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EVALUATION OF STYLOID PROCESS MORPHOLOGY AND CALCIFICATION TYPES IN BOTH GENDERS WITH DIFFERENT AGES AND DENTAL STATUS

Her İki Cinsiyette Farklı Yaş ve Diş Durumlarıyla Birlikte Stiloid Çıkıntının Morfolojisinin ve Kalsifikasyon Tiplerinin Değerlendirilmesi

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ABSTRACT

Purpose: The purpose of this study was to investigate the morphology and calcification pattern of the styloid process (SP) and to determine their relations with subjects' age, gender, and dental status. **Materials and Methods:** 910 panoramic radiographs were stratified by age, dental status and gender. The distance between the points where SP leaves the tympanic plate of the temporal bone and the bony tip of SP was measured. Calcification patterns were classified as : (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. **Results:** The right SPs were found to be longer than the left ($p<0.05$). Types D (right 42.9%, left 42%) and E (right 33.3%, left 30.8%) were the most common morphological calcifications on both sides. No statistical difference was found for bilateral SP length between gender, age, and dental status groups. A significant difference was found only for right SP morphological calcification types as to age groups in both genders ($p<0.05$). No significant difference was found for SP morphological calcification types according to gender and dental status. **Conclusion:** The morphological types are formed at their present area. Even though SP calcification type was determined according to the length of SP, age was not an effective factor on the length, but the morphological calcification type of SP. Therefore, factors other than age may have a role in the development of morphological calcification types. Structural characteristics of SP are not associated with age, gender and dental status.

Keywords: Styloid process; age; dental status; gender; calcification type

ÖZ

Amaç: Bu çalışmanın amacı stiloid çıkıntının (SÇ) morfolojisinin ve kalsifikasyon şekillerinin incelenmesi ve bunların bireylerin yaşları, cinsiyetleri ve diş durumlarıyla olan ilişkilerinin belirlenmesidir.
Gereç ve Yöntem: 910 panoramik radyografi yaş, diş durumu ve cinsiyete göre gruplandırıldı. SÇ uzunlukları ve morfolojik kalsifikasyon tipleri analiz edildi. SP'nin temporal kemiğin timpanik kısmından ayrılan nokta ile SP'nin kemik ucu arasındaki mesafe ölçüldü. Kalsifikasyon yapıları şu şekilde sınıflandırıldı: (A) Bölge 1, yalnız tympanohyal (B) Bölge 2, tek başına stylohyal (C) Bölge 1 ve 2, ayrı (D) Bölgeler 1 ve 2, sürekli (E) Bölge 1, 2 ve 3, sürekli (F) Bölge 1, 2 ve 3, ayrı (G) Bölge 1 ve 2, sürekli fakat 3'ten ayrı (H) Bölge 2 ve 3 ayrı, (I) Bölge 2 ve 3 sürekli, ancak 1'den ayrı (J) Yalnız bölge 3 (K) Bölge 3 ve 4, sürekli (başka bir bölgede kalsifikasyon içerebilir) (L) Görülen herhangi bir stiloid çıkıntı yok.
Bulgular: Sağ taraftaki SÇ'lerin sola göre daha uzun olduğu belirlendi ($p<0,05$). Her iki tarafta en sık görülen morfolojik kalsifikasyon tiplerinin D (sağ % 42.9, sol 42%) ve E (sağ % 33.3, sol% 30.8) olduğu saptandı. Çift taraflı SÇ uzunluklarının arasında cinsiyet, yaş ve diş durumuna göre anlamlı bir fark yoktu. Her iki cinsiyette de, sadece sağ SÇ morfolojik kalsifikasyon tiplerinin yaş gruplarına göre farklılık gösterdiği bulundu ($p <0.05$). SP morfolojik kalsifikasyon tiplerinin cinsiyet ve diş durumuna göre anlamlı farklılık göstermediği tespit edildi.
Sonuç: Morfolojik tipler mevcut alanlarına göre şekillenmektedir. SÇ kalsifikasyon tipleri, SÇ uzunluğuna göre belirlenmesine rağmen, yaş SÇ uzunluğu ile değil, SÇ'nın morfolojik kalsifikasyon tipi ile ilişkiliydi. Buna göre SÇ'nın morfolojik kalsifikasyon tipinin gelişmesinde yaş dışında başka etkenlerin rol oynadığı düşünülebilir. SÇ'nın yapısal özellikleri yaş, cinsiyet ve diş durumu ile ilişkili değildir.

