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ORIGINAL ARTICLE

# Evaluation of canalis sinuosus and accessory canal morphology by cone-beam computed tomography

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## Abstract

**Objective** To evaluate canalis sinuosus (CS) and accessory canalis sinuosus (AC) morphology and their relationship with the impacted canine on cone-beam computed tomography (CBCT) images.

**Methods** The diameter and location of the CS, its distance from the nasal cavity (NC–CS), its distance from the buccal cortical plate (BC–CS), and its distance from the alveolar ridge crest (AR–CS) were evaluated on 1000 CBCT scans. The prevalence and termination of AC and the presence of impacted canines were also evaluated.

**Results** CS was detected in 89 (8.9%) of 1000 CBCTs. The mean CS diameter was found as 1.34 ± 0.53 mm. No statistically significant difference was found between gender, age, direction, and CS presence and diameter. CS was most frequently seen in regions 11 (23.6%) and 13 (23.6%). The average NC–CS, BC–CS, and AR–CS length was 6.14, 6.06 and 4.35 mm, respectively. AC was detected in 22 patients (24.71%). There was no statistically significant difference between the presence of AC and gender, age, CS diameter, NC–CS, BC–CS, and AR–CS distance. BC–CS length and AR–CS length were statistically significantly higher in patients with impacted canines.

**Conclusions** It should be kept in mind that the CS diameter, NC–CS, BC–CS, and AR–CS distance may increase in the presence of an impacted canine and the integrity of the neurovascular structure should be preserved. The fact that the CS is often localized in the palatial region requires a detailed evaluation of the anterior maxillary region with three-dimensional imaging methods.

**Keywords** Canalis sinuosus · Accessory canalis sinuosus · Cone beam computed tomography · Impacted canine

## Introduction

Many surgical procedures such as implant surgery, removal of impacted or supernumerary teeth, periodontal surgery, endodontic surgery, orthognathic surgery, and cyst treatment are frequently performed in the anterior maxillary region [1]. The neurovascular innervation of this region is provided by the maxillary nerve that separates from the fifth cranial nerve, the trigeminal nerve, and the vascular structures accompanying this nerve. The anterior superior alveolar nerve, a branch of the infraorbital nerve, innervates the incisor and canine teeth and soft tissues [2]. Many accessory foramens exist in this region, and these anatomical variations in various sizes and morphological features can be misdiagnosed and confused with apical pathologies [3].

Canalis sinuosus (CS) is a bony canal branching from the infraorbital canal in the maxilla and ending lateral to the anterior nasal spine. CS is often overlooked in anatomical definitions of the maxilla and is a potentially iatrogenic lesion site involving the anterior superior alveolar neurovascular bundle. This canal begins its path as a bifurcation of the infraorbital canal and follows a descending and medial path towards the lateral wall of the piriform opening in the anterior wall of the maxilla. It descends surrounding the lateral and lower edges of the piriform opening and ends laterally on the anterior nasal spine in a foramen called the septal foramen. Under normal conditions, the CS is less than 1 mm in diameter and 5.5 cm in total length, approximately 1.5 cm at the base of the orbit, 2 cm along the maxilla, and

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2 cm in the inferolateral part of the piriform opening [1, 4, 5]. Neurovascular branches in the CS form the dental plexus in the canine tooth region. CS provides sensitivity to anterior teeth, the floor of the nasal fossa, and maxillary sinuses. However, during surgical interventions in this area, neurovascular disorders resulting from iatrogenic damage to the canal sinuosus may also develop [6]. Lack of knowledge about the location of the CS can bring risks during dental surgical procedures and cause pain, local infection, and even paresthesia. Another important anatomical variation in this region is the accessory canal (AC) of the CS. It is an important anatomical variation that can be overlooked in dental practices such as implant surgery, endodontic surgery, cyst, tumor surgery, or impacted canine surgery [7].

