Clinical and Experimental Health Sciences

Prevalence and Pattern of Stylohyoid Chain Complex on Panoramic Radiographs: A Retrospective Study

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ABSTRACT

Objective: The elongated styloid process (SP) and calcified stylohyoid ligament can be evaluated radiologically and are associated with some symptoms and syndromes. This study aimed to define the incidence of different stylohyoid chain patterns and classify them.

Methods: Digital panoramic radiographs of 1217 patients were included in the study. The styloid chain patterns were analyzed according to MacDonald-Jankowski's study. Data analysis was performed using the IBM SPSS Statistics 21.0 (Statistical Package for Social Sciences) program. Descriptive values were analyzed by using descriptive statistics. The data were assessed by using Chi-squared tests. A probability level of less than .05 ($p < .05$) was considered significant.

Results: The prevalence of the stylohyoid chain complex patterns was higher for normal SP (86.5%), followed by elongated SP (7.1%), calcified stylohyoid ligament (2.2%), and absent stylohyoid chain (2.8%). Unclassified SP was detected in twenty individuals on the left (1.6%) and fourteen on the right (1.2%). In view of symmetry of the stylohyoid chain complex, 979 (80.4%) were symmetric, 238 (19.6%) were asymmetric and 14 (1.15%) of the asymmetrical ones were unilateral. There was no significant difference in gender for the type of stylohyoid chain complex pattern ($p > .05$). There was statistically significant difference between the stylohyoid complex pattern and age groups for the right and left sides ($p < .05$).

Conclusion: The authors believe that this study provides additional information about the frequency of the elongated styloid process and provides valuable knowledge of the anatomical variations of the SP. Current findings should be correlated with clinical symptoms in future studies.

Keywords: Styloid process, Digital panoramic radiography, Diagnostic imaging, Ossification, Eagle's syndrome

1. INTRODUCTION

The protrusion of the temporal bone extending down-front from the pars tympanica is referred to as styloid process (SP). The SP is a slender, cylindrical bone extension extending between the internal jugular vein and carotid arteries, posterior to the tonsillar fossa and anteromedial to the stylomastoid foramen. It measures approximately 2.5-3 cm in length and develops from the Reichert's cartilage in the second branchial arch. The styloglossus, the stylopharyngeus, and the stylohyoid muscle, and the stylohyoid ligament are attached to the distal part of the SP. The styloid ligament is located between the SP and lesser horn of the hyoid bone. The SP, the stylohyoid ligament, and lesser horn of hyoid bone form the stylohyoid complex (1-4).

Chronologically, the first elongation of SP and ossification of the styloid ligament was reported by Pietro Marchetti in 1652, and the first enrolled case of elongated SP in which Prof. Josef Weinlechner performed surgery in 1872, in Vienna (5, 6). In 1937 Dr. Watt W. Eagle, an otorhinolaryngologist, reported two symptomatic, mineralized SP cases. He noted the patients' complaints of "nagging or aching sensation in the throat similar to chronic pharyngitis" (7-10). Eagle was also the first to put forth the features of the syndrome in detail, and correlated it to the ossified styloid ligament and elongated SP, which is today known as Eagle's Syndrome. The SP is referred to as elongated when it exceeds 30 mm. Eagle' Syndrome determined that only around 4% of the population had an elongated SP and a calcified stylohyoid ligament, and only between 4-10.3% of these cases showed symptoms (8, 10-12). The clinical signs are foreign body sensation, ear pain, neck pain, facial pain, carotid pain, pain during tongue extension, discomfort when chewing, dizziness, headaches, and sore throats. The SP elongation is more common in women than men, and frequently with bilateral calcification

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(2, 13, 14). Some studies have reported that women have more symptoms than men and occur more frequently in older women, possibly due to menopause (2, 15).

The SP elongation can be determined as a coincidental finding frequently on panoramic radiographs during routine clinical examination in dentistry (2, 16). The imaging methods that detect the SP are panoramic radiography, Towne's view, lateral oblique mandible view, lateral cephalogram, posteroanterior skull view, computed tomography (CT), cone beam computed tomography (CBCT), and magnetic resonance imaging (16-18).

Diagnosis of this condition is not easy for the clinician because of its vague symptomatology and symptoms of the impacted third molar, temporomandibular disorders and dental diseases reflected in the relevant area. Therefore, dentists must have sufficient knowledge of the characteristics of SP to diagnose the cause of SP-related symptoms (19).

The purpose of this study was to investigate the incidence, and calcification patterns of elongated SP in a Turkish subpopulation using digital panoramic radiographs, and its relation, if any to subject sex and age.

