Factors Affecting Condition of Styloid Process

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Abstract

The aim of the current study was to evaluate the condition of the styloid process in dental patients and analyze the factors that might be affecting the mineralized condition of the styloid process. Three hundred digital panoramic radiographs were retrieved from the X-ray data of dental patients who received at least one dental treatment between October and December, 2016. Five factors (including sex, age, tooth status, pulp stone, and side) were recorded vis-à-vis the condition of the styloid process. These were then divided into 11 forms (labelled "a" to "k"). Conditions "a" to "d" were categorized as normal styloid processes. Condition "e" represented an elongated styloid process. Conditions "f" to "k" were calcified stylohyoid ligaments. Two observers cooperated in each radiograph evaluation. Descriptive analyses were done for each condition and each variable. The relationship between each factor was analyzed using a multiple logistic regression. Among the conditions classified, type "d" was found most in both sides, 109 (36.3%) in the right side and 125 (41.7%) in the left. The mean age was 35.42±18.52 years (range, 18-88). The female to male split was 207 (69%) to 93 (31%). Females presented normality of the styloid process on the right side 1.99 times more than males (95% CI =1.01-3.93, p=0.048). There was no significant difference in the condition of the styloid process vis-à-vis age. The number of missing teeth ranged between 0 and 32 teeth in 219 patients (73%). There was no significant difference between dentulous and edentulous patients (p=0.08). Pulp stones occurred in 64 cases (21.3%). The persons who presented a normal left styloid process also presented a normal right styloid process more than any other condition (p<0.0001). In conclusion, the "d" styloid process condition was found most on both sides. The condition and number of styloid processes on the right side differs from the contralateral side. Sex and the side are associated with the styloid process and stylohyoid ligament classification.

Keywords: *Styloid/ Calcification/ Panoramic radiograph/ Elongation*

Introduction

The styloid process is a slim pointed piece of bone below the ear. It projects down and forward from the inferior surface of the temporal bone, and serves as an anchor point for several muscles associated with the hyoid bone, mandible and tongue. The average range of styloid process is about 2-3 cm.[1,2] Some studies have measured the length of the styloid process by various methods.[2-4] With a length of more than 30 mm, the styloid process is considered to be elongated.[5] The tip of the styloid process is continuous with the stylohyoid ligament, which extends to the lesser cornu of the hyoid bone.[6] Calcification of the stylohyoid ligament or elongation of the styloid process maybe the cause of unknown dental and neck pain—known as Eagle's syndrome. In some cases, the styloid process compresses the carotid artery—known as stylocarotid syndrome, causing ischemic stroke and severe cervical pain radiating to the ear. Sometimes the styloid process compresses many nerves causing throat pain, dysphagia, foreign-body sensation, and neck pain.[7] Several studies have expanded the elongated styloid process to include a variety of presentations, and potentially serious complications.

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The prevalence of elongated styloid process and calcified stylohyoid ligaments are reported among various ethnic groups.[8-12] Differences in sex, age, and side are reported in different racial groups. Even though studies in Thais, there is difference in prevalence of elongated styloid process.[8,13] The etiology of the elongated styloid process and stylohyoid ligament calcification—including factors related to their configurations—have been studied to some degree. Okabe et al,[14] reported the existence of morphological variation in calcified stylohyoid complexes, especially in length, apparent on panoramic radiographs, and that this may be a predictor of bone density and high serum calcium concentration level. Breault [1986][15] found the styloid processes occur commonly in older patients due to deposition of calcium salts into the ligaments and processes. These findings suggest that calcium salts may also be deposited on the nearby structures, such as the dental pulp. Some researchers suggest that the pulp stones may be part of systemic biomineralization processes that affect other body parts.[16] The stones are mostly found in the teeth of older people, in teeth that have been subjected to experimental intrusion,[17] and in teeth during orthodontic treatment.[18] It was thought that the formation of stones in dental pulp maybe related to calcification of the stylohyoid ligament.

Considering the number of teeth, and the lack of some teeth may influence on the masticatory muscles, and head and neck muscles, there may also be implications to the condition of the stylohyoid chain.

