Observational Study

Medicine

OPEN

Examination of the frequency and localization of sigmoid canal with CBCT

A retrospective study

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Abstract

Recently, a variational canal starting from the sigmoid notch and extending in the ramus has been reported. The aim of this study was not only to investigate the presence and localization of the sigmoid canal (SC) between the sexes, which has not been studied before, but also to define the morphometric characteristics of the SC. The possible complications that this anatomical variation may cause are also being discussed. Between 2022 and 2024, a total of 546 cone beam computed tomography images obtained in sagittal, coronal, and horizontal planes were retrospectively analyzed. The presence, localization, and morphometric characteristics of the SCs were recorded and evaluated using statistical analysis software. The presence of SC was observed in 5.5% of the images and it was determined that 4.0% of these canals were unilateral and 1.5% were bilateral. The rate of right SC was 3.3% and the rate of left SC was 3.7%. When morphometric evaluation is made, the average value of the length of the SC is 8.0 mm, with a minimum value of 3.1 mm and a maximum value of 13.9 mm. Knowledge of the SC will prevent possible complications in surgical procedures, provide a more accurate diagnosis at the diagnostic stage and ensure that the treatment plan is created appropriately. More studies are needed on this subject.

Abbreviations: CBCT = cone beam computed tomography, SC = sigmoid canal.

Keywords: anatomical variation, cone beam computed tomography, mandible, sigmoid canal

1. Introduction

The mandible is one of the strongest bones in the body.[1] The quadrangular shaped part in the posterior part of the mandible is called ramus. It carries the coronoid and condylar processes on the ramus. The notch between the sigmoid and condylar process is called sigmoid notch.[2] As with all structures in the body, various variations are observed in the mandible.[3,4] Knowledge of these variations will enable the treatment plan to be designed correctly, increase the success in diagnosis and prevent complications.[5] Recently, the existence of an intraosseous canal called the sigmoid canal (SC) starting from the sigmoid notch and descending inferiorly along the ramus has been mentioned. It has been reported that a branch of the maxillary artery travels in the ramus through this canal. This intraosseous canal is important in surgical procedures for the ramus and in the interpretation of diagnostic imaging.[6] In order to make a correct image interpretation, it is necessary to master the anatomical variations in the analyzed structures. Cone beam computed tomography (CBCT) is considered to be a very advantageous method when anatomical variations are to be examined on hard tissues.[7] CBCT, which has isotropic voxels, provides high resolution, relatively low radiation dose and low cost compared to computed tomography.[8]

When the literature was examined, no research articles regarding the SC were found. This study aims to evaluate the presence of the SC not only according to gender and localization, but also to evaluate the morphometric evaluation of this canal.

2. Materials and methods

This study was conducted in accordance with the decision numbered 24.10.06 taken from Harran University Clinical Research Ethics Committee. This study was conducted in accordance with the Declaration of Helsinki. Before all images were obtained, an informed consent form was obtained from the patients in order to use the images in scientific studies. G Power 3.1.9.7 software was used to calculate the sample size of this study. When $\alpha = 0.05$, $1 - \beta = 0.95$ effect size was accepted as medium, the sample size was found to be 145. A total of 906 tomography images of patients who came to Harran University Faculty of Dentistry, Dentomaxillofacial Radiology outpatient clinic for different reasons were obtained and analyzed in a standardized

The authors have no funding and conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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How to cite this article: Kaya MS, Dogan ME, Kotanli S. Examination of the frequency and localization of sigmoid canal with CBCT: A retrospective study. Medicine 2025;104:7(e41579).

Received: 27 October 2024 / Received in final form: 30 January 2025 / Accepted: 31 January 2025

http://dx.doi.org/10.1097/MD.0000000000041579

manner using Castellini X-Radius Trio Plus (Imola, Italy) dental tomography device with a FOV range of 13 × 10 and 13 × 16 cm using 16 mAs and 90 kVp irradiation parameters. The slice thickness was 1 mm and voxel size was 0.3 mm. The images were retrospectively evaluated in coronal, horizontal and sagittal sections by a single dento maxillofacial radiologist (MSK) using IRYS viewer 15.1 software program. It was found that 75 of these patients had a second film for control and the last images of these patients were considered for evaluation. Of the remaining 831 images, 285 were excluded for the following reasons.