Periapical and panoramic radiography are widely used as valuable diagnostic methods by clinicians in dentistry. These radiographic techniques have many limitations such as superposition, magnification, and distortion. For this reason, cone-beam computed tomography (CBCT) is considered the most useful radiographic method to evaluate the anatomical structures of the maxilla before and after surgery in order to prevent possible complications [8]. With the widespread use of CBCT in dentistry, the recognition of these anatomical variations has become easier. It offers advantages to clinicians thanks to its ease of giving detailed images, angular and linear measurements, and multiplanar reconstruction features. It also enables cross-sectional examination before implant surgery [5].

Since we believe that there is a lack of literature on the CS in the Turkish population to date, we aimed to evaluate the morphology of the CS and AC and their relationship with age, gender, and impacted canine teeth on CBCT images, based on the importance of studying this anatomical structure in the Turkish population.

## Materials and methods

### *Ethical approval*

This study was approved by the Local Ethics Committee of the Hatay Mustafa Kemal University (Date: 12.01.2023, Decision no: 09) and the study protocol was conducted in accordance with the principles set out in the World Medical Association Declaration of Helsinki of 1964 and later version. This study was prepared in accordance with the criteria of EQUATOR guidelines such as sample size calculation, significant difference groups, sample preparation and processing, allocation sequence, randomization, and blinding statistical analysis.

### Study design

In the study, CBCT images of a total of 500 patients who applied to Hatay Mustafa Kemal University, Dentomaxillofacial Radiology Department between 2021 and 2022 taken for various reasons during routine examination were retrospectively analyzed. For the images to be included in the study, the conditions were not to have intraosseous pathology (cyst, tumor, etc.) in the anterior maxilla, to have no history of surgical procedure and/or fracture in the anterior maxilla, to be of sufficient diagnostic quality, and to have no cleft palate and/or anomaly that may affect the dentomaxillofacial structures. CS and AC were evaluated on 1000 CBCT sections (500 left, 500 right sides) that meet these criteria.

After the age and gender of the patients were noted, the patients were divided into 3 groups: 18–30 years old, 31–60 years old, and 61 years old and above, and the parameters listed below on the right and left sides were evaluated.

- For localization of CS when CS is detected on CBCT images, seven location regions identified by Oliveira-Santos et al. were noted [4]. These are the central incisor region, the region between the central and lateral incisors, the lateral incisor region, the canine region, the first premolar region, the lateral of the incisive foramen, and the posterior of the incisive foramen.
- CS terminal diameter: When the terminal part of the canalis sinuosus expanded directly into the AC [9], the bifurcation location was set at the level of the nasal floor and the diameter of the canal was measured on the sagittal section as the diameter of the terminal CS [10].
- NC (nasal cavity)–CS: The distance between the CS and the floor of the nasal cavity was measured on the sagittal section [5] (Fig. 1).
- BC (buccal cortical plate)–CS: The distance from the emergence of the CS to the edge of the buccal cortical bone was measured on the sagittal sections, drawing a linear line from the anterior border of the terminal ending of CS to the BC [5] (Fig. 1).
- Alveolar ridge crest (AR)–CS: The vertical linear distance from the emergence of the CS to the most prominent point of the apex of the alveolar ridge was measured on the sagittal sections [5] (Fig. 1).
- Number of ACs and end of AC (The end of AC was recorded as buccal or palatal) from the axial and coronal sections [11]
- The presence of an impacted canine was recorded from the axial and coronal sections.