2. METHODS

The Research Ethics Committee of Necmettin Erbakan University approved this study (approval date and number: 27.05.2021 and 2021/06-65) which was conducted according to the guidelines of the Declaration of Helsinki. All patients singned informed consent.

All images were obtained using a Morita Veraviewepocs 2D panoramic unit (J Morita MFG Corp., Kyoto, Japan) with parameters of 60-70 kVp, 5-7 mA, and 6-8 s exposure time, according to the manufacturer's recommended protocol.

Radiographs that do not contain information about the age and sex of the patients, patients with tonsillectomy, head trauma, and panoramic images with poor quality, and/or do not show SP, having positioning and magnification errors constitute the exclusion criteria. This study used only diagnostically acceptable images. The study was performed on 1217 radiographs with inclusion criteria out of 1450 digitally archived panoramic radiographs at Necmettin Erbakan University, Faculty of Dentistry, Department of Dentomaxillofacial Radiology. Data were evaluated on an LCD monitor in ambient light by two maxillofacial radiologists with more than three and eight years of experience in ten sessions at 5-day intervals to rest the eyes. The final classification and radiographic status was recorded after inter-observer consensus.

The stylohyoid chain complex patterns were classified according to MacDonald-Jankowski's study (20). The SP patterns recorded bilaterally and pattern of calcification was described according to the center of calcification involved: Region 1, tympanohyal (the base of the SP); Region 2, stylohyal (forms the major portion of the SP); Region 3, ceratohyal (forms the stylohyoid ligament); Region 4, hypohyal (forms the minor horn of the hyoid bone). In Figure 1, the 12 patterns are detailed from the minor calcification pattern and whether the zones are continuous or distinct.

The patients' stylohyoid patterns have been grouped as normal (N), elongated (E) and calcified (C) samples coequal with the MacDonald-Jankowski's (20) method. In this process, patients who have absent or unclassified stylohyoid complex (Patterns L or U) were excluded from the analysis. Then remaining patients were analyzed statistically to determine whether age or sex influences groups of stylohyoid patterns. For this purpose, the age range of the patients have been divided into three groups: 18-30 (young adults), 31-50 (middle-aged adults), and 51+ (older adults).

All statistical analyses were performed with SPSS 21.00 software (SPSS, Chicago, IL, USA). In addition to descriptive statistics, the Chi-square test was used to evaluate statistical significance, and the significance level was set at α=.05.

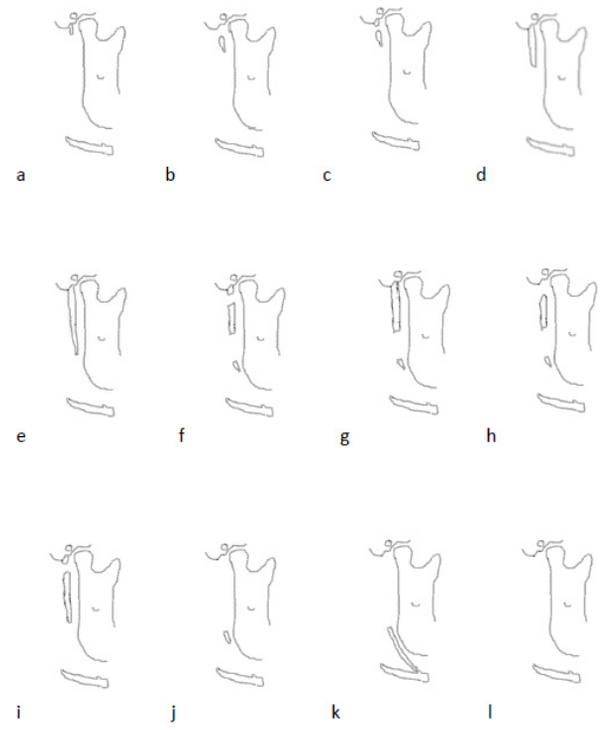

Figure 1. *The 12 patterns of calcification of stylohyoid complex used in this study. Pattern: (a) Region 1=tympanohyal alone: (b) Region 2 stylohyal alone: (c) Region 1 and 2, separate: (d) Regions 1 and 2, continuous: (e) Regions 1, 2 and 3, continuous: (f) Regions 1, 2 and 3, separate: (g) Regions 1 and 2, continuous, but separate from 3: (h) Regions 2 and 3, separate: (i) Regions 2 and 3, continuous, but separate from 1: (j) Region 3 alone: (k) Region 3 and 4, continuous (may include calcification in one other region): (l) No styloid process visible. Regions 1, 2, 3 and 4 coincide with the centres of calcification. Patterns A-D are normal styloid processes. Pattern E is an elongated styloid process. Patterns F-K are calcified stylohyoid ligaments. Pattern L is absent stylohyoid chain complex.*