Anahtar kelimeler: Stiloid çıkıntı; yaş; diş durumu; cinsiyet; kalsifikasyon

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Introduction

The styloid process (SP) is a cylindrical bone that starts from the temporal bone in front of the stylomastoid foramen. The SP tapers toward its tip, which lies in the pharyngeal wall lateral to the tonsillar fossa. The tip of the SP is continuous with the stylohyoid ligament, which extends to the lesser cornu of the hyoid bone. The stylomandibular ligament also attaches to the SP, extending to the angle of the mandible. Many important neurovascular structures lie near the tip of the SP; the internal carotid artery, internal jugular vein, and cranial nerves X, XI, and XII lie on its medial side (1, 2). The reported "normal" length of the SP ranges from 20-32 mm. This varies from person to person and even from side to side in the same person (3-6). Studies have estimated that in 2-28% of the general population, there is radiographic evidence of an elongated SP, although symptoms are present only in some individuals (7). When symptoms are associated with elongation of the SP, the condition is termed as Eagle syndrome (1). Keur *et al.* (8) suggested that an SP longer than 30 mm was considered to demonstrate elongation. Today, reports concerning the SP and measurements of its length are mostly based on panoramic radiographs (9). In previous studies, it was mainly assessed whether age and gender affected the elongation and calcification of SP, but a few researchers hypothesized that dental status impacted these factors (5-7, 9-15). While a number of prevalent etiological and causal theories have been proposed to account for the calcification and elongation of SP, the exact cause of the phenomena remains unclear (16-18). The purpose of this study was to investigate the morphology and calcification pattern of SP lengths in a subgroup of the Turkish population and their correlation, if any, to age, gender, and dental status.

Materials and Methods

Study sample

910 panoramic radiographs taken between 2012 and 2013 as part of routine dental examination of patients over the age of 18 years who had attended Selçuk University, Faculty of Dentistry, Oral and Maxillofacial Radiology Department, were evaluated (Table 1). The research protocol was approved by the Ethical Committee Selçuk University Faculty of Dentistry (Reg. No: 2012/33).

All panoramic images were taken using the same panoramic imaging device (Kodak® 8000 Rochester, New York, NY, USA) by the same technician, in accordance with the manufacturer's reference guide. Only clear radiographs of high quality and with no gross distortion were selected. Selection criteria were as follows: mental foramen, tympanic plate, condyle, the lower border of the mandible, and the posterior border of the ramus had to be readable on the radiograph to measure the structures on both sides. Panoramic radiographs of the patients who had orthognathic surgery, facial asymmetry, and fractures were excluded from the study.

Table. 1. *The distribution of the sample is presented as number (N) and percentage (%) stratified by gender, age group, and dental status.*

	N	%
Gender		
Male	445	48.9
Female	465	51.1
Age (years)		
18-40	154	16.9
41-55	104	11.4
56-69	449	49.3
70 and above	203	22.3
Dental status		
18-40 years old dentate	150	16.5
40 years old and above dentate	154	16.9
40 years old and above partially dentate	150	16.5
40 years old and above maxillary edentulous	150	16.5
40 years old and above mandibular edentulous	156	17.1
40 years old and above totally edentulous	150	16.5

Radiographic measurements

All measurements were performed on both sides of the mandible by a single trained observer, using Adobe Photoshop CS4 software (Adobe Systems Inc., San Jose, CA, USA), after correction for a 30% magnification to better simulate a clinical situation. SP length measurements were made using the ruler function of the same software (Figure 1). The measurements were made by one observer, twice. The observer had three years' professional experience in the oral radiology department. To assess the intra-observer reliability, 50 samples were randomly selected, SP classifications were reassessed, and the measurements were repeated at an interval of one month.

Figure 1. *Anatomical landmarks used for measurement of the styloid process length. Cleft between the lower margin of the tympanic plate of the temporal bone and the styloid process between the contour of the tympanic plate and the styloid process. The circle shows the origin for measurements and arrow length corresponds to the length of the styloid process.*

The SP measurement was determined according to the method described by Jung *et al.* (9). Measurements were started on the frontal side of the SP where it leaves the tympanic plate of the temporal bone. In this area on the PR, a thin transparent line is generally visualized between the shadows of the SP and the tympanic bone. This line corresponds to the cleft between the SP and the tympanic plate of the temporal bone. The tip of the SP is its bony end, including mineralized parts of the ligament. SP morphological calcification types were classified as per the method of MacDonald Jankowski (12), who had rated the types of elongation as follows: 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 centers of calcification. Patterns A-D are normal styloid processes, while Pattern E is an elongated styloid process. Patterns F-K are calcified stylohyoid ligaments.

Classification of dentition

The dentition was assessed using the following classification (third molars not included): (1) 18-40 years old dentate; (2) 40 years old and above dentate; (3) 40 years old and above partially dentate (max. 15 teeth); (4) 40 years old and above maxillary edentulous; (5) 40 years old and above mandibular edentulous; (6) 40 years old and above totally edentulous. Ages were assigned to four groups: 18-40, 41-55, 56-69, and 70 and above.