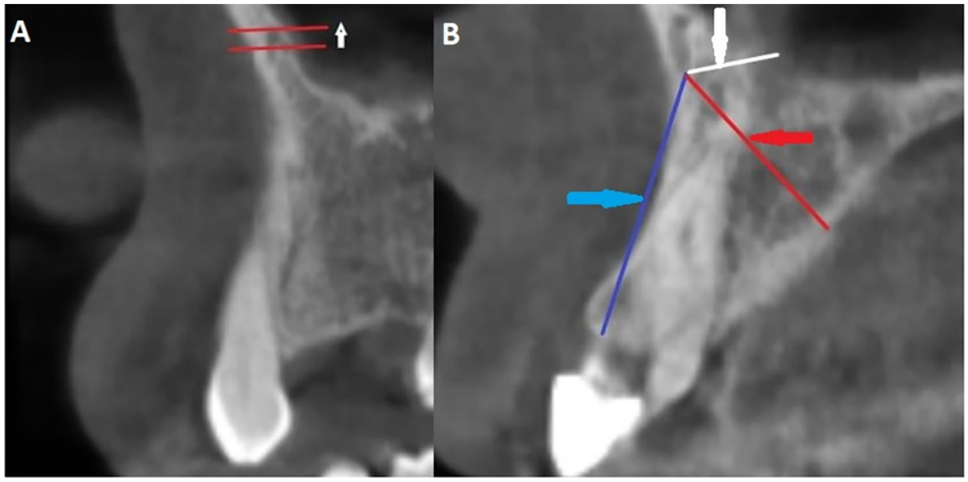



**Fig. 1** A The diameter of terminal CS (white arrow). B. Measurements from CS to reference landmarks; CS–AR blue arrow and line, CS–BC red arrow and line and CS–NC white arrow and line

## Imaging parameters and display features

All CBCT images (Kavo 3D Op Pro, Biberach, Germany) were obtained at 90 kV, 5.0 mA, 4.07 s, 13 × 15 cm FOV, 380 µm voxel size, 0.38 mm slice thickness, and images were evaluated in axial, coronal and sagittal planes. In order to see and measure CS and AC more clearly in the measurements, image contrast, brightness, and zoom adjustments were allowed and the measurements were made on a 1.366 × 768 pixels liquid–crystal monitor (Dell 14-inc.; Dell, Round Rock, TX, USA). For standardization of measurements, all measurements were made at 0.38 mm, which is the smallest section thickness allowed by the device. An oral and maxillofacial radiology research assistant with 2 years of experience, who was about to complete her residency training (ZEH), evaluated all CBCT scans under dim light conditions. The first hundred cases were evaluated and discussed under the supervision of two senior oral and maxillofacial radiologists (CAB and GS) with more than 5 years of experience. The final decision was determined by consensus of two senior oral and maxillofacial radiologists (CAB and GS).

## Statistical analysis

Mean, standard deviation, median, lowest, highest, frequency, and ratio values were used in the descriptive statistics of the data. The distribution of variables was measured by Kolmogorov–Smirnov, Shapiro–Wilk test. Independent sample *T* test, Kruskal–Wallis, and Mann–Whitney *U* test were used in the analysis of quantitative independent data. SPSS v.28.0 (SPSS Inc., Chicago, IL, USA) program was used in the analyses. Statistical significance was set at the level of $p < 0.05$.

## Results

A total of 1000 CBCT scans of 500 patients (243 females, 257 males) between 18 and 77 years (mean 45.1 ± 18.2 years) were evaluated.

CS was detected in 89 (39F; 50 M; 8.9%) out of 1000 CBCT scans. Of the detected CSs, 57 were on the right side (64%) and 32 were on the left side (36%). No bilateral CS was found. Patients diagnosed with CS were divided into 3 groups: 18–30 years old, 31–60 years old, and 61 years and above. Distribution of CS according to age groups: it was determined as 24 (27.0%) in the 18–30 age group, 43 (48.3%) in the 31–60 age group, and 22 (24.7%) in the 61 and over age group. No statistically significant difference was found between gender, direction, and age of CS presence ($p > 0.05$). The trace of CS is shown in Fig. 2.