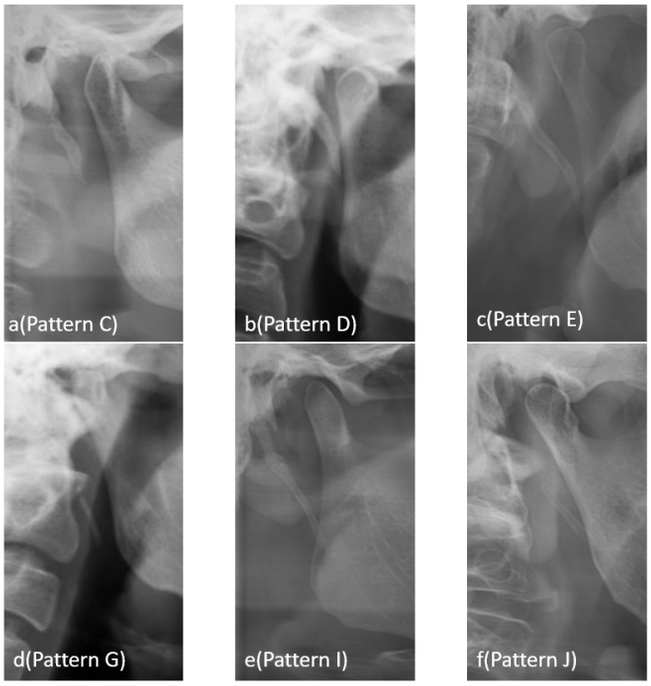

Figure 2. *The different types of stylohyoid chain complex patterns evaluated in this study. a Pattern C, b Pattern D, c Pattern E, d Pattern G, e Pattern I, f Pattern J*

3. RESULTS

The mean age and standard deviation in 1217 patients (745 female, 472 male) were 41.53 (±16.13, min-max:18-91). The mean age for female and male patients with standard deviation were 40.74±15.66 and 42.79±16.79 years, respectively.

The distribution of the twelve patterns of MacDonald-Jankowski's (20) classification was presented in Table 1. Of all cases, 86.5% were normal SP (Patterns A, B, C, and D) on both right and left sides (Fig. 2a-b). Elongated SP (Pattern E) and calcified stylohyoid ligament (Patterns F, G, H, I, J, and K) were 7.1% (Fig. 2c) and 2.2% (Fig. 2d-f), respectively. Approximately, 83.8% of elongated SPs were detected bilaterally, and 16.19% of individuals were unilateral. The absent stylohyoid chain (Pattern L) was 2.8%. Unclassified stylohyoid chain complex pattern was observed in 1.4% of cases. The frequency distribution of patterns was homogeneously on both sides according to sex. Also, 80.4% of the cases have the stylohyoid chain complex symmetry. In 79.2% of females and 82.3% of males, symmetry was found. However, there was no significant association between the sex and the symmetry of the stylohyoid chain ($p > .05$). Cross tabulations were presented in Table 2 and 3 for age groups and sex, respectively. A statistically significant difference was found only between age groups and the affected side.

Table 1. *Patterns of the stylohyoid chain complex according to sex*

Pattern	Side	Male	Female	Total
		n (%)	n (%)	n (%)
A	R	84 (6.9)	130 (10.7)	214 (17.6)
	L	87 (7.1)	133 (10.9)	220 (18.1)
B	R	15 (1.2)	31 (2.5)	46 (3.8)
	L	13 (1.1)	23 (1.9)	36 (3.0)
C	R	26 (2.1)	40 (3.3)	66 (5.4)
	L	28 (2.3)	45 (3.7)	73 (6.0)
D	R	278 (22.8)	446 (36.6)	724 (59.5)
	L	280 (23.0)	445 (36.6)	725 (59.6)
E	R	39 (3.2)	48 (3.9)	87 (7.1)
	L	38 (3.1)	48 (3.9)	86 (7.1)
F	R	1 (0.1)	3 (0.2)	4 (0.3)
	L	2 (0.2)	2 (0.2)	4 (0.3)
G	R	6 (0.5)	9 (0.7)	15 (1.2)
	L	1 (0.1)	7 (0.6)	8 (0.7)
H	R	0 (0)	2 (0.2)	2 (0.2)
	L	0 (0)	1 (0.1)	1 (0.1)
I	R	2 (0.2)	4 (0.3)	6 (0.5)
	L	2 (0.2)	1 (0.1)	3 (0.2)
J	R	2 (0.2)	4 (0.3)	6 (0.5)
	L	2 (0.2)	2 (0.2)	4 (0.3)
K	R	1 (0.1)	0 (0)	1 (0.1)
	L	0 (0)	0 (0)	0 (0)
L	R	11 (0.9)	21 (1.7)	32 (2.6)
	L	12 (1.0)	25 (2.1)	37 (3.0)
U	R	7 (0.6)	7 (0.6)	14 (1.2)
	L	7 (0.6)	13 (1.1)	20 (1.6)

