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Radioanatomic Study of Accessory Canals of Canalis Sinuosus using CBCT

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Aim: To assess prevalence, position, and multiplanar measurements of the canalis sinuosus **(CS)** accessory canals **(ACs)** using cone beam computed tomography **(CBCT)**.

Materials and Methods: Maxillary CBCT images of 218 patients aged between 14 and 60 years were retrospectively selected. Two experienced oral and maxillofacial radiologists evaluated all CBCT images using the multiplanar screen to assess the presence and position of the accessory canals of CS. Then, we conducted different linear measurements to identify the relation between the canal and nearby anatomical structures. Statistical tests were performed to determine prevalence, age, gender, and location distribution.

Results: A total of 136 accessory canals have diameter ≥ 1.00 mm were discovered in 93 patients (42.6%). The common position of the canal was palatal to all anterior teeth. The right central had the highest frequency (28.8%), followed by the left central (26.8). The average diameter of accessory canals on the right and left sides were 1.31±0.29 and 1.23±0.23 respectively. Females showed a higher frequency for the presence of right canals while males had a higher frequency for left canals. There was no statistically significant difference between age and prevalence, canal diameter, and position with a p-value < 0.05.

Conclusion: The canal is frequently present palatal to central, followed by lateral incisor. Before performing any surgical procedures in the anterior maxilla, it is recommended to do a (CBCT) scan to save anatomical components.

Keywords: Cone beam computed tomography, Canalis Sinuosus, Anatomy, Accessory Canals, Maxilla.

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Introduction

The anterior maxillary region usually has multiple surgical operations like insertion of dental implants, surgical extraction of impacted mesiodense, periodontal surgery, endodontic surgery, orthognathic surgery, and cyst therapy.[1] The nasopalatine canal is a well-known significant anatomical component of the premaxilla. The veins and nerves that share the same name and flow through the canal provide blood supply and innervation to the front teeth and surrounding soft tissues.[2] Also, the anterior superior alveolar **(ASA)** nerve is a division of the infraorbital nerve and provides sensory innervation to the incisors, canines, and soft tissues.[3]

The canalis sinuosus **(CS)** is a neurovascular canal that houses the anterior superior alveolar nerve and its associated blood vessels. Many Oral surgeons miss this anatomical structure. **Jones**[4] was the first to describe the anatomical location of this canal. ASA nerve and vessels exit the infraorbital foramen and course laterally through a bony canal **(CS)** approximately 2 mm in diameter adjacent to the nasal cavity.[5] This canal has numerous accessory foramina with varying sizes and morphological features that can sometimes be missed and misinterpreted as apical pathosis.[6]

Standard panoramic and periapical radiographs are inadequate for the detection of accessory channels due to limitations of 2-dimensional images such as superimpositions, magnifications, and distortions. The utilization of CBCT 3-dimensional imaging in dentistry has facilitated the detection of all fine anatomical structures due to its high special resolution, cross-sectional view, and diagnostic reliability.[7]

Prevalence of CS accessory canals in different population nations like Turkey, France, Brazil, China, Germany, and Australia ranged from 15,7% to 70,8%.[6,8–15] Based on the literature review, there were no previous studies on the Egyptian population. The lack of comprehensive data on this anatomical structure and the limitations of traditional radiography can hinder the accurate visualization of accessory structures. This can pose challenges in diagnosing these structures, potentially resulting in misdiagnosis and difficulties before or after surgical interventions.[16,17] So this study was aimed to identify prevalence, position of accessory canals of CS and their distance in many planes in relation to surrounding anatomy using CBCT.

Materials and Methods

A retrospective study was approved by the Ethics Committee of the Ain Shams University, Faculty of Dentistry (FDASU-RecEM012227). Sample size calculation was performed using OpenEpi, Version 3, open-source calculator—SSPropor. Power analysis was done by adopting a confidence level (90%), a margin of error of (5%) with finite population correction, and according to **Orhan et al**.,[14] the predicted sample size (n) was found to be (218) cases.

