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Length of the styloid process and anatomical implications for Eagle's syndrome

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The styloid process is a bony projection, located just anterior to the stylomastoid foramen, the normal length of which is approximately 20–25 mm. Elongation of the process may cause various clinical symptoms such as neck and cervicofacial pain, described as Eagle's syndrome. The present study aimed to determine the mean length of the styloid process on cadavers, panoramic radiographs, and dry skulls, and to investigate the incidence of the elongated styloid process, while assessing the elongation in relation to Eagle's syndrome. When the measurements from the panoramic radiographs were assessed, the mean length of the styloid processes in males and females on the right and left sides were found to be the following: 25.78 ± 5.68 mm; 22.69 ± 3.68 mm, 25.80 ± 5.75 mm; and 22.75 ± 3.65 mm, respectively. The males had greater styloid process lengths than the females, and the differences in length on both the right and left sides were statistically significant. Descriptive statistics and comparison results according to age groups were determined. There was no statistically significant difference between right or left styloid process lengths according to age groups. The mean length of the styloid process of the cadavers and dry bones was 22.54 ± 4.24, and there was no significant difference between the right and left sides of the cadavers and dry bones. The incidence of the elongated styloid process was determined as 3.3%, and the elongations revealed a female dominance. The average length of the elongated styloid process was 36.06 ± 6.12 mm, while the mean length of the styloid processes of the subjects reporting Eagle's syndrome was 40 ± 4.72 mm. The results of this morphological study will assist clinicians in the diagnosis of Eagle's syndrome. (Folia Morphol 2009; 68, 4: 265–270)

Key words: elongation of the styloid process, panoramic radiograph, Eagle's syndrome

INTRODUCTION

Eagle's syndrome or elongated styloid process syndrome was first described by Eagle, an otorhinolaryngologist, who first presented two cases with symptomatology of elongated styloid process, in his article of 1937 [8]. The syndrome presents with ipsilateral cervicofacial pain which may be referred to the ear. The pain frequently focuses on the angle of the mandible and worsens when the head rotates. A protrusion may often be felt on palpation of the ipsilateral tonsillar fossa. Symptoms such as sensation of a foreign body in the throat, dysphagia, tin-

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nitus, and otalgia may accompany. Diagnosis can usually be made during a physical examination by digital palpation of the styloid process in the tonsillar fossa. When palpated, the symptoms of the patient may intensify [2, 7, 9].

The styloid process (SP) is a bony projection located just anterior to the stylomastoid foramen, the length of which averages from 20 to 25 mm. The tip of the process is situated laterally from the pharyngeal wall and immediately behind the tonsil fossa, and critically between the internal and external carotid arteries. Three muscles and two ligaments are attached to the SP. It is considered elongated when it is longer than 30 mm [16]. Panoramic radiography is the most common projection to detect an elongated SP. The mean length of the SP, determined by measuring from panoramic radiograph (PR), was reported to range from 20 to 30 mm [14].

The aims of the present study were: 1) to determine the mean length of the styloid process on PRs, cadavers, and dry bones, 2) to evaluate elongation of the styloid process, 3) to present the incidence, and 4) to investigate the relationship of the anatomy of the styloid process with Eagle's syndrome.

MATERIAL AND METHODS

Measurements on panoramic radiographs

PRs were obtained from the radiology archive of the Anatomy Department in the Dental Faculty at Istanbul University. The measurements of the styloid processes on the radiographs that revealed certain anatomical depictions were determined by a single author, using a digital calliper. Retrospective reviews of the patients' charts concerning Eagle's syndrome along with the analysis of the PRs were performed.

In most of the studies performed on the PRs, a styloid process measuring 30 mm or more in length was considered as elongated [6, 11, 12, 18]. We classified the length of the SPs measured on the PRs, in this respect.

Population and sampling

The size of the sample required for the study was calculated using the G*Power Ver. 3.0.10 (G*Power, Franz Faul, Universität Kiel, Germany) program. It was found that, in order to obtain 90% power at an error level of $\alpha = 0.05$ and at $d = 0.40$ effect size, a total of 216 subjects (108 males and 108 females) for each group would be sufficient. However, as 108 male subjects could not be included, the study was completed with a total of 227 participants with the included substitute participants.

Statistical analysis

The consistency of right and left styloid process lengths obtained from the subjects was analyzed for normality using the Shapiro-Wilk test. Neither of the measurements was found to be normally distributed amongst the study group. The presentation of descriptive studies used average ± standard deviation and median presentation. The differences between the ages of the subjects according to gender were analyzed using Student's t-test. A Mann-Whitney test was used to analyze the difference between right and left styloid process length according to gender. A Kruskal Wallis variance analysis was used to compare right and left styloid process length according to age groups. Spearman's rank correlation coefficient was calculated for the correlation between age and styloid process lengths. Microsoft Excel and SPSS (version 15.00 for Windows. SPSS Inc., Chicago, IL, USA) programs were used for statistical analysis. For statistical tests, a value of $p \leq 0.05$ was accepted as statistically significant.