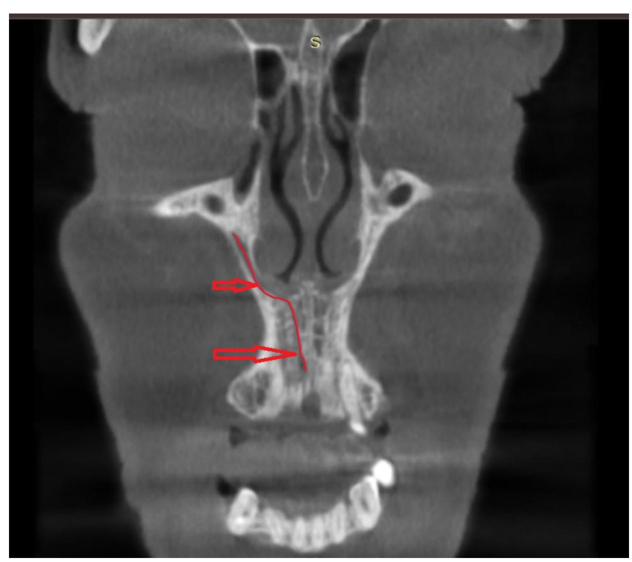



**Fig. 2** The trace of canalis sinuosus in the frontal section (red arrows)

It was determined that CS was most frequently seen in regions 11 (23.6%) and 13 (23.6%). All CSs were seen posterior to the incisive canal. The distribution of CS according to their localization is given in Fig. 3. The mean terminal CS diameter was found as 1.34 ± 0.53 mm (min 0.58 mm – max 3.39 mm). No statistically significant difference was found between gender, age groups, direction, and terminal CS diameter ($p > 0.05$) (Table 1).

The average NC–CS length was calculated as 6.14 ± 2.54 mm (min 2.03 mm, max 9.92 mm). No statistically significant difference was found between gender, age, side, and NC–CS length ($p > 0.05$) (Table 2).

The average BC–CS length was found as 6.06 ± 2.60 mm (min 1.23, max 10.66 mm). No statistically significant difference was found between gender, age, side, and BC–CS length ($p > 0.05$) (Table 3).

The mean AR–CS length was determined as 4.35 ± 2.53 mm (min 0.54 mm, max 10.54 mm). No statistically significant difference was found between gender, age, side, and AR–CS length ($p > 0.05$) (Table 4).

Of the 89 sides in whom CS was detected, 27 ACs (30.3%) were detected in 22 patients (12 M; 10F). 1 AC was detected in 19 patients, 2 ACs were detected in 1 patient, and 3 ACs were detected in 2 patients of 22 patients. 19 ACs (70.4%) had terminal ending at the palatal cortical line, while 8 ACs (29.6%) were found to end at the buccal cortical line (Graphic 1). There was no statistically significant difference between the presence of AC and gender, or age ($p > 0.05$). Also, there was no statistically significant difference between the presence of AC and the CS diameter (Table 1), NC–CS distance (Table 2), BC–CS distance (Table 3), and AR–CS distance (Table 4) ($p > 0.05$).

Impacted canines were detected in 24 of the 89 sides (26.9%) with CS. There was a significant relationship between CS diameter (Table 1), BC–CS length (Table 3), AR–CS distances (Table 4), and the presence of impacted canines ($p < 0.05$). CS diameter, BC–CS, and AR–CS