A total of 218 maxillary CBCT images obtained between January 2020 and May 2022 were retrieved from the Department of Oral and Maxillofacial Radiology. All patient identifiers were removed from the image files. Patients who showed the following criteria were excluded: those who had undergone surgical procedures or bone grafting in the anterior maxilla, those presenting pathological lesions or trauma (plate and screws) in the anterior maxilla, and those whose CBCT scans failed to present satisfactory quality. All the CBCT images were acquired using an i-CAT nextgeneration machine (Imaging Sciences International, Hatfield, PA) operating at 120 kV, 5 mA, voxel size of 0.2 mm, a field of view (FOV) of 16x 4 cm, and an acquisition time of 26.9 s. The DICOM files were imported into OnDemand3D software (cybermed Inc, Seoul, Korea). Cross-section, axial, coronal, and sagittal images were standardized for 0.1 mm thickness,1mm interval, and "x1" image sharpen filter. Two oral and maxillofacial radiologists with 10- and 7-years' experience evaluated the images using the same monitor. They were allowed to adjust the image density and contrast freely.

CBCT image analysis

The following data were registered: sex, age, and number of ACs. **The AC Diameter** was measured at the palatine opening on coronal and cross-sectional images, so only the ACs with foramina in the maxilla were included in the study. **The location** of the AC concerning the adjacent teeth was determined on the axial sections and categorized using the FDI tooth numbering system as follows: 11(palatal to right central), 11-12 (between right central and right lateral), 12(palatal to right lateral), 12-13 (between right lateral and right canine),13(palatal to right canine), 13-14 (between right central and right lateral),14(palatal to right first premolar),21-11(between right central and left central).[8] Several **Distances** between the AC and surrounding anatomy were measured on the cross-sectional cuts. First, the distance between the accessory CS and the floor of the nasal cavity **(FNC)**; Second, the distance from the emergence of the CS to the edge of the buccal cortical plate **(BCP)** was measured in a straight line; and third, the distance from the emergence of the CS to the most prominent point of the alveolar ridge crest **(ARC)**.[18]

Figure 1 show AC location and different measurements.

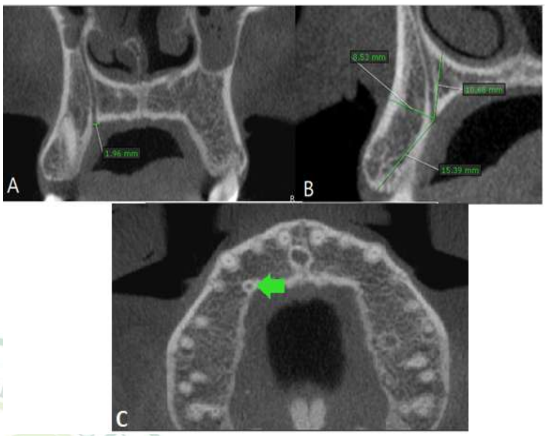

Figure 1: A; coronal, B; cross sectional and C; axial cuts showing diameter of accessory canal of canalis sinuosus at 13 location and its distances form surrounding anatomy.

Results

The total number of accessory canals of CS was 136 in 93 patients (63 female, 30 male) out of 218 patients (150 female, 68 male). The prevalence of accessory canals of CS was 42.6 %. i.e., some patients have more than one canal. 42% of females and 44.1% of males had accessory canals of CS.

The prevalence of accessory canals of CS was significantly higher on the right side 68 patients (31.2%) than on the left side 53 patients (24.3%) ($p<0.001$). Regarding the number of canals per side, most of the patients have only one accessory canal (Table 1). The right accessory canals of CS were more prevalent in females, while left canals were more prevalent in males with a p-value ($p<0.05$).

Table (1): Prevalence of the accessory canals of CS in patients for (right/left) [n=218].

No. of Canals per side	Side				x2	p-value
	Right		Left			
	No. of patient	%	No. of patient	%		
1	56	25.7%	50	22.9%	32.423	<0.001**
2	12	5.5%	3	1.4%		
Total	68	31.2%	53	24.3%		

In the present study, the patient's age ranged from 14 to 60 years (34.47±11.49). We found that there was no significant difference between age and number of ACs on both right and left side p-values 0.670 and 0.082, respectively. Table 2 shows that the most prevalent location of accessory canals of CS was the axial position 11 (figure 2), followed by 21, then axial position 12 and 22. The least possible position for accessory canals of CS was between central incisors (position 21-11).