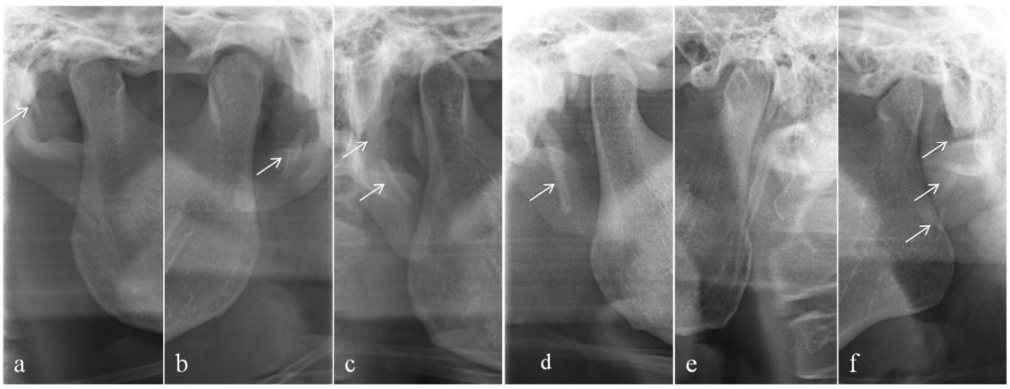
An awareness of any factors related to the condition of the styloid process is important to all physicians and dentists involved in the diagnosis and treatment of head and neck pain management. With the presumption that dental force and calcium level might be associated with the elongation of styloid process and calcification of stylohyoid ligament, the number of remaining tooth and pulp stone were added up to be associated factors in this study. The aims of the current study were to evaluate the prevalence of calcification of the stylohyoid complex in a sample of dental patients using digital panoramic radiographs and to explore the possible associations between an elongated styloid process including calcified stylohyoid ligaments with sex, age, tooth status, the presence of pulp stone(s), and side, and to compare the results with published data. The outcomes of our study should provide the dental practitioner with information about the factors related to the condition of the styloid process.

Materials and methods

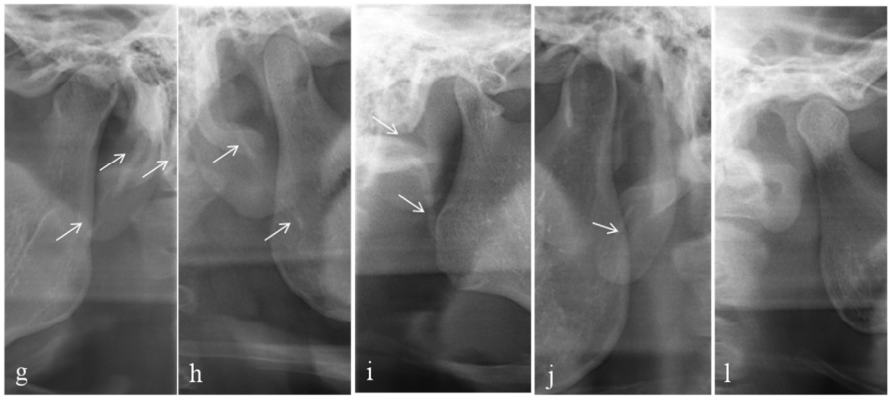
Three hundred digital panoramic radiographs were retrieved from an X-ray database of dental patients who had received at least one dental treatment between October and December, 2016. Patients under 18 were excluded due to potential skeletal immaturity. Only diagnostically acceptable images were included in the study. The digital panoramic radiographs were generally obtained as part of routine radiographic screening for oral diagnosis. The radiographs were taken using Panoramic machine Orthophos 3 DS (Sirona, Dental Systems GmbH, Bensheim, Germany) with 60-80 kVp, 6-11 mA, and 11.3 s. The digital images were evaluated in ambient light on a LCD monitor. The examiners were trained by reading 20 radiographs separately before the investigation began. Together, the examiners re-read a sample of panoramic radiographs 2 week after the first examination and 100% agreement was obtained. The examiners then evaluated the radiographs together and a combined decision was made. The images were evaluated for the prevalence and condition of calcification of the stylohyoid complex. Five factors including sex, age, tooth status, pulp stone, side were recorded. Results for males and females were recorded. Age was divided into three groups: 18-29, 30-39, and 40 and over. Tooth status was divided into 2 subgroups: dentulous = no tooth loss at all and edentulous = at least one tooth lost. Pulp stone was defined as discrete calcified masses found in the dental pulp. Side means left or right side of the jaw.