2.1. Exclusion criteria

- Imaging artifacts
- The imaging field does not include the ramus
- Mismatch in imaging parameters
- Poor image quality
- Systemic diseases that give an image in the jaw bones
- Cysts, tumors and infective lesions in the imaging area
- Fracture line in the area to be examined

In cases of uncertainty, another dento maxillofacial radiologist (MED) with 5 years of experience was consulted. A sum of 546 images were evaluated using a 27-inch ASUS screen with a maximum screen resolution of 1920 × 1080. Twenty per cent of the available images were reevaluated after a minimum of 14 days to assess intra-observer agreement. The variables evaluated for the SC are as follows.

- Nonmetric: SC presence and localization (right/left). Horizontal, sagittal and coronal sections were analyzed. Figure 1 gives a view of the SC in different sections.
- Metric: SC length, SC distance to the anterior ramus, SC distance to the posterior ramus. During the metric evaluation of the length of the SC, measurements were made in the sagittal plane from the beginning to the end of the SC, following the slope of the canal from the midline of the canal. When measuring the distance between the SC anterior ramus, a tangent line was drawn from the anterior border of the ramus in the sagittal section and lowered perpendicular to this tangent from the starting point of the canal. When measuring the distance between the posterior ramus of the SC, a tangent line was drawn from the posterior border of the ramus in the sagittal section and lowered perpendicular to this tangent from the starting point of the canal. Figure 2 gives how the metric measurements of the SC are made.

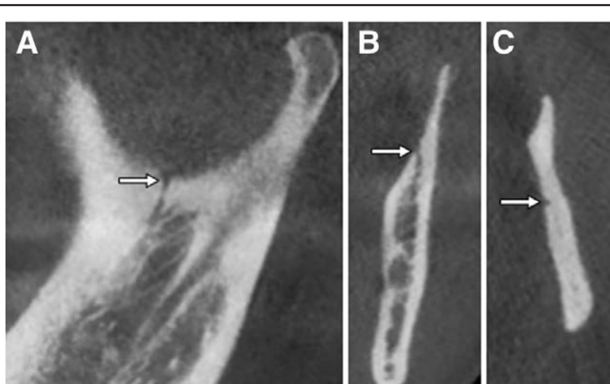

Figure 1. (A) CBCT sagittal image arrowheads point to the sigmoid canal; (B) CBCT coronal section image arrowheads point to the sigmoid canal; (C) CBCT axial section image arrowheads point to the sigmoid canal. CBCT = cone beam computed tomography.

2.2. Statistical analysis

Cohen's Kappa statistical analysis method was applied to evaluate intraobserver agreement. All data were entered into an Microsoft Office Excel® 2016 (Microsoft Corp., Redmond) file. The data in the excel file were entered into the IBM SPSS Statistics Version 25 package program (Armonk) and analyzed. Descriptive statistics were used to calculate the number (N), percentage, mean, minimum and maximum values. Pearson chi-square test was used to examine the relationship between categorical variables. Significance value $P < .05$ was accepted. Only descriptive statistics were used to analyze the metric variables of the SC.

3. Results

Of the 546 patients analyzed in this study, 267 (48.9%) were male and 279 (51.1%) were female. The mean age was 35.26 years with an age range of 5 to 89 years. Intraobserver agreement was found to be maximum (1.0) for nominal variables such as the presence of SC and SC localization. The presence of SC was observed in 5.5% of the images and it was determined that 4.0% of these canals were unilateral and 1.5% were bilateral. While the rate of right SC was 3.3%, the rate of left was 3.7%. Bilateral absence of this canal showed a higher and statistically significant difference than bilateral presence ($P < .001$). The right and left SC distribution is shown in Table 1. The incidence of right SC in men were 2.2% while incidence of right in women were 1.5%. There was no significant difference between both genders in terms of right SC localization ($P = .217$). While the incidence of left SC in men were 1.5%, the incidence of women were 1.8%. There was no significant difference between both genders in terms of left SC localization ($P = .443$). Table 2 shows the distribution of SC by gender.