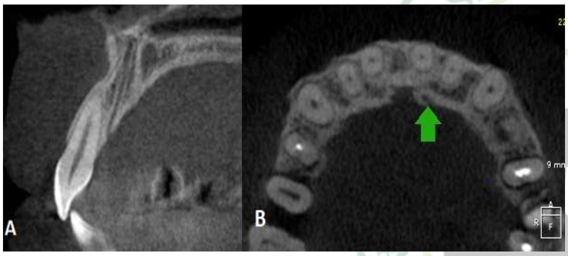

Figure 2: A; cross sectional and B; axial cuts shows accessory canal of canalis sinuosus at 21 location

Table (2): The distribution of the canals at different areas (right and left).

Location	No.	%
Right canal (n=80)		
11	23	28.8%
11-12	6	7.5%
12	21	26.3%
12-13	6	7.5%
13	7	8.8%
13-14	10	12.6%
14	6	7.5%
21-11	1	1.3%
Left canal (n=56)		
21	15	26.8%
21-22	7	12.5%
22	14	25.0%
22-23	5	8.9%
23	8	14.3%
23-24	5	8.9%
24	2	3.6%

Table 3 shows the accessory canal of CS diameter, distances from BCP, FNC, and CAR. The right accessory canals had a wider diameter (1.31±0.29) than the left ones (1.23±0.23). The right accessory canals were closer to FNC, while the left accessory canals were closer to the crest of the ridge. No statistical difference was found between the right and left canals according to distance from BCP. Finally, the patient's age and gender showed no effects on the canal diameter and different distances to BCP, FNC, and crest of the ridge.

Table (3): Comparison between right side and left side according to diameter, distance from (BCP), (FNC), and (ARC).

		Right side	Left side	t-test	p-value
Diameter	Range	0.72-2.4	0.77-1.83	3.057	0.002*
	Mean±SD	1.31±0.29	1.23±0.23		
Distance from Buccal Cortical Plate	Range	5.4-13.48	4.4-13.37	0.586	0.558
	Mean ± SD	7.72±1.47	7.63±1.60		
Floor of Nasal cavity	Range	3.82-20.9	5.85-25.1	2.010	0.045*
	Mean±SD	14.16±3.87	14.95±3.99		
Alveolar Ridge Crest	Range	4.7-82	3.53-17.8	2.244	0.025*
	Mean±SD	10.05±3.14	7.93±3.09		

p-value >0.05 is insignificant; *p-value <0.05 is significant; **p-value <0.001 is highly significant.

Discussion

Knowledge of anatomical landmarks and their variations is of utmost importance. It decreases complication possibility and increases the prognosis.[19] Several neurovascular bundles are present in the anterior maxilla. It is a strategic location and receives several operations: Endosurgery, immediate implant procedures, and surgical removal of lesions. **Shah *et al.***[16]. reported a case of traumatized maxillary central incisors in which CBCT examination disclosed the presence of accessory canals of CS that were misinterpreted as external root resorption on the primary periapical radiograph.[16] Similarly, clinical cases reported the presence of postoperative pain after implant placement in the premaxilla due to the close relationship of the implants with accessory canals of CS, as confirmed by postoperative CBCT.[9] Moreover, in another case, the canalis sinuosus accessory canal was misdiagnosed as a periapical inflammatory lesion related to the upper canine.

The visualization of the accessory branches of CS with regular radiographic methods is complicated by the small canal diameter, the presence of porous cortical bone, and variable courses of accessory canals. [9,16] With the increasing rate of CBCT examination in clinical practice, the accessory canals of CS become an attention-grabbing variation.

The prevalence of the accessory canals of the CS showed a wide range between 15,7% [15] and 70,8%.[14] In our study, the prevalence of accessory canals of CS was 42,66%. Likewise, several studies reported a prevalence of less than 50 %.[6,11,15] Our study and those previous studies considered only accessory canals ≥1 mm due to their higher possibility of causing clinical complications. On the contrary, other studies reported a high prevalence of accessory canals of the CS 67,6%[10], 66%.[20] This significant difference between the prevalences could be attributed to accounting all canals with no minimal diameter, different sample sizes in different populations, and methodological differences (voxel size, use of different CBCT scanners, exposure parameters, inclusion/exclusion criteria, etc.).

Regarding the prevalence of accessory canals of CS in different genders, we found no significant difference between males and females like in previous studies. [6,14,15] On the contrary, Machado *et al.* [9] study showed male dominance. While Sekerci *et al.* [11] reported a female dominance. We also found that the prevalence of accessory canals of CS was higher on the right side than on the left one. The right canals were associated with females, while the left canals were associated with males, with a p-value ($p<0.05$).