The classification of the stylohyoid chain was recorded as per MacDonald- Jankowski's Method.[19] The area affecting the consideration of the styloid process shape was divided into 4 regions before classifying the styloid process (i.e., "a" to "l") (Fig.1): Region 1 –tympanohyal (the base of the styloid process); Region 2 – stylohyal (forms the major portion of the styloid process); Region 3 – ceratohyal (forms the stylohyoid ligament); and, Region 4– hypohyal (forms the minor horn of the hyoid bone).

Twelve conditions of stylohyoid chain were used in this study. Condition "a" = region1 = tympanohyal alone; "b" = region2 = stylohyal alone; "c" = region 1 and 2 separately; "d" = region 1 and 2 continuous; "e" = region 1, 2, 3 continuously; "f" region 1, 2, 3 separately; "g" region 1 and 2 continuously, but separate from 3; "h" = regions 2 and 3 separately; "i" = regions 2 and 3 continuously, but separate from l; "j" = region 3 alone;and, "k" = region 3 and 4 continuously. "l" = no styloid process visible. In the current study, conditions "a" to "d" were classified as normal styloid processes; condition "e" an elongated styloid process; and condition "f" to "k" as calcified stylohyoid ligaments (Fig.1).[19]



a - Regional 1 = tympanohyal alone
b - Regional 2 = stylohyal bone
c - Region 1 and 2, separated
d - Regions 1 and 2 continuous
e - Regions 1 ,2 and 3, continuous
f - Regions 1,2 and 3 separate



g - Regions1 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 another region)
This pattern was not found in this study.
l - No styloid process visible

Figure 1 Pattern of styloid process according to O'Carroll's classification in MacDonald–Jankowski. [19] Patterns"a" to "d" are classified as normal styloid processes. Pattern "e" is an elongated styloid process. Pattern "f" to "k"are calcified stylohyoid ligaments.

Table 1 Prevalence of styloid patterns on right and left sides

Pattern	Right side		Left side	
	number	percentage	number	percentage
a	55	18.3	42	14.0
b	54	18.0	57	19.0
c	42	14.0	36	12.0
d	109	36.3	125	41.7
e	13	4.3	12	4.0
f	1	0.3	2	0.7
g	4	1.3	5	1.7
h	1	0.3	2	0.7
i	4	1.3	2	0.7
j	1	0.3	2	0.7
k	0	0	0	0
l	16	5.3	15	5.0
Total	**300**	**100.0**	**300**	**100.0**

This study was reviewed and approved by the Ethics Committee for Human Research at Khon Kaen University, based on the Declaration of Helsinki and the ICH Good Clinical Practice Guidelines (HE 592250).

Statistical analysis

Descriptive analyses were performed for each condition of the styloid process, and for each variable. The relationship between each factor was analyzed using a multiple logistic regression with the backward stepwise method. The relationship between the normal right and left styloid process side was analysed by Chi- squared. The significance level was set at ≤0.05.

Results

Among conditions classified, "d" condition was found most commonly on both sides, 109 (36.3%) on the right and 125 (41.7%) on the left (Table1). "K" condition was not found in our study. Factors related to the normality of right and left styloid process are presented in Table 2-5.

The mean age was 35.42 ± 18.52 years (range, 18-88). The youngest age group (18-29) among both males and females had the greater normality for both sides. Age showed no significant difference vis-à-vis the condition of the styloid process (p=0.05). The sample comprised 93 (31%) males and 207 (69%) females. A normal right styloid process was found in a respective 80.6 and 89.4 males and females. There was no significant difference in left styloid process by sex. Missing teeth numbered 0 to 32 teeth among 219 patients (73%). Edentulous patients showed less normal styloid process than dentulous patients on both sides. There was no significant difference between dentulous and edentulous patients (p=0.08). Pulp stones occurred in 64 cases (21.3%). Persons with pulp stones had a normal styloid process more frequently than persons who had no pulp stones on either side. The number of styloid process conditions on the right side differed from the left side.

