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RESEARCH ARTICLE

ASSESSMENT OF THE ANATOMICAL STRUCTURE OF CANALIS SINUOSUS IN THE ANTERIOR MAXILLA TO AVOID SURGICAL COMPLICATIONS

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Abstract

Aims: The study's objective was to evaluate the canalis sinuosus (CS) anatomical structure in the front maxilla in order to prevent surgical problems in an adult Yemeni population sample acquired using cone-beam computed tomography (CBCT).

Materials and Methods: **A** retrospective descriptive cross-sectional study was carried out to assess 226 participants' CBCT pictures. 452 sides in total were assessed. There were 140 females (61.9%) and 86 males (38.1%) among the samples. The age distribution was 18–34 years (65%) and over 35 years (35%), with a mean age of 32.13. Version 25 of the Statistical Package of the Social Sciences (SPSS) was used for all statistical analyses.

Result: It was discovered that 160 right (35.4%) and 175 left (38.7%) of the 226 patients and 452 sides had CS. Among these individuals, 117 (51.8%) had unilateral CS and 109 (48.2%) had bilateral CS. The CS was 8.12 mm from the nasal cavity floor (D1), 6.99 mm from the buccal cortical bone ridge (D2), and 13.47 mm from the crest of the alveolar ridge (D3), as the mean distances were measured. Males and females had somewhat higher mean values for the linear measurements D1 and D3, but females had slightly higher mean values for the linear measurement D2. The CS had a mean diameter of 1.11 mm. Left central incisor area was the most commonly observed location of CS, and palataly was the most frequently recorded location of CS.

Conclusion: Since the CS is present in 100% of adult Yemenis, it is imperative that general practitioners and maxillofacial surgeons become more knowledgeable about the position and structure of the CS.

Keywords: Anatomical variation, canalis sinuosus (CS), cone beam-computed tomography (CBCT), Carestream 3D imaging software.

INTRODUCTION

The anterior region of the maxilla is a crucial area for dental function and facial aesthetics, containing important structures like alveolar bone, periodontal ligament, gingiva, and neurovascular structures[1]. Recent studies emphasize the importance of understanding the anatomy of the anterior region of the maxilla for dental professionals, as it minimizes complications and aids in treatment planning[2]. The maxillary anterior teeth are supported by alveolar bone, periodontal ligament, gingiva, and neurovascular structures. The anterior maxilla develops during embryology, with maxillary prominences forming by the 6th week[3]. The anterior maxilla nerves, including the anterior superior alveolar nerve and the infraorbital nerve, are crucial for providing sensation to the teeth, gums, and surrounding tissues. The anterior maxillary blood vessels, including the anterior superior alveolar artery and the infraorbital artery, are crucial for supplying oxygen and nutrients to teeth and surrounding tissues[4]. The canalis sinuosus, also known as the sinus tract or accessory canal, is a common anatomical variation found in the anterior region of the maxilla. It is a narrow channel that contains nerves and blood vessels[5].

In the anterior region of maxilla, the canalis sinuosus is often located in the region of the central incisors. It can

be a potential site for infection or inflammation and can affect the success of dental surgical procedures such as implant placement, root canal therapy, and removal of impacted canines[6]. Dental implant placement is a surgical procedure involving the insertion of a titanium fixture into the jawbone, influenced by factors like bone quality, implant design, and anatomical structures. LeFort fractures, involving the midface, account for 10-20% of maxillofacial fractures. Understanding the CS location is crucial for nerve and vascular protection resulting from blunt trauma with significant force[7]. Orthognathic surgery corrects skeletal discrepancies in the jaw and facial structures, treating conditions like malocclusion, sleep apnea, and temporomandibular joint disorders. The surgical approach depends on the patient's condition and goals. Incidence varies based on patient demographics and prevalence[8]. Rhinoplasty is a nose shape or size alteration procedure involving the nasal spine or septum for esthetic or functional reasons. It's performed for breathing improvement or correcting a deviated septum, with rates ranging from 5 to 5 per 100,000 individuals[9]. Dental professionals must understand potential risks and complications of procedures, including nerve injury in the anterior region of the maxilla, which can lead to sensory deficits or altered sensation in the upper lips. Bleeding during dental procedures in the anterior maxilla can lead to complications like hematoma formation and delayed healing. Dental professionals use cone beam computed tomography (CBCT) imaging to identify and map canalis sinuosus. Cone beam computed tomography (CBCT) is a valuable tool for assessing the anterior region of the maxilla before and after surgical procedures. It provides detailed 3D images, aiding in treatment planning and assessment of outcomes. CBCT also aids in evaluating implant placement success, orthognathic surgery outcomes, and changes in bone position, morphology, and volume[10].

