± 6.2 mm and 26.4 ± 5.4 mm, respectively.

Eagle⁴ reported that a normal styloid process measures between 25 mm and 30 mm and any length more than the above, should be considered as a pathogenic factor for Eagle syndrome. Kaufman et al.¹⁸ reported that the upper limit for a normal styloid process is 30 mm. According to Jung et al.¹⁹ a styloid process of only more than 45 mm length should be considered to be elongated.

The reported incidences of elongated styloid process vary considerably in different population groups. Eagle estimated the incidence of an elongated styloid process in the general population to be 4%, of which he reported only 4% displayed symptoms. Ilguy et al.⁶ reported an incidence of elongated styloid process as 3.7%, (female/male ratio:

Table 1
Measurements of the styloid process on the right and left side of males and females.

Measurement	Right Side	Left Side	Males		Females	
			Right side	Left side	Right side	Left side
Length (mm)	26.9 ± 5.4	25.5 ± 5.5	28.4 ± 6.2 27.4 ± 5.9	26.4 ± 5.4	25.8 ± 4.4 25.3 ± 4.9	24.8 ± 5.5
Medial angulation (°)	24.8 ± 9.4	24.6 ± 11.4	22.1 ± 10.5	24.2 ± 10.3	26.8 ± 7.9	24.9 ± 12.2
Maximum Length (mm)	43.2	41	43.2	41	37	34
Maximum Angle	42.4	50.9	42.4	48.4	42.4	50.9

Table 2
The Occurrence of elongated styloid process.

	Total number of SPs examined	Elongated process (> 30 mm)	Percentage (%) of elongated SPs	Percentage of radiographs with unilateral elongation (%)	Percentage of radiographs with bilateral elongation (%)
Females N (n)	57 (105)	14 (18)	24.6	17.5	7.1
Males N (n)	43 (80)	15 (22)	34.9	18.6	16.3

N – Number of subjects; n – Number of styloid processes.

Table 3
Types of elongation of styloid process (according to classification based on radiologic features by Langlais et al.¹⁴).

	Type I	Type II	Type III	Total
Right Side	13	11	1	25
Left Side	9	5	1	15
Total (%)	22 (55)	16 (40)	2 (5)	40

3:1) with most being bilateral in a Turkish population. In a Brazilian population, Custodio et al.²⁰ examining dry skulls, reported an incidence of 6.6%. Bozkir et al.²¹ reporting an incidence as 4% stated that 63% of patients showing elongated processes were male and 75% of the cases were bilateral. In another study Balcioglu⁸ examining panoramic radiographs estimated the incidence of elongated styloid process as 3.3% for the total sample. They further detected 6 (55%) bilateral cases, and the male/female ratio was 1/9 in the radiographs.

The incidences determined in these studies agree with the findings of Eagle. However, in contrast to these findings a considerable difference was demonstrated with the findings of Correll et al.²² Kauffman et al.¹⁸ and Keur et al.²³ where the incidence reported was as 18.2%, 28% and 30%, respectively. The incidence of elongated styloid process estimated as 26% in males and 20% in females in the present study which is comparable with the findings of Kaufmann et al.¹⁸ and Keur et al.²³ Higher incidences have been reported in a North Italian (33%)¹² and a central Brazilian (43.89%) population.¹¹ The discrepancies in the results may be attributed to the differences in populations studied and image interpreting criteria applied.

Although different studies have reported different incidences of elongation of the styloid process, it is widely agreed that only a small number of cases with elongation present with symptoms.^{4,8} In the present study, the elongated styloid process was more frequently found in males than in females. This finding is consistent with the observations reported by other authors,^{9,24} who identified a higher prevalence of elongated styloid process among the male population. However, in contrast to this finding Ilguy et al.⁶ observed a female-male ratio of 3:1.

The exact cause of elongation of SP is still not clearly understood. Various theories have been put forward to explain the elongation. According to Steinman²⁴ the theory of reactive hyperplasia proposes that trauma can cause such ossification; the theory of reactive metaplasia explains that it is a post traumatic healing response, and the theory of anatomic variance states that such ossification is simply an anatomical variation that occurs without any recognizable trauma. This latter theory explains the early occurrence of such ossification in children and young adults who have not experienced any prior cervicopharyngeal trauma. A precise understanding of the mechanism of styloid process elongation requires a knowledge of its embryogenesis. The ligament has the potential to mineralize because of its cartilaginous origin. According to the Langlais et al.¹⁴ the most common type of elongation observed within the study group was type 1 (55%) that is as a single unit and this finding is in conformity with the findings of most previous studies.^{6,10,25}

6. Conclusions

Present study provides valuable knowledge of the anatomical

variations of the SP among Sri Lankans which may help clinicians from various specialties to diagnose Eagle syndrome. This study demonstrates the normal range of length of SP which can be used in diagnosing ES and will help in minimizing under or over treatment of the condition. Knowledge of this disorder can prevent the worsening of the painful symptoms related to the elongated SP. We believe that this study provides additional information about the frequency of elongated styloid process in a Sri Lankan population.

Sources of funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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