Table 2 Factors related to normal right styloid process calculated by bivariable analysis

Variables	Right styloid process		Statistic	p-value
	Condition-efghijkl Number (row percentage)	Normal-abcd Number (row percentage)		
1. Sex				
- female	22 (10.6)	185 (89.4)	χ^2=4.229	0.04**
- male	18 (19.4)	75 (80.6)		
2. Age (year)				
- 18- 29	19 (11.2)	150 (88.8)	χ^2=1.47	0.47
- 30-39	4 (15.4)	22 (84.6)		
- ≥40	17 (16.2)	88 (83.8)		
3. tooth loss				
- yes	34 (15.5)	185 (84.5)	χ^2=3.37	0.084
- no	6 (7.4)	75 (92.6)		
4. pulp stone				
- yes	7 (10.9)	57 (89.1)	χ^2=0.525	0.67
- no	33 (14.0)	203 (86.0)		

**Statistically significant level at p<0.05

Table 3 Factors related to normal left styloid process calculated by bivariable analysis

Variables	Left styloid process		Statistic	p-value
	Condition-efghijkl Number (rowpercentage)	Normal-abcd Number (rowpercentage)		
1. Sex				
- female	23 (11.1)	184 (88.9)	χ^2=2.85	0.091
- male	17 (18.3)	76 (81.7)		
2. Age (year)				
- 18- 29	21 (12.4)	148 (87.6)	χ^2=0.297	0.862
- 30-39	4 (15.4)	22 (84.6)		
- ≥40	15 (14.3)	90 (85.7)		
3. tooth loss				
- yes	31 (14.2)	188 (85.8)	χ^2=0.47	0.49
- no	9 (11.1)	72 (88.9)		
4. pulp stone				
- yes	7 (10.9)	57 (89.1)	χ^2=0.525	0.67
- no	33 (14.0)	203 (86.0)		

**Statistically significant level at p<0.05

Persons who had a normal left styloid process usually presented a normal right styloid process more often than any other condition of the stylohyoid chain (p=0.0001) (Table 6). On the right side, the 18-29 age group had the most normal styloid process (88.8%), followed by the 30-39 age group (84.6%) and those over 40 (83.8%). As the age group increased, the normality of the styloid process decreased. On the left-hand side, the 18-29 age group had the most of normal styloid process (87.6%), followed by those over 40 (85.7%) and 30-39 age group (84.6%). The missing tooth factor or edentulous patient had a normal left styloid process (85.8%) less than dentulous patients (88.9%). The person who had pulp stones had a normal left styloid process (89.1%) more often than persons with no pulp stones (86%). After logistic regression, the independent variables were sex, age, tooth loss, and pulp stones. The dependent variable was normality of the left styloid process. No factors were related to normality of the left styloid process in the current study.

Bivariable analyses and multivariable logistic regression showed that a factor related to the normality of the right styloid process was sex. The styloid process among females occurred 1.99 times more often on the right sided than it did among males (95% CI=1.01-3.93, p=0.048) (Table 4). In the present study, there was, however, no factor related to normality of a left styloid process.

Table 4 Factors related to condition of right styloid process analyzed by multivariable logistic regression using the backward stepwise method

Variables	Right styloid process		Adjusted Odds ratio 95% CI	p-value
	Condition- efghijkl Number (percentage)	Normal- abcd Number (percentage)		
1. Sex				
- female	22 (10.6)	185 (89.4)	1.988 (1.01-3.93)	0.048**
- male	18 (19.4)	75 (80.6)	1	
2. tooth loss				
- yes	34 (15.5)	185 (84.5)	1	0.08
- no	6 (7.4)	75 (92.6)	0.44 (0.178-1.103)	

**Statistically significant level at p<0.05, after adjusted gender, age, tooth loss and pulp stone

Table 5 Factors related to condition of left styloid process by multivariable logistic regression with Backward stepwise method

Variables	Left styloid process		Adjusted Odds ratio (95% CI)	p-value
	Condition -efghijkl Number (row percentage)	Normal-abcd Number (row percentage)		
1. Sex				
- female	23 (11.1)	184 (88.9)	1.78 (0.90-3.53)	0.094
- male	17 (18.3)	76 (81.7)		

**Statistically significant level at p<0.05, after adjusted gender, age, tooth loss and pulp stone

Table 6 The relationship between normal right styloid process and normal left styloid process

Variables	Left styloid process		Statistic	p-value
	Condition-efghijkl Number (row percentage)	Normal-abcd Number (row percentage)		
Normal right styloid process				
– yes	14 (5.4)	246 (94.6)	χ^2= 106.6	<0.0001**
– no	26 (65.0)	14 (35.0)		