The purpose of this study is to determine the prevalence of the canalis sinuosus in an adult Yemeni sample using cone beam computed tomography. It also describes the diameter of the canalis sinuosus in CBCT scans according to gender and age, as well as its location and distance from major structures like the alveolar ridge crest, nasal cavity floor, and buccal cortical bone.

MATERIALS AND METHODS

Study Design: This was a retrospective descriptive cross-sectional study survey that was undertaken to estimate the prevalence of canalis sinuosus (CS) among a sample of Yemeni adults based on CBCT scan evaluation. CBCTs were examined in order, beginning with the most recent. Images that supplied the anterior area of the maxilla up to the distal aspects of the first premolar posteriorly and from the alveolar crest to superiorly at least the medium height of the pyriform aperture were determined among the scans. Images that had motion or metal artifacts or were of poor quality were omitted from the research.

Study area: This study was conducted in the faculty of dentistry at Sana'a University. Data received from the centers of CBCT images (Sana'a city): Al Waleed center for digital radiography (Sana'a city), Al Mass digital radiographic center (Sana'a city), and Al Mamoon digital radiographic center (Sana'a city).

Study Population: The target population was all cases that had CBCT images of the area of the anterior region of the maxilla that had CS present in the records of the radiograph centers in Sana'a city in Yemen that met the inclusion criteria from cone-beam computed tomography images that were taken from the period of January 2021 to December 2022. In which three centers only met the inclusion criteria: (Al Walled, Al Mass, and Al Mammon) x-ray centers in Sana'a city in Yemen.

Study sample size: CBCT images of 1450 subjects were found, but only 486 CBCT images met the inclusion criteria, from which the study population was selected randomly (systemic random sampling). Sample size is (226) cone beam. Computed Tomography images were calculated by the formula of cross-sectional survey sample size. Where the standard normal variate is at 5%, standard type 1 error $p < (0.05)$ is 1.96. In addition, the expected frequency p is 18% (from the pilot study), with a significant level equal to 95% and precision (5%).

Inclusion criteria: Patient aged 18 years of both males and females, all CBCT x-ray images, which clearly showed border of the premaxilla, and cone-beam computed tomography images that were taken from the period of January 2021 to December 2022.

Exclusion criteria: The presence of technical artifacts that would hinder the evaluation of the necessary structures, images that had a dental implant, grafted alveolar ridge, or a supernumerary, retained, and missing tooth in the anterior maxilla. Also, the presence of a pathological lesion in the anterior maxilla and subjects below 18 years old were excluded.

Data Collection: It took three months to acquire the data. The initial author used data gathering sheets to gather them.

Statistical Method: All statistical analyses were carried out using the statistical package for social science (SPSS) version 25. Data were examined descriptively using the mean, median, maximum, minimum, and standard deviation. After being collected, the data were recorded and put into SPSS for analysis. Tables were used to display the results. To describe the prevalence of CS across sides, genders, and ages, frequency and distribution were calculated. To study the relationship between CS and sides, genders, and ages, the odds ratio (OR) was utilized. The Chi-square test and the confidence interval (CI) (95% confidence level) were used to explore significant variations in the prevalence rate of CS between sides, genders, and ages; the result is deemed significant when the p-value is less than 0.05. The Welch's t-test was performed to compare the significant variations in the mean values of CS linear measures based on sides, genders, and ages. This test was chosen because the variances of the two sets of data are not comparable (independent sample t-tests), and the result

is considered significant when the *p*-value is less than 0.05.

Reliability of Measurements: The observer re-measured the linear measurements for each included CBCT image with the same means of measurements mentioned later. A comparison was made between the first and second measurements to determine the reliability of measurements by using Cronbach's alpha coefficient (<0xC8>), which is the most frequently used index of reliability.