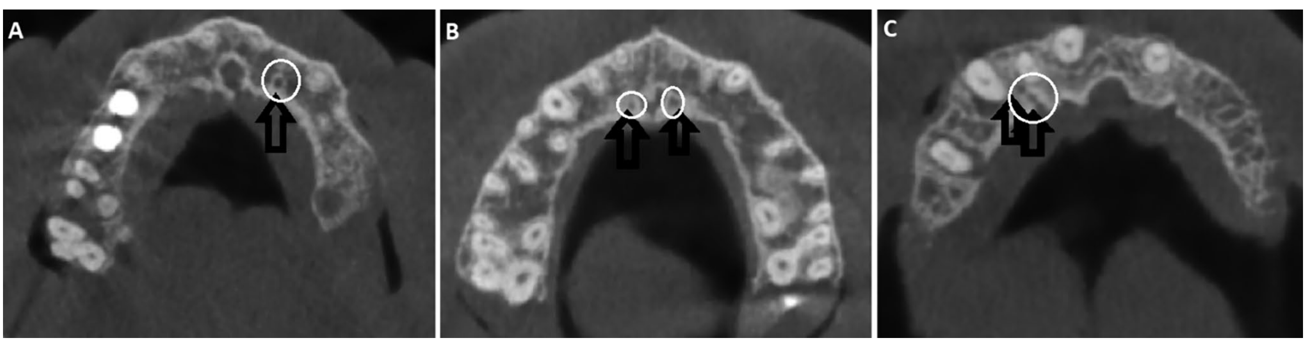



**Fig. 3** The number of accessory canals (black arrows and white circles)

**Table 1** Change of CS diameter according to parameters

| | | CS diameter | | | | | | | $p$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Min–Max | | | Median | Mean ± SD | | | | |
| Gender | Female | 0.71 | – | 3.19 | 1.19 | 1.33 | ± | 0.52 | 0.941 | m |
| | Male | 0.58 | – | 3.39 | 1.22 | 1.35 | ± | 0.54 | | |
| Age (years) | 18–30 | 0.73 | – | 2.48 | 1.16 | 1.35 | ± | 0.52 | 0.721 | K |
| | 31–60 | 0.71 | – | 3.39 | 1.17 | 1.35 | ± | 0.61 | | |
| | ≥ 61 | 0.58 | – | 1.82 | 1.29 | 1.31 | ± | 0.33 | | |
| Side | Right | 0.58 | – | 3.19 | 1.20 | 1.33 | ± | 0.51 | 0.791 | m |
| | Left | 0.71 | – | 3.39 | 1.20 | 1.36 | ± | 0.56 | | |
| Accessory canal | (Absent) | 0.58 | – | 3.19 | 1.19 | 1.30 | ± | 0.49 | 0.349 | m |
| | (Present) | 0.80 | – | 3.39 | 1.24 | 1.46 | ± | 0.63 | | |
| Impacted canine | (Absent) | 0.58 | – | 3.39 | 1.19 | 1.32 | ± | 0.53 | ***0.049**** | m |
| | (Present) | 1.19 | – | 2.06 | 1.85 | 1.74 | ± | 0.38 | | |

*SD* Standard deviation

m Mann-whitney u test

K Kruskal-wallis

*Indicated with bold and italic was found statistically significant

**Table 2** Distribution of nasal cavity floor–canalis sinuosus distance according to parameters

| | | NC–CS | | | p |
|---|---|---|---|---|---|
| | | Min–Max | Median | Mean ± SD | |
| Gender | Female | 5.7 – 9.2 | 6.0 | 6.7 ± 1.4 | 0.421 [t] |
| | Male | 2.00 – 9.9 | 6.11 | 5.91 ± 2.92 | |
| Age (Years) | 18–30 | 5.72 – 8.73 | 7.22 | 7.22 ± 1.50 | 0.638 [K] |
| | 31–60 | 2.11 – 9.45 | 6.93 | 6.11 ± 2.64 | |
| | ≥ 61 | 2.20 – 9.98 | 5.74 | 5.71 ± 3.01 | |
| Side | Right | 2.01 – 9.41 | 5.81 | 5.82 ± 2.60 | 0.398 [t] |
| | Left | 0.54 – 8.70 | 7.61 | 6.71 ± 2.41 | |
| Accessory canal | (Absent) | 2.01 – 9.31 | 5.84 | 6.12 ± 2.59 | 0.872 [t] |
| | (Present) | 2.01 – 9.92 | 6.04 | 6.11 ± 2.51 | |
| Impacted canine | (Absent) | 2.01 – 9.81 | 6.20 | 6.21 ± 2.61 | 0.872 [t] |
| | (Present) | 5.71 – 5.71 | 5.71 | 5.71 | |

[t] Independent sample t test, [K] Kruskal–Wallis, *SD* standard deviation, *NC* Nasal cavity floor, *CS* canalis sinuosus