**Statistically significant level at p<0.05

Discussion

Elongation of styloid process including calcification of the stylohyoid ligament is a frequent condition. Its prevalence has been studied in various populations worldwide.[9-12,20] Alpoz et al. [2014][9] reported a prevalence of 28.8% in Turkish population. Omami [2018][10] studied calcification of the stylohyoid complex in Libyans and found it elongated in 17.2%, and calcified in 17.8%. Radfar et al. [2008][20] found a prevalence of 22% in the US population. The prevalence of an elongated styloid process in the Saudi population of the Aseer region was 63.2% among males vs. 36.8% among females.[21] Vieira et al. [2015][12] revealed a prevalence of 43.9% of elongated styloid process in the Central Brazilian population, while More and Asrani [2010][22] reported a prevalence of 19.4% in the Indian population. The results of the current study show a prevalence of 13.3% of the elongated styloid process among dental patients attending dental treatment at a dental hospital in northeastern Thailand. Cholitkul et al. [2015][8] reported a prevalence of 10.5% of elongated styloid process in a Thai population over 20 years of age at Rangsit University. Sakaew et al. [2016][13] reported the prevalence of an elongated styloid process in dry skulls from northeast Thailand was 26.5%. Promthale et al. [2012][23] studied 176 Thai dry and 150 cadaveric skulls and found the mean length of all styloid processes was 24.12±7.28 mm; of which 18.4% had an elongated styloid process. The high variability might be ascribed to (a) real anatomical differences among different populations and (b) different measurement criteria.

In the present study, there was a significant difference in the presence of elongated styloid process between males and females. It occurred more often in males, consistent with another Thai study by Cholitkul [2015],[8] but in contrast to other reports. Omami et al. [2018][10] reported it occurred significantly more often in females than males (p=0.0404). Meanwhile Alpoz et al. [2014][9] and Vieira et al. [2015][12] reported no significant difference between the sexes. Sakaew et al. [2016][13] indicated that the styloid process has a good potential for sex identification; by measuring the interstyloid distance at both the base and the tip of these processes.

The different conditions of the styloid process among males and females maybe explained by differences in the hormonal level, especially the parathyroid hormone, the function of which is to control the calcium level in the blood. Okabe et al. [2006][14] reported that there is a significant relationship between the length of the stylohyoid process and high serum calcium concentrations; the higher the serum calcium concentration, the longer the stylohyoid process. It was

suggested that an elongated styloid process may be a predictor of bone mineral density and a high serum calcium level. In a study conducted on osteoporotic population, a correlation between an elongated stylohyoid chain complex and systemic osteoporosis was found.[24]

Ectopic calcification might have a role in elongation of the styloid process. Pulp stones area phenomenon related to calcium salt deposits. The relationship between elongation of the styloid process—including stylohyoid ligament calcification and pulp stone—has not been reported. Our study is the first to report on this condition. Even though the relationship between both factors has not yet been established, the mechanism of calcium salt deposit in different places is suggested and needs further research. The incidence of pulp stones has been reported related to age, caries, operative procedures, periodontal disease, idiopathic, orthodontic tooth movement, and genetic predisposing factors. The formation of pulp stones remains something of an enigma.

The percentage of elongated styloid process and stylohyoid ligament in those over 40 years in the current study was found most frequently, consistent with other reports[19,25] measured the styloid process in panoramic radiographs and indicated that the styloid process length was associated with increasing age. Ekici et al.[4] recorded the highest rate of elongated styloid process among those in their fifth decade (65.4%). Cholitkul et al. [2015],[8] however, reported a greater frequency among Thais between 20 and 29 years. Age-related degeneration of the stylohyoid ligament with deposition of calcium salts may result at a higher frequency with increasing age.[26] Some studies, however, did not observe any correlation between age and the length of the stylohyoid ligament. [27,28]

Bozkir et al.[29] studied the incidence of elongated styloid process in panoramic radiographs of 200 patients who have a totally edentulous ridge at a Turkish hospital. Elongation and calcification of the styloid process were found (4%). The effect of the number of remaining teeth on the condition of styloid process has not been proven. There is a case report of an elongated styloid process becoming symptomatic after wisdom teeth were removed.[30] The current study showed that the number of teeth was not significantly different between dentulous and edentulous patients (error< 5%). Magat and Ozcan[31] studied morphology and calcification pattern of styloid process in dentate, partially dentate, maxillary edentulous and mandibular edentulous and concluded that calfcification of styloid process is independent from the number of teeth.

Morphology of styloid process is important to all physicians and dentist in cope with head and neck pain.[32] The limitation of this study is the small number of the sample sizes. The possible related factors should be further investigated.