Statistical analysis

Statistical Package for the Social Science (SPSS) (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0, IBM Corp., Armonk, NY, USA) software was used for statistical analysis. Descriptive statistics for each variable were calculated. Cohen's kappa and intra-class correlation coefficients (ICC) were calculated for SP morphological calcification types and and for SP length, respectively. The Kolmogorov-Smirnov test was used to determine uniform distribution; the Wilcoxon test was used to determine whether there were differences of the means values between the right and left parameters, and the Mann-Whitney U-test was used for testing the difference in measurements between genders. Kruskall Wallis test was employed to analyze the variation in measurements among age and tooth groups. Categorical variables were evaluated using the chi-square test. The significance level was set at 5%.

Results

All possible observations were readable and were included in the present analysis. Measurements of all distances were made on both sides. For right and

left reassessments of SP morphological calcification types, kappa values were 0.91 and 0.92 (almost perfect agreement) respectively. ICC values were 0.896, 0.828, 0.946, and 0.935 (nearly perfect agreement) for right and left measurements of SP length, respectively.The mean age ± standard deviation of the 910 patients was 59.29 ± 14.41. Table 1 shows the age distributions. Results for distances and distributions are presented in Tables 2, 3, and 4, according to gender, age groups, and dental status. There were statistical differences in the values of SP length in the right and left sides; the right SP lengths had significantly greater values than the left side in both genders ($p<0.05$). It was found that the length of SP did not show any variation based on the age, gender, and dental status in both genders (Table 5). Types D (right 42.9%, left 42%) and E (right 33.3%, left 30.8%) were the most common morphological calcifications on both sides respectively. A statistical difference was only found for right SP morphological calcification types as regards age groups in both sexes ($p<0.05$) (Table 5). In females, type D was the most common type in the 18-40, 56-69, and 70 and above age groups. In the 41-55 age group, type E was the most prevalent. In males, a more considerable increase was seen for type D in the 18-40 and 56-59 groups. Type E was more prevalent in the 41-55 and 70 and above groups ($p<0.05$). No significant difference was found between SP morphological calcification types according to gender and dental status (Table 5).

Table 2. *Mean measurement values in millimeters stratified by age groups, quadrant, and right and left styloid process (SP) measurements. Standard error (SE) values for each measure are also included.*

	18-40				**41-55**			
	Female		**Male**		**Female**		**Male**	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Right SP length	27.41	13.08	28.06	9.51	30.46	9.61	29.88	10.31
Left SP length	26.81	11.02	29.01	11.97	27.62	9.02	28.19	11.76
	56-69				**70 and above**			
	Female		**Male**		**Female**		**Male**	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Right SP length	27.3	9.65	29.96	11.29	30.8	11.56	30.76	14.48
Left SP length	27.26	9.59	29.79	11.72	29.32	10.17	29.49	13.8

Table 3. *Mean measurement values in millimeters by gender, quadrant, and right and left styloid process (SP) measurements. Standard error (SE) values for each measurement are also included.*

	Female		**Male**		**Total**	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**
Right SP length	28.39	10.74	29.81	11.77	29.08	11.27
Left SP length	27.65	9.90	29.40	12.28	28.50	11.15

Discussion

The study group of patients was not selected on the basis of any radiographic or medical criteria and was not chosen from any particular dental specialty. All measurements were assessed on panoramic radiographs that had been taken for routine dental examination of patients. To ensure reliability and consistency, a dentomaxillofacial radiologist evaluated each image to select only those radiographs of the highest quality. The ICC and kappa values were perfect, indicating that the method of indices for assessment was very reliable. The panoramic radiograph is a common modality for evaluating SP elongation. The skull lateral view is optimum for showing the length of the styloid process, but anteroposterior views are also required to determine whether there is bilateral involvement and the presence of lateral deviation. Regarding the radiographic examination, lateral cephalometric radiographs are considered more reliable than their panoramic counterparts because they suffer less distortion and produce a more accurate image (19).

However, due to the superimpositions seen on lateral cephalograms, reliable measurement of the SP becomes difficult. Although spiral CT with subsequent 3D reconstruction is the method of choice

for precise determination of the localization of the styloid processes, it involves a greater radiation dose than conventional radiographies, and the elongated styloid ligament is often asymptomatic and does not require treatment (20). Studies have denoted that panoramic machine magnification was about 15-30% (21-25). In the present study, all measurements were reduced to the original size of the mandibular features, based on the magnification of the panoramic machine used (27%, according to the manufacturer). This compensation allowed for comparison with other studies, because different panoramic machines have varying magnification factors. That said, it must be pointed out in this context that the theoretically well understood complexity regarding magnification and distortion in panoramic radiography is not adequately reflected by applying a crude global magnification factor (21-25). However, the use of indices largely compensates for the unknown local magnification in the image.