**Table 3** Distribution of buccal cortical plate—canalis sinuosus distance according to parameters

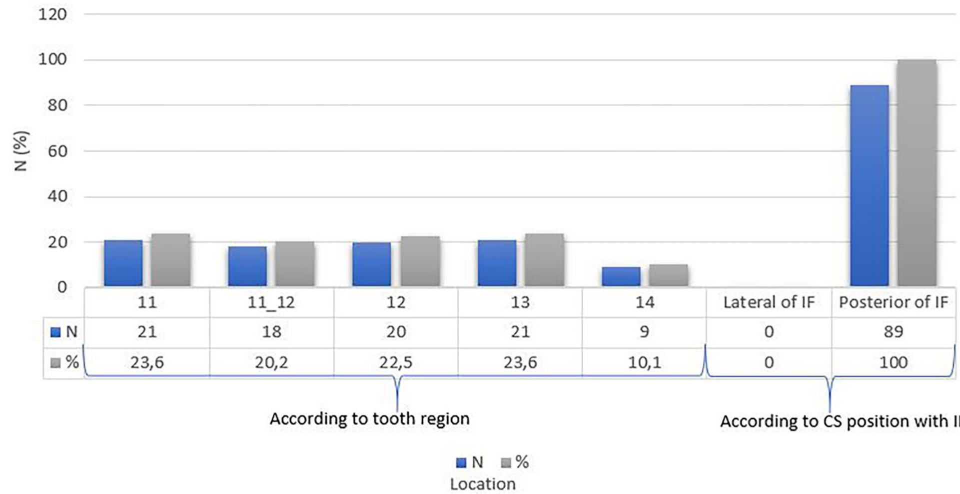
| | | BC–CS | | | p |
|---|---|---|---|---|---|
| | | Min–Max | Median | Mean ± SD | |
| Gender | Female | 1.23 – 10.66 | 6.87 | 6.59 ± 2.76 | 0.091 [t] |
| | Male | 1.27 – 9.86 | 5.80 | 5.65 ± 2.42 | |
| Age (years) | 18–30 | 1.23 – 10.50 | 5.79 | 5.80 ± 2.15 | 0.120 [K] |
| | 31–60 | 1.27 – 10.66 | 6.97 | 6.61 ± 2.36 | |
| | ≥ 61 | 1.41 – 10.34 | 4.17 | 5.28 ± 3.29 | |
| Side | Right | 1.23 – 10.66 | 6.20 | 6.14 ± 2.67 | 0.719 [t] |
| | Left | 1.27 – 10.18 | 6.05 | 5.93 ± 2.51 | |
| Accessory canal | (Absent) | 1.23 – 10.66 | 6.20 | 6.15 ± 2.58 | 0.565 [t] |
| | (Present) | 1.61 – 9.86 | 5.38 | 5.78 ± 2.73 | |
| Impacted canine | (Absent) | 1.23 – 10.66 | 6.20 | 6.12 ± 2.62 | ***0.048***[a] [t] |
| | (Present) | 1.73 – 6.87 | 5.49 | 4.89 ± 2.21 | |

[t] Independent sample t test, [K] Kruskal–Wallis, *SD* standard deviation, *BC* buccal cortical plate, *CS* canalis sinuosus. [a]Indicated with bold and italic was found statistically significant

**Table 4** Distribution of alveolar ridge crest–canalis sinuosus distance according to parameters

| | | AR–CS | | | p |
|---|---|---|---|---|---|
| | | Min–Max | Median | Mean ± SD | |
| Gender | Female | 1.68 – 10.54 | 4.01 | 4.93 ± 2.82 | 0.083 [m] |
| | Male | 0.54 – 9.61 | 3.35 | 3.90 ± 2.21 | |
| Age (years) | 18–30 | 1.48 – 10.42 | 3.35 | 4.56 ± 2.82 | 0.085 [K] |
| | 31–60 | 1.51 – 10.54 | 4.30 | 4.61 ± 2.31 | |
| | ≥ 61 | 0.54 – 10.12 | 2.78 | 3.61 ± 2.59 | |
| Side | Right | 1.44 – 10.54 | 4.01 | 4.87 ± 2.74 | ***0.013***[a] [m] |
| | Left | 0.54 – 8.70 | 2.95 | 3.43 ± 1.82 | |
| Accessory canal | (Absent) | 1.48 – 10.54 | 3.78 | 4.30 ± 2.34 | 0.686 [m] |
| | (Present) | 0.54 – 9.77 | 3.18 | 4.50 ± 3.10 | |
| Impacted canine | (Absent) | 1.73 – 6.87 | 3.60 | 4.43 ± 2.56 | ***0.027***[a] [m] |
| | (Present) | 2.43 – 3.32 | 2.53 | 2.70 ± 0.42 | |

[m]Mann–Whitney *U* test, [K] Kruskal–Wallis, *Indicated with bold and italic was found statistically significant, *AR* alveolar ridge crest, *CS* canalis sinuosus




**Graphic 1.** The distribution of canalis sinuosus according to localization

distances were found to be significantly higher in patients with impacted canines.