When morphometric evaluation was made, the length of the SC was 8.0 mm with a minimum value of 3.1 and a maximum value of 13.9 mm. The mean of this canal length was 7.4 mm in women and 8.6 mm in men. The minimum distance of the SC to the anterior ramus was 7.2 mm and the maximum distance was 16.2 mm. The mean distance of this canal to the anterior ramus was 11.5 mm. The average distance of the SC to the anterior ramus in women was 11.6 mm, while the average distance of this canal to the anterior ramus in men was 11.4 mm. When the distance of the SC to the posterior ramus was evaluated, the minimum distance was 10.5 mm and the maximum distance was 27.4 mm, and the average distance was 16.2 mm. The average distance of the SC to the posterior ramus in women was 15.6 mm, while the average distance of this canal to the posterior ramus in men was 16.8 mm.

4. Discussion

There are many anatomical variations in the body. Research on these variations has accelerated especially since the first half of the 19th century.[9] According to Bergman et al,[10] the formation of anatomical variations originates from our past genetic structure. It is possible that the change in mortality rates, along with the loosening of the influence of natural selection on the human population after the industrial revolution, increased hereditary diversity and increased the prevalence of anatomical variations. Two hypotheses can be put forward to explain the increase in these variations. The first hypothesis is that the acceleration of embryonic development due to improved embryonic living conditions prevents the retraction of an embryonic vessel. The second hypothesis is that the selective pressure of anatomical variations that may cause any pathology decreases with the development of treatment methods.[11] Not all of these variations are clinically symptomatic.[9] However, they have the potential to cause errors in diagnosis and complications in treatment. Therefore, it is very important to master the anatomy. According to Bergman et al,[10] the fact that anatomical variations are not unlimited will enable us to fully comprehend these variations and obtain a broad knowledge of human anatomy. Phylogenetic analysis of this variation was not possible due to the lack of information in the literature on the subject.

In the past, anatomical examinations were performed only by dissection on cadavers, but with the development of imaging systems in recent years, anatomical examinations can also be performed with medical imaging.[12] If the variation to be examined is associated with hard tissue, it is advantageous to examine this structure with CBCT. The low radiation dose and high spatial resolution of CBCT compared to multislice computed tomography provide this advantage.[8,13,14] In addition, while CBCT is widely used in dentistry, multislice computed tomography has not been widely used in hospitals.[15] Since the anatomical variation examined in this study is related to hard tissue, CBCT was preferred as the examination tool. Although CBCT provided the opportunity to examine hard tissues in detail, the canal content could not be detected in this study.

In the case report in which the SC was described, the content of the canal was stated as a branch of the maxillary artery.[6] In this study, the possible content of this canal was accepted as a branch of the maxillary artery. In this case, there is a possibility of unwanted maxillary artery hemorrhage in surgical interventions for the ramus. Considering the location of the canal, there is a possibility of artery injury complications in the upper part of the mandibular foramen, which is considered relatively safe in vertical ramus osteotomy and horizontal ramus osteotomy.[16] Possible maxillary artery injuries can also be observed in the anterior ascending ramus osteotomy, which is used when a large donor area is required, due to the location of the SC.[17] In addition, it is not known whether there is a nerve bundle in this canal. If there is a nerve bundle accompanying the vessel, nerve injuries may occur. It has been previously mentioned that accessory foramen may facilitate tumor dissemination due to the absence of periosteum.[18] It is likely to disrupt periosteal continuity in the SC and facilitate tumor spread to the cancellous bone. Considering the characteristics of the variation examined in the study, it is possible that this canal may be confused with the fracture line in the diagnosis. In our study, the presence and localization of the SC as well as its morphometric features were examined, but it was not possible to estimate the content of the canal.