Measurements on cadavers, dry skulls, and isolated temporal bones

The dissections were performed bilaterally on 22 formalin-fixed cadavers (19 males, 3 females) in the Department of Anatomy at Gulhane Military Medical Academy. The styloid processes were dissected with utmost care considering the relationship with the carotid arteries in order to investigate a possible impingement of internal or external carotid artery.

Dry bones were obtained from the Osteology Lab of the Anatomy Department in the Dental Faculty at Istanbul University. The number of measurable SPs out of 110 dry skulls and 38 isolated temporal bones was 41.

Owing to the fact that the sex and ages of the dry skulls and isolated temporal bones were unknown, and that the measurable SPs of the dry bones and cadavers were inadequate in number, only the mean lengths were determined by using Student's t-test.

RESULTS

Panoramic radiographs

The study was carried out with a total of 227 participants: 103 (45.4%) male and 124 (54.6%) female. The youngest participant was 18 years old while the oldest participant was 70 years old (average age

Table 1. Comparison of the styloid process lengths according to sex

Sex	Location	Mean	SD	Median	Z	P
Male (n = 103)	Right	25.78	5.68	24.93	0.106	0.915
	Left	25.80	5.75	24.88		
Female (n = 124)	Right	22.69	3.68	22.47	0.109	0.913
	Left	22.75	3.65	22.25		

SD — standard deviation

Table 2. Comparison of the styloid process lengths according to the age groups

Location	Age groups	N	Mean	SD	Median	X^2	P
Right	18–34	74	24.20	4.79	23.72	0.270	0.874
	35–49	73	23.93	5.01	23.72		
	> 50	80	24.13	5.05	23.84		
Left	18–34	74	24.30	4.81	23.99	0.550	0.760
	35–49	73	24.12	5.32	23.97		
	> 50	80	23.99	4.77	23.97		

SD — standard deviation

43.35 ± 14.88 years). No significant difference was found in the ages of the participants, according to gender (t = 0.468; p = 0.640). Male and female participants were of similar ages. The subjects were divided into three groups according to their ages; 18–34 years old, 35–49 years old, and 50+ years old. Descriptive statistics of the measured right and left SP length of the participants according to gender are given in Table 1.

Table 1 indicates that right and left styloid length does not show a statistically significant variation between females and males (p > 0.05). Right and left styloid process lengths of the females are statistically similar. Similarly, right and left styloid process lengths of the males are statistically similar.

The males had greater styloid process lengths than females (Table 1). The differences in SP length at both right and left sides were statistically significant (Z = = 4.211; p < 0.001, Z = 4.244; p < 0.001, respectively).

Descriptive statistics and comparison results according to age groups are given in Table 2.

Table 2 indicates that there is no statistically significant difference between right or left styloid process lengths according to age groups. No statistically significant correlation was found between right and left styloid process lengths and age, which supports our finding (R = –0.017; p = 0.794, R = –0.032; p = 0.630, respectively).

There are statistically significant differences between males and females in all of the age groups on both right and left sides (p < 0.05). The length of the styloid process of males is statistically greater than the females in all age groups and on both sides (Table 3).

Cadavers, dry skulls, and isolated temporal bones

The mean length of the SP of the cadavers and dry bones was 22.54 ± 4.24, which indicates similarity with the mean length of the SPs measured on PRs. There was no significant difference between the right and left sides of the cadavers and dry bones (p > 0.05).

In addition, the following results are notable:

— the average length of the elongated styloid process was 36.06 ± 6.12 mm;
— 10 of 250 panoramic radiographs and 2 of 22 cadavers revealed elongation of styloid process (Figs. 1, 2), which means an incidence of 3.3%;
— among the 10 radiographs, only one belonged to a male, the rest of the patients were female. Both of the two cadavers revealing elongated styloid process were male. Bilateral elongation was depicted in 6 of 10 PRs;
— no elongation was detected on dry bones, but most of the SPs were broken;
— 4 of the 10 subjects showing elongated styloid process in their panoramic radiographs reported symptoms of Eagle's syndrome. The mean length of these 4 processes was 40 ± 4.72 mm;

Table 3. Sex-related comparison of the styloid process lengths according to the age groups

Age group	Location	Sex	N	Mean	SD	Median	Z	P
18–34	Right	Male	35	26.13	5.21	25.18	2.751	0.006
		Female	39	22.47	3.64	21.46		
	Left	Male	35	26.22	5.28	24.88	2.946	0.003
		Female	39	22.58	3.62	21.50		
35–49	Right	Male	33	25.47	5.78	24.20	2.097	0.036
		Female	40	22.67	3.92	22.59		
	Left	Male	33	25.94	6.30	24.53	2.291	0.022
		Female	40	22.62	3.82	22.24		
> 50	Right	Male	35	25.73	6.17	25.18	2.315	0.021
		Female	45	22.89	3.57	22.95		
	Left	Male	35	25.24	5.78	24.88	2.043	0.041
		Female	45	23.02	3.58	23.38		

SD — standard deviation

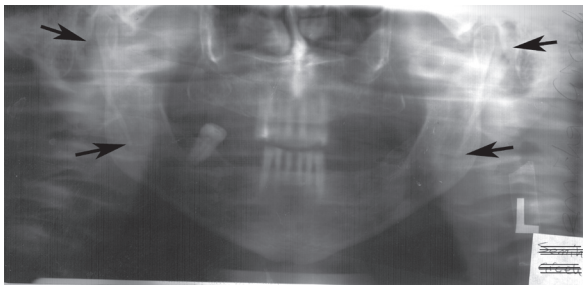

Figure 1. Bilateral elongation of the styloid process on a panoramic radiograph.