## Discussion

In the guideline of the American Academy of Oral and Maxillofacial Radiology, both surgical and prosthetic implant evaluations are complicated due to the prominence of aesthetic concerns in the maxillary anterior region. Following tooth loss, decreases in the height and/or volume of the alveolar crest often lead to the need for bone augmentation. CS is shown as one of the points to be considered in pre-operative implant examination in the maxillary anterior region [12]. CS helps innervation of the maxillary anterior teeth, nasal fossa floor, and maxillary sinus. Therefore, knowing the existence of the accessory canal before operations in this area is very important to prevent complications such as possible bleeding, paresthesia, and delay in wound healing [13]. A review of the literature has shown that CS can cause pain, and paresthesia due to damage during surgery in the maxillary anterior region [14], or sometimes it may appear to be a periapical lesion, leading to inappropriate endodontic treatment [2].

In our study, CS was found in only 89 (8.9%) of the CBCT scans. Looking at the literature, the percentage of CS presence is quite wide. Aoki et al. [13] reported CS in 66.5% of 200 patients, Oliveira-Santos et al. [4] in 15.7% of 178 patients, Manhães Júnior et al. [5] in 36.20% of patients, and Şalli et al. [15] in 8.17% of 673 patients. As a common aspect of all studies, it has been stated that the presence of CS has no statistical relationship with age and gender. Although the patient population scanned is different from our study, this result is compatible with our study.

Orhan et al. [16] reported that the most common termination site of CS was the maxillary inter-central region (44.72%), while Beyzade et al. [11] reported that it was the lateral incisor region followed by the central incisor region. Gurler et al. [14] reported that it most commonly terminates on the nasal floor near the incisive canal. Shelley et al. [17] reported that CS may also terminate at the apex of the maxillary canine and should not be confused with periapical lesions. In our study, it was found that CS most frequently terminated in the maxillary central and canine region, and consistent with three literatures, CS was predominantly seen posterior to the incisive foramen. Knowing the most common ends of the CS in operations to be performed in the premaxillary region is useful in preventing complications such as possible bleeding and paresthesia, and also prevents it from being confused with any odontogenic pathologies as stated by Shelley et al. [17].

Oliveira-Santos et al. [4] found the mean CS diameter is 1.4 mm. Gurler et al. [14] reported that the mean canal diameter was 1.37 mm. Similarly, Aoki et al. [13] stated that the average CS terminal diameter was greater than 1 mm. A common point in both studies is that the diameter of the CS is not affected by demographic characteristics such as age and gender. This study we present overlaps with the literature, both in terms of the average CS diameter and its lack of correlation with demographic information.

When the distance measurements in the literature were examined, it was observed that there was no uniform measurement point. Manhaes-Junior et al. [5] calculated the average NC–CS distance as 11.05 mm on the right and 10.44 mm on the left. Shan et al. [10] stated this distance as 10.44 mm. Also, Shan et al. [10] calculated the average BC–CS distance as 19.3 mm, Gurler et al. [14] as 16.81 mm, and Manhaes-Junior et al. [5] as 6.83 mm on the right and 7.94 mm on the left. Manhaes-Junior et al. [5] calculated the average AR–CS distance as 7.71 mm on the right and 9.28 mm on the left. In our study, the results also differ due to the different patient populations and different measurement points, and different slice thickness of the CBCT. Nevertheless, distances consistent with the literature were recorded. In general, there is a consensus in the literature that although a large alveolar crest volume and buccal cortical distance is desirable for implant surgery, it also poses a risk of complications due to the increased incidence of AC and/or variations in the anatomical course of the CS [5, 10].