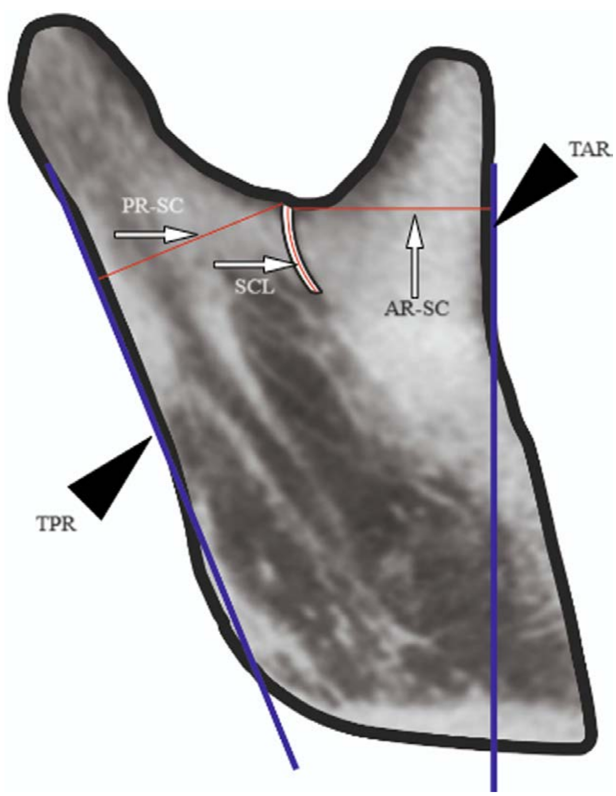

Figure 2. Purple lines with black arrowheads represent imaginary lines tangent to the anterior and posterior ramus. Imaginary tangent line to the posterior ramus is indicated by TPR. Imaginary tangent line to the anterior ramus is indicated by TAR. The red lines indicated by the white arrow visualize the measurements related to the sigmoid canal. The posterior ramus sigmoid canal distance is shown as PR-SC. The anterior ramus sigmoid canal distance is shown as AR-SC. The sigmoid canal length is shown as SCL.

5. Limitations

- Inability to detect canal content due to the nature of the study
- Possible obliteration process of the canal with age could not be detected due to the distribution of age groups
- The study could not be performed on patients with different ethnic origins
- All information was obtained retrospectively from hospital records; therefore, the effect of SC on the current medical condition could not be investigated
- Failure to evaluate the frequency of the SC from past to present

In summary, knowledge of the SC will prevent possible complications in surgical procedures, provide a more accurate diagnosis at the diagnostic stage and ensure that the treatment plan is created appropriately. CBCT was found

Table 1

The distribution of the right and left sigmoid canal.

		Left sigmoid canal			
		Presence	Absence	Total	*P*
Right sigmoid canal	Presence	8 (1.5%)	10 (1.8%)	18 (3.3%)	.000
	Absence	12 (2.2%)	516 (94.5%)	516 (96.7%)	
Total		20 (3.7%)	526 (96.3%)	546 (100.0%)	

Table 2

Dispersion of the sigmoid canal according to gender.

		Gender			
		Male	Female	Total	*P*
Right sigmoid canal	Presence	12 (2.2%)	8 (1.5%)	20 (3.7%)	.217
	Absence	255 (46.7%)	271 (49.6%)	526 (96.3%)	
Left sigmoid canal	Presence	8 (1.5%)	10 (1.8%)	18 (3.3%)	.443
	Absence	259 (47.4%)	269 (49.3%)	528 (96.7%)	

to be adequate in the examination of SC morphology, but MRI and histological examination were recommended for the examination of the SC content. Studies should be carried out in different ethnic origins and different age groups by expanding the sample size.

Author contributions

Conceptualization: Menduh Sercan Kaya.
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