Ethical Approval: Ethical approval was obtained from the Medical Ethics Committee of the Faculty of Dentistry, Sana'a University. All data, including patient identification and CBCT images, were kept confidential. The study used records of CBCT images taken in the past for the purpose of surgical and dental procedures or other causes for which the participants were not exposed to radiation x-rays because of this study. There is no special private information (identity) that can be obtained from a radiograph other than the nationality of the subject (Yemeni).

RESULTS

Of 226 subjects and 452 sides, 226 (100%) subjects and 335 (74, T1%) sides were found to have CS and a total of 335 CS with a present and 117 CS with a Absence. The bilaterally with total number of (109) respondents and represent (48.2%) of the total respondents. While the unilaterally with total number of (117) Subjects and represent (51.8%) of the total Subjects. Unilaterally of Subjects shows that the greatest numbers of the Subjects were left, as the study indicates that 56.4% of the Subjects (66) were left while the remaining of 43.6% with (51) Subjects were right (Table 1, Table 2, Figure 1, Figure 2).

Table 1: Prevalence of the canalis sinuosus of 226 Yemeni patients in Sana'a city.

Characters	Subjects (n=226)	Sides (n=452)
Present	226 (100%)	335 (74.1%)
Absence	0 (0.0%)	117 (25.9%)
	Subjects (n=226)	**Sides (n=335)**
Bilaterally	109 (48.2%)	218 (65.1%)
Unilaterally	117 (51.8%)	117 (34.9%)
On Right (n= 51)	51 (43.6%)	51 (43.6%)
On Left (n= 66)	66 (56.4%)	66 (56.4%)

The study found that the Central incisor region had the highest number of males and females, followed by the Lateral incisor region, the Canine region, and the First Premolar region. There was a statistically significant difference between males and females in these locations. The age distribution was also highest in the Central incisor region, with the highest number of males aged 18-34 years and females aged over 35 years. The Canine region had the highest number of males aged 18-34 years and females aged over 35 years. However, there was no significant difference between the age groups (Table 3).

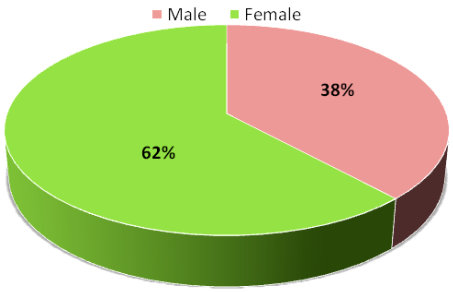

Figure 1: The sex distribution of 226 patients involved in the study.

The study found that males had the greatest distance between the CS and the nasal cavity floor, with a mean of 8.433, while females had a mean of 7.924. There were no significant differences in distance from the CS to the buccal cortical bone ridge, the most prominent point of the alveolar ridge, or diameter between genders. The greatest distance between the CS and the nasal cavity floor was for those over 35 years old, with a mean of 8.175. Age did not significantly affect distance between the CS and the nasal cavity floor. The study found no statistically significant differences in age between the emergence of the CS to the buccal cortical bone ridge, the distance from the CS to the most prominent point of the alveolar ridge, or the diameter between 18-34 years.

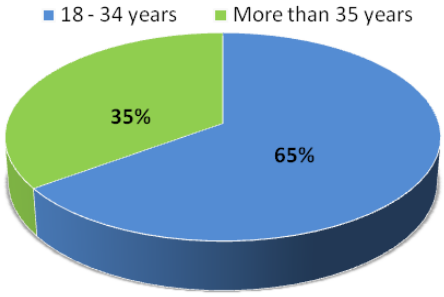

Figure 2: The age distribution of the 226 studied patients.

The mean distance from the CS to the most prominent point of the crest of the alveolar ridge was also similar, with no significant differences observed for more than 35 years. The study found no statistically significant differences in distance between the CS and the nasal cavity floor, buccal cortical bone ridge, most prominent point of the alveolar ridge crest, or diameter between the CS and the nasal cavity floor, buccal cortical bone ridge, most prominent point of the alveolar ridge crest, or diameter between the CS and the nasal cavity floor. The mean diameter was also not significantly different between the two groups (Table 4).

Table 2: The present of Canalis sinuosus according to the side for participant patients.