Patterns A-D are normal styloid prcesses. Pattern E is an elongated styloid process. Patterns F-K are calcified stylohyoid ligaments. Pattern L is absent stylohyoid chain complex. Pattern U is unclassicified stylohyoid chain complex .R, right; L, left.

Table 2. *Distribution of the styloid complex according to age groups and side*

Age Group (years)	Right				Left			
	N n (%)	E n (%)	C n (%)	Total n	N n (%)	E n (%)	C n (%)	Total n
18-30	364 (92.2)	17 (4.3)	14 (3.5)	395	363 (92.8)	18 (4.6)	10 (2.6)	391
31-50	357 (87.6)	35 (8.7)	10 (2.9)	402	365 (91.0)	29 (7.2)	7 (1.7)	401
51+	324 (88.5)	34 (9.2)	8 (2.2)	366	323 (88.7)	38 (10.4)	3 (0.8)	364
Total	1045 (89.9)	86 (7.4)	32 (2.8)	1163	1051 (90.9)	85 (7.4)	20 (1.7)	1156

χ^2 (right)=9.599, df=2, p=.048; χ^2 (left)=2.368, df=2, p=.015. N, normal; E, elongated; C, calcified; n number of cases, % frequency

Table 3. *Prevalence of the styloid complex according to gender and side*

Gender	Right				Left			
	N n (%)	E n (%)	C n (%)	Total n	N n (%)	E n (%)	C n (%)	Total n
Male	402 (88.9)	38 (8.4)	12 (2.7)	452	406 (90.2)	37 (8.2)	7 (1.6)	450
Female	643 (90.4)	48 (6.8)	20 (2.8)	711	645 (91.4)	48 (6.8)	13 (1.8)	706
Total	1045 (89.9)	86 (7.4)	32 (2.8)	1163	1051 (90.9)	85 (7.4)	20 (1.7)	1156

X^2 (right)=1.119, df=2, p=.572; χ^2 (left)=.926, df=2, p=.629. N, normal; E, elongated; C, calcified; n number of cases, % frequency

4. DISCUSSION

The styloid complex, which develops embryologically from Reichert's cartilage, consists of the SP, the stylohyoid ligament, and the lesser horn of the hyoid bone (21, 22). The stylohyoid ligament is normally composed of dense fibrous connective tissue and may show partial or complete ossification which is not fully understood (13, 23-25).

Clinical diagnosis of the elongated SP is often difficult (23), and confirmation by radiological imaging is necessary (26, 27). Dentists can detect an elongated SP on panoramic radiographs, widely used in dental clinics (2, 28).

Although panoramic radiography has advantages such as availability, low cost, diagnostic performance, and low radiation dose, magnification and distortion limit the accurate measurement of SP (27, 29), it is not always possible to detect the SP due to the superposition of anatomical structures such as anteriorly by mandible, and posteriorly by cervical vertebra. Also, the variability of patient positioning could affect the measurements. Therefore, misdiagnosis may also occur (1).

There are many classification models in the literature (30-33). To be in accordance with the previous studies, O'Carroll's (33) classification was used which is preferred in the recent studies (20, 30, 31).

In addition, advanced imaging techniques were preferred in some studies. Öztunç et al. (34) and Andrei et al. (35) used CBCT in Turkish and Romanian samples, respectively. Gözil et al. (36) and Başekim et al. (37) used CT to estimate the SP elongation in various samples of the Turkish population. Three-dimensional systems effectivelly appraise SP angulations, length, and other morphological features (37). In these studies, two methods were preferred for the determination of elongated SP: I.İlgüy et al. (8) and Eagle W. (10) evaluated the SP as elongated if it was more than 30 mm; II. Rodriguez et al. (21) and Omami (38) assessed the SP as elongated when the SP's tip extends below the mandibular foramen. Consistent with previous studies, we refrained from measuring the lengths of SPs due to technical (panoramic radiography machine differences, magnifications, manual versus digital measurement and calibration) and epidemiological (ethnic and genetic variety) circumstances (36-39). Therefore, the types of SP were compared according to MacDonald-Jankowski's study (20).