Table 4. *Mean measurement values in millimeters by dental status, quadrant, and right and left styloid process (SP) measurements. Standard error (SE) values for each measure are also included.*

	18-40 years old dentate				**40 years old and above dentate**			
	Female		**Male**		**Female**		**Male**	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Right SP Length	27.59	13.29	27.98	9.54	27.66	9.79	27.43	7.67
Left SP Length	26.52	11.14	28.09	12.01	26.69	9.94	27.09	9.24
	40 years old and above partial dentate				**40 years old and above mandibular edentulous**			
	Female		**Male**		**Female**		**Male**	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Right SP Length	26.24	8.45	30.51	14.44	26.24	8.45	29.81	11.73
Left SP Length	27.33	10.07	29.85	12.68	27.33	10.07	28.87	11.91
	40 years old and above maxillary edentulous				**40 years old and above totally edentulous**			
	Female		**Male**		**Female**		**Male**	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Right SP Length	27.83	8.79	29,50	11.76	32.07	12.38	33.81	13.75
Left SP Length	27.04	7.88	30.00	14.25	30.18	10.40	31.79	13.09

Table 5. *The differences between age groups, gender, and dental status (*p<0.05, SP: styloid process).*

	Age		**Dental status**		**Gender**
	Female	**Male**	**Female**	**Male**	
	p value		**p value**		**p value**
Right SP length	0.055	0.665	0.064	0.104	0.062
Left SP length	0.121	0.998	0.071	0.271	0.052
Right SP type	0.019*	0.001*	0.115	0.056	0.36
Left SP type	0.534	0.08	0.528	0.665	0.37

In the present study, the SP mean lengths of the left and right sides were 28.50 ± 11.15 mm and 29.08 ± 11.27 mm, respectively. The mean values of the length presented in the literature (25-32 mm) correlated well with those found in our study (11-13, 19, 26-28). There was a statistical difference between the left and right SP measurements, which confirms the findings of Guo *et al.* (29). These differences may be derived from the increased function on the preferred chewing side (21). If this hypothesis is correct, it can be concluded that the function of the mastication muscles has a particular effect on the SP calcification. However, this result differs from those of More and Asrani (3), Ferrario *et al.* (5), and Jung *et al.* (9). This difference may be due to ethnic variations.

According to the findings of the present study, in terms of length of the SP, no significant difference was found between age groups and gender on both sides, which is similar to the findings of some previous studies (11-13, 19, 26-28). However, it is inconsistent with the results of others (3, 9, 10, 24). The discrepancies could be due to different age groupings and unequal distribution in age subgroups in prior studies. Also according to the results of the

present study, although the SP lengths in males were longer than in females on both sides, there was no significant difference between genders statistically. This is supported by the results of several studies (5, 9, 12, 14, 26, 30). However, others had different findings (3, 6, 11, 31). This disparity may be due to unequal distribution of genders and ethnic variation.

Few studies evaluated the association of dental status and SP length (6, 11). This is because the muscle tension from occlusal disarrangements and changes in both bones' height in partially or completely edentulous patients can be a probable factor in the incidence of a correlation between the number of teeth present in the mouth and SP length (6). However, no statistical difference was found between dental status and SP lengths. This finding is consistent with the literature (6, 11). It was stated that there was a progression in the length of calcification with advancing age on the right side (3, 30). The findings of this study were in accordance with the literature on this point (3, 10, 15, 29). According to the results, gender had no statistically significant influence on the SP morphological calcification types on both sides. This finding is consistent with previous reports (11-13).

However, it was not in agreement with others (5, 14). This could be due to ethnic variation. (12). In our study, types D and E were more frequent morphological types. This result is consistent with those of Kursoglu *et al.(13)* and Nalçacı and Mısırlıoğlu (28). Therefore, this finding favors the hypothesis that ethnic variations affect SP morphological calcification types. In our study, there were no statistical differences between aforementioned types and dental status; based on the findings, the type of calcification of SP is an independent structure from the number of teeth. No study reporting similar association could be found.

The morphological types are formed at their present area (12). Even though the determination of the type of SP calcification is based on the length of SP, the age is not an effective factor in terms of the length of SP, but neither is it associated with the morphological calcification type of SP, according to the findings of the present study. It can be concluded that factors other than age may play a role in the development of said type.

Conclusion

Based on the results of this study, SP is an autonomous structure from age, gender, and dental status. The changes in SP lengths are accepted as being signs of certain abnormal situations. The differences in length are either physiological or pathological, and the possible related factors should be investigated.

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Conflict of interest
None declared

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