Side	Canalis sinuosus		Chi Square	*p* value
	No	Yes		
	N (%)	N (%)		
Right	66 (14.6)	160 (35.4)		
Left	51(11.3)	175 (38.7)	2.273	0.107
Total	117 (25.9)	335 (74.1)		

Table 3: Frequency Distribution– Location according to Olivera-Santos *et al.*, classification.

Location	Total % (n)	Gender % (n)			Age % (n)		
		Male	Female	*p* value	18 - 34	> 35	*p* value
Central incisor region	177(52.8%)	56(31.6%)	121(68.4%)		124(70.1%)	53(29.9%)	
Region between the central and lateral region	34 (10.1%)	16(47.1%)	18 (52.9%)		22(64.7%)	12(35.3%)	
Lateral incisor region	75 (22.4%)	41(54.7%)	34 (45.3%)		49(65.3%)	26(34.7%)	
Canine region	37 (11.0%)	10(27.0%)	27 (73.0%)		19(51.4%)	18(48.6%)	
First premolar region	1 (0.3%)	1 (100%)	0 (0.0%)	.007*	0 (0.0%)	1 (100%)	.104
Lateral to incisive foramen	4 (1.2%)	1 (25.0%)	3 (75.0%)		4 (100%)	0 (0.0%)	
Posterior to incisive foramen	7 (2.1%)	4 (57.1%)	3 (42.9%)		3 (42.9%)	4 (57.1%)	
Total	335(100%)	129(38.5%)	206(61.5%)		221 (66%)	114 (34%)	

The study found that the central and lateral region was the most frequently observed distance between the CS and the nasal cavity floor, while the posterior to incisive foramen was the most frequently observed distance from the CS to the buccal cortical bone ridge. The first premolar region was the least frequently observed distance, while the canine region was the most frequently observed distance from the CS to the most prominent point of the alveolar ridge. The lateral to incisive foramen was the most frequently observed diameter location. The study found significant differences in facial-palatal positions between the central sphenoid (CS) and nasal cavity floor, buccal cortical bone ridge, alveolar ridge crest, and diameter. The central position was the most frequently observed, with a mean of (8.963), followed by the palatal position (7.862) and the facial position (5.057). The palatal position was the most frequently observed, with a mean of (14.051), followed by the facial position (12.158).

Table 4: Distribution all linear measurements and diameter of Canalis sinuosus with gender, age and side.

Variables	D1	*p* value	D2	*p* value	D3	*p* value	Diameter	*p* value
Gender								
Male	8.433	0.017*	6.884	0.418	13.710	0.183	1.14	0.390
Female	7.924		7.058		13.327		1.10	
Age								
18 - 34 years	8.091	0.697	7.036	0.567	13.449	0.802	1.11	0.635
> 35 years	8.175		6.904		13.523		1.13	
Side								
Right	8.009	0.308	6.951	0.713	13.605	0.364	1.14	0.361
Left	8.222		7.028		13.355		1.10	

D1: distance between the CS and the nasal cavity floor. D2: instance from the CS to the buccal cortical bone ridge. D3: distance from the emergence of the CS to the most prominent point of the crest of the alveolar ridge.

Table 5: Distribution of CS with location and facial-palatal position.

Variables	D1	*p* value	D2	*p* value	D3	*p* value	Diameter	*p* value
Location								
Central incisor region	8.019		7.089		12.921		1.0602	
Region between the central and lateral region	8.776		6.909		13.526		1.1203	
Lateral incisor region	8.275	0.268	6.607	0.032*	14.155	0.000*	1.1933	0.017*
Canine region	7.949		6.900		14.551		1.1757	
First premolar region	7.200		6.400		9.600		1.2000	
Lateral to incisive foramen	7.025		7.775		13.900		1.7000	
Posterior to incisive foramen	7.486		9.171		14.529		.9571	
Facial-palatal position								
Facial	8.360	0.001*	5.057	0.000*	12.158	0.000*	1.0075	0.043*
Central	8.963		6.224		12.620		1.0878	
Palatal	7.862		7.730		14.051		1.1527	

D1: distance between the CS and the nasal cavity floor. D2: instance from the CS to the buccal cortical bone ridge. D3: distance from the emergence of the CS to the most prominent point of the crest of the alveolar ridge.

Table 6: Distribution of CS with different diameters and location between right and left sides.