The prevalence of AC is also given in a wide range in the literature. Oliveira-Santos et al. [4] performed in Belgium, calculated a prevalence of 7.86% of AC, and von Arx et al. [1] reported a prevalence of 27.8% of AC, in Switzerland. The prevalence of AC was reported by Von Arx et al. [1] to be more common in men and the older age group, while Oliveira-Santos et al. [4] reported no correlation with age and gender. The common feature of both studies was that the AC terminated predominantly in the palatal region. In our study, the presence of AC was detected in 30.3% of the patients, in line with the literature, and the terminal ending of the AC was observed to be predominantly palatal region. However, buccal termination was detected in three patients. In addition, no correlation was found between age and gender and the prevalence of AC. It can be thought that these differences are due to both the scanning of a larger data set and the different populations scanned.

In the literature, there is only one study investigating the relationship between CS morphology and impacted canines. To the best of our knowledge, this study is the second study in the literature investigating this. [14] investigated the relationship between impacted canine and CS morphology and reported that the two were not related. In this study, CS diameter, BC–CS, and AR–CS distances were found to be significantly higher in patients with impacted canines. This different result found in our study will shed light on the literature and will be a guide for future studies. However, maxillary canines are the most frequently impacted teeth, so extraction is one of the treatment options that clinicians use when indicated. In this case, it is very important to identify the anatomical landmarks and variations in the canine region before the operation in terms of physician comfort and patient health.

Not only for impacted canine surgery, CS should also be considered during the preoperative evaluation of trauma cases involving the midface, such as Le Fort I osteotomy, where the lower third of the maxilla is fractured [18]. CS should also be considered when performing anesthetic procedures and flap lifts in the anterior palatal region because aberrant canal extensions toward the palate often provide innervation to areas not connected to the anterior superior alveolar nerve; likewise, the neurovascular supply may be interrupted during flap lifts [7, 19]. All these reasons highlight the importance of CS and variation awareness for oral and maxillofacial radiologists and surgeons.

Since the CS and AC are dimensionally small anatomic structures, they should be evaluated in three dimensions with high spatial resolution, away from superpositions. CBCTs that meet these imaging criteria have been selected as the imaging method both in the literature and in our study [1, 4, 5, 10, 11, 14, 16].

This study has some limitations. In the distance measurements, bone loss due to periodontal problems was ignored in order to determine the relationship of CS morphology with age. This can be overcome by future studies in a younger population. There is also a need for further studies in the literature to investigate the effect of CBCT slice thickness on CS visibility and the effect of impacted canine on CS morphology.

## Conclusions

Based on the findings of this retrospective study of 1000 CBCT images from 500 patients, the following conclusions were drawn:

(1) The presence of CS was calculated as 8.9%, and the presence of AC was calculated as 24.71% without significant sex- or age-related variations.
(2) It is thought that the CS diameter, NC–CS distance, BC–CS distance and AR–CS distance do not change with demographic characteristics such as age and gender, but CS diameter, BC–CS distance and AR–CS distance may increase in the presence of impacted canines and that the integrity of the neurovascular structure should be preserved, especially in operations to be performed in the maxillary anterior region, and attention should be paid to this issue against complications such as possible hemorrhage, paresthesia, bleeding, and delay in healing.
(3) It has been concluded that the termination site of the CS is often located palatially in the maxillary central and canine regions and that the region should be evaluated with 3D imaging methods. Identifying individual anatomical variations using 3D tomography provides the surgeon with more confidence pre-operatively, helping to prevent under-treatment or complications.

**Data availability** The datasets used and analysed in the present study are available from the corresponding author upon reasonable request.

## Declarations

**Conflict of interest** The authors declare that they have no conflicts of interest.

**Ethical approval** All procedures followed were 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. The study protocol was approved by the local ethics committee of the Hatay Mustafa Kemal University (Date: 12.01.2023, Decision no.: 09).

**Informed consent** Not applicable as no identifying information of patients or human subjects is included in the paper.

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