Conclusion

In conclusion, the prevalence of the "d" condition was found most commonly in both sides. The styloid process condition may result from several factors involving the oral structure. In the current study, dental status—including age and presence of pulp stones—did not affect the stylohyoid condition. Sex and side had implications for the various conditions of the styloid process. Knowledge of the morphology of the styloid process may help in the proper diagnosis and management of head and neck pain.

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ปัจจัยที่มีผลกระทบต่อลักษณะของก้านสไตลอยด์

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บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อประเมินรูปร่างของก้านสไตลอยด์ในผู้ป่วยทางทันตกรรมและวิเคราะห์ปัจจัยที่อาจมีผลกระทบต่อรูปแบบการสะสมแร่ธาตุของก้านสไตลอยด์ การศึกษานี้ใช้ข้อมูลจากภาพรังสีแพโนรามาระบบดิจิตัลของผู้ป่วยทางทันตกรรม จำนวน 300 ภาพ โดยผู้ป่วยเข้ารับการรักษาทางทันตกรรมอย่างน้อย 1 อย่าง ระหว่างช่วงเดือนตุลาคม ถึงธันวาคม พ.ศ. 2559 ปัจจัยต่างๆ 5 ปัจจัย ได้แก่ เพศ อายุ จำนวนฟันในช่องปาก นิ่วในฟันและต้าน จะถูกบันทึกพร้อมข้อมูลลักษณะก้านสไตลอยด์ซึ่งถูกแบ่งออกเป็น 11 แบบ (เอถึงเค) แบบเอถึงดีจะจัดเป็นกลุ่มที่เป็นก้านสไตลอยด์ปกติ แบบอีเป็นก้านสไตลอยด์ที่ยื่นยาว แบบเอฟถึงเคเป็นเอ็นยึด สไตลอยด์ที่มีแคลเซียมเกาะ ผู้อ่านภาพรังสี 2 คนช่วยกันประเมินภาพรังสีแต่ละภาพ ลักษณะก้านสไตลอยด์แต่ละแบบและปัจจัย ที่เกี่ยวข้องจะถูกวิเคราะห์โดยใช้สถิติเชิงพรรณนา ความสัมพันธ์ระหว่างแต่ละปัจจัยถูกวิคราะห์โดยมัลติเปิ้ลโลจิสติกรีเกรสชัน ผลการศึกษาพบว่าก้านสไตลอยด์แบบดีพบมากที่สุดทั้งสองข้าง คือ 109 (ร้อยละ 36.3) ในด้านขวาและ 125 (ร้อยละ 41.7) ในด้านซ้าย เพศหญิงพบ 207 ราย (ร้อยละ 69) เพศชาย 93 (ร้อยละ31) ในเพศหญิงพบก้านสไตลอยด์ด้านขวาปกติมากกว่าในเพศชาย เป็นเท่า 1.99 อย่างมีนัยสำคัญทางสถิติ ช่วงความเชื่อมั่นร้อยละ 95=1.01-3.93 (p=0.048) อายุเฉลี่ย 35.42+ 18.52 ปี ช่วงอายุ 18-88 ปี อายุไม่มีความสัมพันธ์ทางสถิติกับลักษณะก้านสไตลอยด์ จำนวนฟันที่หายไปมีตั้งแต่ 0 ถึง 32 ซี่ ในผู้ป่วย 219 คน (ร้อยละ 73) ไม่มีความแตกต่างอย่างมีนัยสำคัญระหว่าง ผู้ป่วยที่มีฟันและผู้ป่วยไร้ฟัน (p=0.08) นิ่วในฟันพบ 64 ราย (ร้อยละ 21.3) ผู้ที่มีก้านสไตลอยด์ด้านซ้ายปกติจะแสดงลักษณะก้านสไตลอยด์ ด้านขวาปกติด้วยอย่างมีนัยสำคัญทางสถิติ (p<0.0001) กล่าวโดยสรุป ลักษณะและจำนวนของก้านสไตลอยด์ด้านขวาแตกต่างจากด้านซ้าย จำนวนฟันที่เหลือในช่องปากไม่ได้มีผลกระทบต่อลักษณะของก้านสไตลอยด์ เพศและด้านเกี่ยวข้องกับการจัดประเภทลักษณะของก้านสไตลอยด์ และเอ็นยึดสไตโลไฮออยด์

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