Variables	Right side	Left side	*p* value
Presence of CS ≤ 1 mm n (%)			
Absent	66 (56.4%)	51 (43.6%)	0.107
Present	160 (47.8%)	175 (52.2%)	
Diameter of CS ≥1 mm			
Mean±SD	1.137±0.423	1.095±0.415	0.361
Median (Min-Max)			
Location			
Central incisor region	88 (49.7%)	89 (50.3%	0.428
Region between the central and lateral region	13 (38.2%)	21 (61.8%)	
Lateral incisor region	39 (52.0%)	36 (48.0%)	
Canine region	15 (40.5%)	22 (59.5%)	
First premolar region	0 (0%)	1 (100%)	
Lateral to incisive foramen	3 (75.0%)	1 (25.0%)	
Posterior to incisive foramen	2 (28.6%)	5 (71.4%)	

Table 7: Frequency of distance measurements and diameter of CS.

	Mean	Std. Deviation	Minimum	Maximum
D1 distance between the CS and the nasal cavity floor	8.120	1.9109	4.0	15.0
D2 distance from the emergence of the CS to the buccal cortical bone ridge,	6.991	1.9009	2.0	13.3
D3 distance from the emergence of the CS to the most prominent point of the crest of the alveolar ridge.	13.474	2.5098	7.5	22.5
Diameter of CS	1.1149	0.41887	.09	2.70

The diameter position was the most frequently observed, with a mean of (1.153) (Table 5). The study found 335 canals (CS) with a diameter of less than 1 mm and 117 CS with a diameter of at least 1 mm in the anterior maxilla. The mean canal diameter was 1.137±0.423 on the right side and 1.095±0.415 on the left side. The most common location was the left central incisor region (Table 6). The study found that the distance between the CS and nasal cavity floor, buccal cortical bone ridge, and prominent alveolar ridge point had a mean of 8.12, 6.99, and 13.47 meters, respectively, and the diameter of the CS was 1.115 (Table 7). Table 8 shows the distribution of AC per subject, with the highest number being (2) with 77 males and 127 females. Other groups had (1) with 227 males and 447 females, followed by location group (3) with 23 males and 29 females, and (4) with 2 males and 3 females. No statistically significant difference was found between genders (Table 4.11). Table 9 shows the number of AC per subject in different age groups. The highest number was found in subjects aged 18-34, followed by those aged 35+.

Table 8: Frequency distribution–accessory canals number of the Canalis sinuosus of gender.

Number of AC per subject	Number of male subject (%)	Number of female subject (%)	Total number of AC (%)	Chi Square	*p* value
1	27 (36.5%)	47 (63.5%)	74 (22.1%)		
2	77 (37.7%)	127 (62.3%)	204 (60.9%)		
3	23 (44.2%)	29 (55.8%)	52 (15.5%)	0.902	0.825
4	2 (40.0%)	3 (60.0%)	5 (1.5%)		
Total	**129 (38.5%)**	**206 (61.5%)**	**335 (100%)**		

The number of AC per subject group varied, with the highest number found in subjects aged 18-34 and the lowest in those aged 35+. However, there was no statistically significant difference between the age groups. Table 12 shows that the most significant gender distribution was found in Palatal, with 75 males and 146 females, followed by Facial with 227 males and 388 females. There was a statistically significant difference between males and females. Age distribution was also highest in Palatal, with 147 males aged 18-34 and 74% over 35 years, followed by Facial with 41 males aged 18-34 and 24 over 35 years.

Table 9: Frequency distribution–accessory canals number of the Canalis sinuosus of age.

Number of AC per subject	Number of 18 -34 years subject (%)	Number of more than 35 subject (%)	Total number of AC (%)	Chi Square	*p* value
1	47 (63.5%)	27 (36.5%)	74 (22.1%)		
2	135 (66.2%)	69 (33.8%)	204 (60.9%)		
3	36 (69.2%)	16 (30.8%)	52 (15.5%)	0.528	0.913
4	3 (60.0%)	2 (40.0%)	5 (1.5%)		
Total	**129 (100%)**	**206 (100%)**	**335 (100%)**		

Table 10: CS localization regarding to facial-palatal position.