— none of the styloid processes in the cadaver specimens revealed an extreme proximity or deviation that might have caused an impingement of carotids.

DISCUSSION

The styloid process, which arises embryonically from the Reichert cartilage of the second branchial arch, is a long and thin outgrowth at the base of the temporal bone, immediately in front of the stylomastoid foramen, posterior to the mastoid apex. It serves as a point of attachment for the stylomandibular ligament as well as the styloglossus, stylohyoid, and stylopharyngeus muscles. Elongation of it is a poorly understood process. Commonly admitted theories about the actual cause of the elongation of the styloid process are defined as congenital elongation of the styloid process, calcification of the stylohyoid ligament by an unknown process, and growth of osseous tissue where the stylohyoid ligament inserts [1, 4].

The reported incidences of elongated styloid process are not within a wide range, but some of the

Figure 2. Elongated left styloid process measured with a digital calliper on a cadaver head; *stylohyoid ligament; +styloglossus muscle; #stylohyoid muscle.

patients may not show clinical symptoms. Ilguy et al. [10] reviewed 850 PRs and reported the incidence of elongated styloid process as 3.7%, and a 1/3 male/female ratio was noticed in their study. They stated that elongated styloid processes were mostly bilateral. Bozkir et al. [3] claimed that 63% of patients showing elongated process were male and 75% of

the cases were bilateral. They reported the incidence as 4%. The incidence of elongated styloid process was estimated at 3.3% for the total sample in our study. We detected 6 (55%) bilateral cases in PRs, and the male/female ratio was 1/9 in the radiographs. The two elongated processes detected in the cadavers were both male. The 3.3% incidence we determined agrees with the findings of Eagle [8], Winkler et al. [19] (4%), Ilguy et al. [10] and Bozkir et al. [3], whereas a considerable difference occurred with the findings of Scaf et al. [18], Correll et al. [6] and Keur et al. [11]. The latter three found the incidence as 12.6%, 18.2%, and 30% in their study, respectively. The discrepancies in the results may arise from the differences in radiographic criteria applied and populations studied.

Woolery [20] stated that Eagle's syndrome occurs more frequently in women. Our findings fitting with the assertion of Woolery are not in agreement with other studies declaring no relationship to sex [10]. Larger samples should be investigated for a briefer hypothesis about sexual dimorphism. However, since the incidences determined by the studies performed in Turkish samples appear to be almost the same (3.7%, 4%, and 3.3%; Ilguy, Bozkir, Balcioglu), the incidence in Turks may be speculated to be 3–4%.

Bozkir et al. [3] stated that the average length of the elongated styloid process was 53 mm but did not state the mean length of the SPs in their sample. In a cadaver study of Moffat et al. [13], the length of SP was reported to vary between 15.2 and 47.7 mm, while Montelbetti et al. [15] claimed the length of normal SP was less than 25 mm. In a computed tomography study, Onbas et al. [17] estimated the length of the SP on both sides to vary between 0 and 62 mm (mean 26.8 mm). Our findings agree with these earlier reports.

SP greater than 25 mm in length, as measured on the PR from the cranial base to the tips of the processes, is considered elongated [19]. However, since the most common findings vary between 20––30 mm, and when the mean lengths we found are considered, the SP should be considered to be elongated when it is more than 30 mm in length.

The disadvantage of magnification and distortion on the PRs must be taken into consideration when assessing the comparisons given here and in the other studies.

Eagle's syndrome is reported to occur unilaterally or bilaterally [2], and the consensus among researchers is that symptomatic subjects are over 40 years of age [4]. In the present study, the symptomatic subjects were all older than 40, and all had the symptoms unilaterally.

Lateral or medial deviation of the SP, which may result in impingement of the internal or external carotid artery, is described as another form of the syndrome. A referred pain may accompany the distribution of the artery, caused by stimulation of the sympathetic nerve plexus associated with the artery. Facial pain by impingement and stimulation of the external carotid artery plexus may develop [5]. We did not find any carotid artery showing an impingement by a deviated SP during the cadaver dissections.

It is crucial for the dentists, otolaryngologists and neurologists to be aware of the elongation of the SP and its anatomical basis. If any of the symptoms exist, digital palpation of the SP as a simple diagnostic procedure should be routine during the examination. Owing to the fact that SP with normal length is not normally palpable, the examination may easily reveal the problem. In addition to the physical examination, use of PR, which is a cheap and non-invasive imaging method, is a gold standard for the exact diagnosis.

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