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CONGRESS PROCEEDING

Comparison of Elongation and Calcification Patterns of Styloid Process on Panoramic and Cone Beam Computed Tomography Images

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Abstract

Purpose: The styloid process (SP) is part of the temporal bone that is a cylindric bony projection located immediately in front of the stylomastoid foramen. The normal reported length of the SP ranges from 20 to 32 mm and longer than 30 mm was considered to be elongated SP. The aim of this study was to compare the SP findings (length, type, and calcification pattern) on panoramic and cone beam computed tomography (CBCT) images.
Materials and Methods: : 163 patients who had panoramic and CBCT images in the same year were included to the study. On panoramic images calcifications beyond the mandibular foramen were classified as elongated SP while on CBCT images SP which had measured more than 30mm were accepted as elongated. Varying SP calcification classifications were reported by different researchers and in this study Langlais classification (Type 1 Elongated, Type 2 Pseudoarticulated, and Type 3 Segmented), the most accepted classification, was used. Calcification pattern were classified as calcified outlined, partially calcified, nodular, and completely calcified.
Results: This study included 35 (21.5%) men, 128 (78.5%) women, 163 patients with mean age 46.13 ± 0.91 (21-65) years. On panoramic images 101 (62%) normal, 45 (27.6%) bilateral and 17 (10.4%) unilateral elongated SP were detected. On CBCT images 85 (52.1%) normal, 56 (34.4%) bilateral and 22 (13.4%) unilateral elongated SP were detected. The agreement of the two imaging modalities was calculated as moderate (58.4%). Type 1 SP and partially calcified were the most common features of SP in both imaging modalities.
Conclusions: Some SP cases, which are evaluated as not elongated in panoramic images, can be detected as elongated in CBCT images. Therefore, it is recommended to evaluate SP with CBCT in prevalence studies and cases where length is critical.

Key words: cone beam computed tomography; panoramic; styloid process

Introduction

The styloid process (SP) is a part of a bone-ligament complex, the stylohyoid chain (SHC), with the stylohyoid ligament and the lesser horn of the hyoid bone.[1] SP is a cylindric bony projection of temporal bone located near the stylomastoid foramen. Stylopharyngeous, stylohyoid, and styloglossal muscles, stylohyoid and stylomandibular ligaments attach to the SP.[2] The normal reported length of the SP ranges from 20 to 32 mm and longer than 30 mm was considered to be elongated SP.[3,4] Although the elongated SP is usually asymptomatic, symptoms like a dull, aching pain localized in the throat, pain on swallowing (dysphasia) or an abnormal sensation of a foreign body in the pharynx (Eagle's Syndrome) can be seen.[5] Elongated SP prevalence was reported in a wide range as 3.7-84.4% in various studies that used different imaging techniques.[2,3,5–10] There are different classifications for SP calcification. In these classifications besides SP length, elongation type and calcification pattern were categorized.[4,5,7] Panoramic imaging is one of the most commonly used imaging technique in dentistry and has been used for the evaluation of elongated SP in many studies.[2,3,5] Not only its ability to show an extensive visualization of the structures of the maxillofacial complex but also, it is a low-cost procedure with lower radiation exposure compared to cone beam computed tomography (CBCT). However, in some cases it is difficult to examine the

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SP due to the overlapping of adjacent anatomic structures.[10] In recent years, CBCT has also been used in the evaluation of SP.[1,9,11] The size and morphology of the SP can be easily assessed by CBCT without superpositions.[11] The aim of this study was to compare the SP findings (length, elongation type, and calcification pattern) on panoramic and CBCT images. To the best of our knowledge this is the first study investigating the comparison of elongation and calcification patterns of SP on panoramic and CBCT images.