Position	Total n (%)	Gender n (%)			Age n (%)		
		Male	Female	*p* value	18 – 34	> 35	*p* value
Facial	65 (19.5%)	27 (41.5%)	38 (58.5%)	0.02*	41 (63.1%)	24 (36.9%)	0.862
Central	49 (14.7%)	27 (55.1%)	22 (44.9%)		33 (67.3%)	16 (32.7%)	
Palatal	221 (65.9%)	75 (34.1%)	146 (65.9%)		147 (66.4%)	74 (33.6%)	
Total	**335**	**129 (38.6%)**	**206 (61.4%)**		**221 (65.9%)**	**114 (34.1%)**	

DISCUSSION

This is the first study conducted in Yemen to examine the anatomical characteristics of Canalis sinuosus (CS) and ascertain the prevalence of the condition in an adult Yemeni population using cone beam computed tomography (CBCT). The prevalence of CS has been found to vary widely in earlier research conducted in different nations. The current study's 100% CS prevalence was in line with findings from research by Lopes *et al.*[11], Gurler *et al.*[12], and Olenczak *et al.*[13], although it was marginally higher than findings from studies by Beckenster *et al.*[14], (98.0%), Brücker *et al.*[15], (97.4%), and Machado *et al.*[16], (97.4%). Alkhaer *et al*.[17], on the other hand, found that 46% of Colombians had the condition. A number of variables, including as imaging methods, voxel resolution, sample size, inclusion and exclusion standards, ethnic differences, and the absence of a generally recognized, standardized method for determining whether AC of the canal sinuosus is present, can be blamed for these discrepancies.

Regarding gender preference, the current study found that males have a 100% prevalence of CS, which is equal to that of females. These findings were different from studies by Manhases *et al.*[18], who found CS prevalence was higher in females than males, and in the study by Devathambi and Aswath[19], ACs were observed more in females than in males. However, Tomrukçu and Köse[20], Aoki *et al.*[21], Gurler *et al.*[22], Von Arx *et al.*[23], and Machado *et al.*[16], reported that the prevalence of CS in males was higher than that of females. On the other hand, in the studies by Orhan *et al*.[24], Ghandourah *et al.*[25], and de Oliveira-Santos *et al.*[26], there was no significant difference between the presence of AC in both sexes. In the current study, the prevalence of CS in all age groups was similar, in contrast to several studies by Orhan *et al.*[24], von Arx *et al*.[23], Devathambi and Aswath[19], and Ghandourah *et al*.[25], that reported a higher incidence in older age groups compared to younger adults.

In terms of side preference, the left side of the study had a slightly higher prevalence of CS (38.7%) than the right side (35.4%). These findings were similar to the study by Van Arx *et al.*[23], and Lopes *et al.*[11], in which CS is more found on the left side of the anterior maxilla. In contrast, the study by Backer *et al.*[27], reported that the right sides tended to have more CS than the left sides, in addition. However, Beckenstrater *et al.*[14], found no statistically significant difference between the presence of CS on the left and right sides. These discrepancies could be brought about by gender differences, imaging methodologies, and anatomical variability such as maxillary bone shape, age-related changes, and nasopalatine canal interaction[27]. The present investigation revealed that ACs were primarily located in the area surrounding the central incisors, with the lateral incisor region following suit. The canine region came next, then the location group. These results are similar to the report given by Van Arx *et al.*[23]. Ghandourah *et al.*[25], reported that the CS is mostly located in the region of the central incisors, followed by the lateral incisors and canine regions. Also, current result is in contrast to the results of Orhan *et al.*[24], who stated that CS were most frequently observed in the maxillary inter-central region. In addition, Devathambi and Aswath[19], and Anatoly *et al.*[28], reported that the accessory canals were located most frequently in the lateral incisor region. The last location for CS in the anterior maxilla was in the first premolar region; this result is similar to the report given by Van Arx *et al.*[23], who reported that CS is rarely seen in the first premolar region.