Our results for the stylohyoid complex pattern were (both sides independent of each other): the normal pattern 86.5%; the elongated pattern 7.1%; the calcified pattern 2.2%. This reveals that the frequency of the elongated type is higher than the calcified type, consistent with the study of MacDonald-Jankowski (20). The prevalence of calcified type was higher for both sides in the young adult group (18-30 year-old). The presence of elongated SP was associated with increasing age for both sides. The findings cited above are consistent with the results of MacDonald-Jankowski (20) but contradictory to Bagga et al. (40). These different results between the studies may be caused by sample size, techniques used, age range, and ethnic/racial variety (30, 31).

In our research, symmetry was detected between the left and right sides (80.4%) in most cases. This result was consistent with previous studies (2, 20, 30).

Rizatti-Barbosa et al. (41) evaluated the stylohyoid complex calcification on panoramic images of 2252 patients in an adult and partially edentulous Brazilian population of both sexes. A calcified pattern was detected in 451 of the 2252 patients. Most of these calcified patterns were bilateral (n = 248, 54.9%). Although a complex anatomical variant of the stylohyoid ligament is more common in older women, this abnormality occurs in both men and women. The abnormality

was more common in patients aged 60–79. Rizatti-Barbosa et al's (41) findings differ from those of the present study. The inconsistency in results may be due to differences in ethnicity, as noted by previous researchers (20, 31).

In the study of Jankowski (20), which included radiographs of 1662 patients from different races, it was determined that there was no statistical difference in the prevalence of elongated SP (8.6% in Hong Kong Chinese and 7.8% in Londoners). Also, no significant difference was found in age for an elongated SP, contrary to the results of our study.

According to our findings, the prevalence of elongated SP (7.1%) was lower than some similar studies. However, there was a wide range for the elongated SP frequency of 1.4 to 83.6% in the literature (23, 34, 40, 45-47). Bruno et al. (47) observed the SP as a 66.6% normal and 33.40% elongated type. 56.2% of the elongated SP were bilateral, while 43.28% were unilateral. In the present study, elongated SP was lower than the results of Bruno et al., and 16.19% were unilateral. Taşsöker et al. (48), in a study they conducted on the Turkish population, measured the length of the SP on panoramic radiographs. They found that the SP differed according to age groups and gender, and the rate of being elongated was 16.3%. In another study on Turkish population conducted by Öztaş et al. (2), stylohyoid ligament calcification was evaluated according to the O'Carrol classification in panoramic images of 2000 patients. It has been observed that stylohyoid ligament calcification is more common in women than men, and the most common age group is 50-59 years. Mağat et al. (49) evaluated the styloid process in panoramic images according to the MacDonald-Jankowski classification. Patterns D and E were observed for both sides at approximately 42% and 32%, respectively. In the present study, the most observed patterns were D (59.5%), A (17.8%), and E (7.1%), respectively. A significant difference was found only for right SP morphological calcification types as to age groups in both genders ($p < .05$). In the present study, while a statistically significant difference was observed between both sides ($p < .05$) for the right side and the left side, Table 2) and age groups, it was not observed for gender. Alpoz et al. (30) evaluated styloid process patterns according to the MacDonald-Jankowski classification of panoramic images. Similar to our results, the authors concluded a high number of cases was found to be symmetrical for the SP (%83.3). A normal pattern was observed in 68.3%, an elongated pattern in 27.1%, and a calcified pattern in 1.7%. In our study, normal, elongated, and calcified patterns were found to be 86.5%, 7.1%, and 2.2%, respectively. Although it was studied in the same population, the results may be due to different age groups and sample sizes.

Since the retrospective design of this study, and the relationship between the radiological and clinical findings could not be evaluated. However, different types of SPs could be detected due to the large sample size, and a homogeneous distribution was achieved.

5. CONCLUSION

The present study highlighted the patterns of the elongated SP and calcification/ossification of the stylohyoid ligament. The SP patterns could be detected incidentally on panoramic radiographs in routine dental practice. Knowing the radiological findindgs of the SP variations may be beneficial for radiologists, surgeons, and neurologists to make more accurate diagnoses and avoid misinterpretation.

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