Methods

This retrospective study was reviewed and approved by the Non-Interventional Clinical Research Ethics Board of Hacettepe University with registration number GO 21/1189 and all procedures were followed in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. For this type of study, formal consent is not required. All images were obtained from the records in the Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Hacettepe University. Patients whom panoramic and CBCT images were obtained in the same year were included the study. The panoramic and CBCT images which the relevant region was not visualized properly, patients with fracture or pathology in the region of the SP, and images with poor image quality were excluded. Initially, the CBCT scans were selected from the images obtained between January 2018 and December 2018 (n=837) and then coupled with available panoramic images. Finally, 163 pairs of panoramic and CBCT images that SP was clearly visible were included the study. The CBCT scans were acquired with an i-CAT Next Generation (Imaging Sciences International, Hatfield, PA, USA) unit. Digital panoramic images were obtained using Orthophos XG 5 (Sirona Dental Company, Bensheim, Germany) or Veraview IC5 (Morita Corporation, Kyoto, Japan) equipment. On panoramic images SP was categorized as elongated if it is localized below the mandibular foramen.[8] Then, SP elongation type and calcification pattern were categorized. Langlais4 classified SP elongation as type 1 (elongated: an uninterrupted integrity of the SP), type 2 (pseudoarticulated: SP is apparently joined to the mineralized stylomandibular or stylohyoid ligament by a single pseudoarticulation), and type 3 (segmented: consists of either short or long noncontinuous portions of the SP or interrupted segments of mineralized ligament). SP calcification pattern was classified as calcified outline (thin radiopaque border with a central radiolucency), partially calcified (thicker radiopaque outline and almost complete opacification, with small, sometimes discontinuous radiolucent cores), nodular (knobby or scalloped outline with partially or completely calcified), and completely calcified (totally radiopaque with no evidence of a radiolucent interior). Reddy et al.5 added a fourth type for elongation pattern to this classification as type 4 (distant: elongation of SP due to distant ossification). In this study SP length, elongation pattern (Type 1, 2, 3, and 4) and calcification pattern (calcified outline, partially calcified, nodular, and completely calcified) were recorded for left and right side independently. On CBCT images SPs were evaluated by using the volume rendering feature of Invivo5 Software (Ver. 5.2, Anatomage Dental, San Jose, CA, USA). SP length was measured from the base of the SP to the tip (Figure 1). The measurement was made including the non-ossified parts in segmental calcifications.1 Also, SP elongation and calcification patterns were recorded on volume rendered 3D images. Two observers evaluated the panoramic and CBCT images and performed SP measurements. The images were evaluated by the same observers for a second time after two weeks.

Figure 1. SP length measurement on 3-D CBCT images from the base of the SP to the tip.

Statistics

Frequency and percentage (n, %) were used as descriptive statistics for categorical variables where median (interquartile range) were used for numerical variables. Kolmogorov-Smirnov normality test was used for assessing normality in numerical variables. Both intra- and inter-rater agreement were evaluated by using Kappa coefficient in categorical variables. Intra-class correlation coefficient with considering Two-way mixed effects model with consistency in single measurement formula as ICC (3,1)c used for evaluating agreement in numerical measurements such as length. In addition to intra- and inter-rater agreement, we evaluated agreement between two different measurement methods as panoramic, CBCT by using Kappa coefficient in categorical variables and ICC (3,1)c for numerical variables. Statistical analysis was carried out using IBM SPSS Statistics for Windows v23.0 (Released 2015. Armonk, NY: IBM Corp.). Significance level was set at α = 0, 05 for all analysis.

Results

This study included 35 (21.5%) men, 128 (78.5%) women, 163 patients with mean age 46.13 ± 0.91 (21-65) years. On panoramic images 101 (62%) normal, 45 (27.6%) bilateral and 17 (%10.4) unilateral elongated SP were detected. On CBCT images 85 (52.1%) normal, 56 (34.4%) bilateral and 22 (13.4%) unilateral elongated SP were detected. The agreement of the two imaging modalities was calculated as moderate (58.4%). The median length of SPs on CBCT images was 27.62 mm for left side with an interquartile range (the range between 25th percentile and 75th percentile) 10.99 mm, and 28.13 mm for right side with an interquartile range 11.99 mm. Type 1 SP and partially calcified were the most common features of SP in both imaging modalities. The agreement of panoramic and CBCT images for left side SP elongation type and calcification pattern were moderate (%48 and %40.8, respectively). Although the agreement of panoramic and CBCT images for right side SP elongation type was moderate (%52.5), the agreement on calcification pattern was poor (%10.1) Table 1. Agreement between first and second measurements of the same observer was almost perfect in all measurements except right side SP calcification pattern on CBCT images which has substantial agreement. Agreement between two observers were moderate to substantial for categorical measurements where the agreement was almost perfect for CBCT SP length measurement of both sides. Generally, agreement level was lower in CBCT compared to panoramic images.

	Panoramic (Left side) Frequency (%)	CBCT (Left side) Frequency (%)	Kappa Coefficient
Elongation type			
Type 1 (Elongated) Type 2 (Pseudoarticulated) Type 3 (Segmented) Type 4 (Distant)	136 (83.4) 21 (12.9) 2 (1.2) 3 (1.8)	119 (73) 30 (18.4) 9 (5.5) 5 (3.1)	%48 Moderate
Total	162 (99.3)*	163 (100)	
Calcification pattern			
Calcified outline Partially calcified Nodular Completely calcified	8 (4.9) 132 (81) 1 (0.6) 21 (12.9)	0 (0) 144 (88.3) 0 (0) 19 (11.7)	% 40.8 Moderate
Total	162 (99.3)*	163 (100)	
	Panoramic (Right side)	**CBCT (Right side)**	
Elongation type			
Type 1 (Elongated) Type 2 (Pseudoarticulated) Type 3 (Segmented) Type 4 (Distant)	134 (82.2) 21 (12.9) 2 (1.2) 6 (3.7)	116 (71.2) 31 (19) 13 (8) 3 (1.8)	%52.5 moderate
Total	163 (100)	163 (100)	
Calcification pattern			
Calcified outline Partially calcified Nodular Completely calcified	12 (7.4) 143 (87.7) 2 (1.2) 6 (3.7)	1 (0.6) 155 (95.1) 0 (0) 7 (4.3)	%10.1 Poor
Total	163 (100)	163 (100)	