The current study found that the CS was more frequently observed palataly based on the palatofacial position. This finding is consistent with numerous earlier studies, including those by Fernlin *et al.*[29], Ghandourah *et al*.[25], Von Arx *et al*.[23], and Shan *et al.*[5], which found that the CS is primarily found on the palatal aspect of the maxillary anterior teeth. Obtained findings, however, are at odds with those of de Oliveira-Santos *et al.*[26], who showed that the buccal position was the primary location of the ACs of CS. Anatomical variability including gender differences, nasopalatine canal interaction, age-related changes, maxillary bone structure, and CBCT imaging processes may be the cause of these variances[5]. The current study indicated that the arithmetic mean of the diameter of CS was 1.115 mm (Table 7). These findings were in line with earlier research by Devathambi and Aswath[19], and the mean canal diameter of 1.12 mm was reported by Von Arx *et al.*[23]. Furthermore, the majority of studies discovered that the CS's width was less than 1.20 mm[20,28,30]. Gurler *et al.*[22], study, on the other hand, discovered that CS had a diameter greater than 1.20 mm since the variations between the broadest and narrowest diameters are so tiny as to be meaningless in terms of clinical importance.

The results of this investigation show that the average separations between the buccal cortical plate D2 and the CS were 6.99 mm (maximum 13.3 mm, minimum 2.0 mm) and 13.5 mm (maximum 22.5 mm), in that order (Table 7). It is possible to emphasize the fact that the diameter of the neurovascular bundle may increase the risk of surgical complications, specifically the amount of bleeding[20], even though the relationship between canal diameter and complication prevalence is unclear. This is because there is an 11.3 mm difference between the min and max values of the distance to the

buccal cortical plate and a 15.0 mm difference between the min and max values of the distance to the crest of the alveolar ridge[20]. The average circumference of the CS in men is 1.114. The *p*-value was (0.390) and the mean for females was (1.1), however the diameter of the ACs of the CS does not differ statistically substantially between the sexes. The findings of Von Arx *et al.*[23], Machado *et al.*[16], Gurler *et al.*[22], and Tomrukcu *et al.*[20], show that the canal diameter was considerably greater in males than in females. These findings are in contradiction to this one. A can be utilized as a personal indicator to determine the optimal site for bone harvesting and dental implant implantation based on the separation between the canal opening and the alveolar crest. According to the current investigation, the average distance in females between the CS and the alveolar crest was 13.3 mm. In a similar vein, men' alveolar crest and CS were separated by an average of 13.7 mm. Therefore, the mean distance in both males and females between the CS and the alveolar crest did not differ in a way that was statistically significant. These findings are in line with those of Gurler *et al.*[22], who found that in males, the mean distance between the terminal portion of the CS and the alveolar ridge was 16.81 mm, while in females, it was 16.3 mm. On the other hand, the findings of Shan *et al.*[5], and Wanzeler *et al.*[31], revealed that the average distance in males and females between the alveolar crest area and the terminal portion of CS was 25.82±6.7 mm and 14.97±5.37 mm, respectively. The current study found that the mean distance in males and females (p=0.017) between the CS and the nasal cavity floor was 8.433 mm and 7.924 mm, respectively. This notable disparity between the sexes.

Limitation of the study

The data (CBCT images) were taken from only one location (Sana'a city), which is the digital radiography centers (Al-Waleed, Al-Mas, Al-Mamoun) in the city of Sana'a only, which may not represent the entire Yemen. There was difficulty in obtaining complete data from radiology centers at times, and we also found it difficult to obtain original programs at times.

CONCLUSIONS

This study highlights the importance of mapping the canalis sinuosus (CS) in pre-surgical treatment planning using CBCT to prevent neurosensory disturbances and complications. CS is present in all Yemeni populations, with a majority being unilateral. It is not uniform in distribution and is most common in the central incisor region. Protecting the CS is recommended during dental implant installation in the anterior area of the maxilla. CBCT should be performed before maxilla surgery to prevent complications. Further studies in Yemen are needed to identify factors like dental implant failure and postoperative pain associated with CS.

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AUTHOR'S CONTRIBUTIONS

Ahmed STA: formal analysis, conceptualization, data organization, and clinical and laboratory examinations to obtain a master's degree in Oral and Maxillofacial Surgery. **Da'er SAA:** Methodology, formal analysis, visualization. **Homaid WAHA:** Clinical work. **Al-Shamahy HA:** critical review. **Mabkhout ANA:** data organization, clinical work. **Khalid BSM:** literature survey. **Al-Ankoshy AAM:** conceptualization, data organization. All authors reviewed the article and approved the final version.

DATA AVAILABILITY

The accompanying author can provide the empirical data that were utilized to support the study's conclusions upon request.

CONFLICT OF INTEREST

There are no conflicts of interest in regard to this project.

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