Table 1. SP elongation types and calcification pattern on panoramic and CBCT images and agreement of two imaging methods

*1 SP was undetected on panoramic image

Discussion

Calcified SP is relatively common and there are many studies from different countries that studied the SP calcification.[4] In these studies, different imaging methods were used. In former studies mostly panoramic imaging.[2,3,6] and lesser computed tomography (CT) scans[1] were used for the evaluation of SP calcification. In some cases, SP cannot be assessed clearly on panoramic images due to the superimposition of adjacent anatomic structures, magnification and position errors. On the other hand, CBCT provides unobstructed views of anatomic structures with the ability to enable the three-dimensional imaging. Also, CBCT has both lower radiation dose and cost than CT.[12] Therefore, in recent years CBCT imaging is preferred for SP calcification evaluation.[9,11] In this study the agreement of panoramic and CBCT imaging at the evaluation of SP calcification was found moderate (58.4%). On CBCT images more SP were classified as elongated than panoramic images. There were studies that made linear measurements of SP on panoramic images[5] however, the panoramic technique may distort dimension of the process and magnification of the X-ray image may vary with the angulation of the process itself.[7] Therefore, to determine the length of SP on panoramic images, linear measurement was not chosen. In this study O'Carroll's method, that considered any SP elongated if it extended below the mandibular foramen, was used at the determination of SP elongation.[8] It was reported that CBCT provides accurate and reliable linear measurements for reconstruction and imaging of dental and maxillofacial structures.[13] Therefore, in this study SP length was measured on CBCT images. The median length of SPs on CBCT images was 27.62 mm for left side with an interquartile range (the range between 25th percentile and 75th percentile) 10.99 mm, and 28.13 mm for right side with an interquartile range 11.99 mm. These results were compatible with the literature.[1,11] In this study SP calcification prevalence was found 38% on panoramic images and 47.8% on CBCT images. Variation of anatomic structures is common and SP calcification prevalence was reported in a wide range as 3.7-84.4%.[2,3,5–10] This prevalence variations could be attributed to many factors including the different imaging techniques used, age range and ethnicity of the study population, and methods used for SP calcification classification. In the present study, bilateral SP elongation was more common than the unilateral SP elongation and this was consistent with the other studies.[6,7,9] Type 1 (elongated) SP was the most common elongation type in both imaging techniques and this was similar with the studies that panoramic imaging is used,[2,3,5] but different from the studies that CBCT imaging is used.[9,11] The agreement of panoramic and CBCT imaging methods was moderate for both left and right sides. Some of the SP that were classified as type 1 (elongated) on panoramic images, were classified as pseudoarticulated or segmented on CBCT images and this may affect the agreement. Kursoglu et al.[2] used panoramic imaging for SP evaluation and reported the calcified outline as the most common calcification pattern. Differently Ilguy et al.[3] reported the partially calcified as the most common calcification pattern. In the present study although the partially calcified was the most common calcification pattern in both imaging techniques, the agreement of panoramic and CBCT images on the calcification pattern of SP was moderate for left side and poor for right side. Those classified as calcified outline, partially calcified and nodular in panoramic images were classified as partially calcified on CBCT images. This may cause the poor agreement of the two imaging techniques. In this study only 3 SPs had nodular calcification on panoramic images and this was similar with the literature.[2]

Conclusion

Panoramic imaging is widely used in dentistry as in evaluation of SP elongation. However, it has some limitations such as magnification and superimposition of anatomic structures. In this study the agreement of panoramic and CBCT images was found moderate for the evaluation of SP. Some SP cases, which are evaluated as not elongated in panoramic images, can be detected as elongated in CBCT images. Therefore, it is recommended to evaluate SP with CBCT in prevalence studies and cases where length is critical.

Author Contributions

G.A : Contributed to the conception and design of study, acquisition, analysis and interpretation of the data. Drafting of article and/or critical revision. Final approval of the version to be published. , D.K. : Contributed to the acquisition, analysis and interpretation of the data. Drafting of article and/or critical revision Final approval of the version to be published. , S.U. : Contributed to the conception and design of study, and interpretation of the data. Drafting of article and/or critical revision Final approval of the version to be published. , H.Y.Z. : Contributed to analysis and interpretation of the data. Drafting of article and/or critical revision. Final approval of the version to be published.

Conflict of Interest

The authors deny any conflicts of interest related to this study.

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