In the present study, there was no statistically significant difference between age groups and the prevalence of accessory canals of CS ($p>0.05$). Similarly, Von Arx *et al.* [6] reported an increasing frequency of accessory canals of CS in the older ages > 60 years group, Orhan *et al.*[14] reported the highest frequency of AC in the 50-59 age group, and Machado et al.[9] reported the highest frequency in the 41-60 age group. However, they reported no significant difference between age groups.

The literature analysis of the accessory canals of CS anatomical location has revealed significant variations. Like previous studies,[6,9–11] we found that the palatine region of central incisors is the most common location of accessory canals of CS (11 followed by 21), and the least possible location is the midline due to the presence of nasopalatine canal and foramen. On the other hand, Manhaes Junior et al. [18] and Orhan et al. [14] reported that the maxillary inter-central region is the most frequent location for accessory canals of CS.

Regarding the diameter of accessory canals of CS, we found that the mean diameter for the right and left canals were 1.31±0.29 and 1.23±0.23, respectively. In agreement with previous studies, the mean diameter ranged from (1.19 to 1.4)[6,9,11,15]. We estimated the diameter of the terminal canal opening. Only accessory canals with terminal foramen with a width ≥ 1mm was considered. These values closely approximated the data acquired in prior investigations.

Our study found a statistically significant difference between right and left-side accessory canals regarding different distances. The right canals were closer to FNC, while the left canals were

closer to ARC. There was no difference between the right and left canals' distance to BCP. Also, there was no notable discrepancy between males and females in any group for the distances from accessory canals of CS to FNC, BCP, and ARC. In contrast, studies conducted by Wanzeler et al. [21] and Oliveira Santos et al. [15] found statistically significant differences in the distance between the terminal portion of the CS and the alveolar ridge crest, which were associated with gender. The accessory canals had a greater distance from ARC in males than in females. Given that the male's alveolar ridge size is larger than the female's, it is logical that this distance is also greater.
Moreover, Manhaes Junior et al. [18] concluded that the right and left sides had different distances between the accessory canals of CS and the ARC and BCP. This could be explained by morphological changes in the alveolar bone plate that occur over time.

One of the limitations of this study may be the large voxel size 0.2 mm used for single arch scanning. So, detections of accessory canals in images with smaller voxel size may be more obvious and change its prevalence. For future studies, we recommend assessing samples have edentulous premaxilla and other have impacted canines to find out their effects on accessory canal prevalence and location.

Conclusion

In conclusion, the presence of accessory canals of CS in the Egyptian population is moderately frequent. It is commonly related to maxillary central incisors, which contain nerves and blood vessels. It is essential to perform CBCT imaging to identify the architecture of the CS and its accessory branches prior to surgical procedures in the anterior maxillary region to avoid possible complications due to canal invasion or destruction.

Declarations

Ethics approval

Ethical approval was granted from the research ethical committee at Faculty of Dentistry, Ain Shams University (Approval number FDASU-RecEM012227).

Consent for publication

Not applicable. It is a retrospective study

Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

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References

1. Angelopoulos C, Scarfe WC. The Jaws, Oral Cavity, and Nasopharynx. In: Scarfe WC, Angelopoulos C, editors. Maxillofacial Cone Beam Computed Tomography: Principles, Techniques and Clinical Applications [Internet]. Cham: Springer International Publishing; 2018 [cited 2023 Sep 20]. p. 287–324. Available from: https://doi.org/10.1007/978-3-319-62061-9_10
2. Robinson S, Wormald PJ. Patterns of innervation of the anterior maxilla: a cadaver study with relevance to canine fossa puncture of the maxillary sinus. The Laryngoscope. 2005 Oct;115(10):1785–8.
3. Rodella LF, Buffoli B, Labanca M, Rezzani R. A review of the mandibular and maxillary nerve supplies and their clinical relevance. Arch Oral Biol. 2012 Apr;57(4):323–34.
4. Jones FW. The anterior superior alveolar nerve and vessels. J Anat. 1939 Jul;73(Pt 4):583–91.
5. Lozanoff S, Von Arx T. Anterior superior alveolar nerve (ASAN): A morphometric-anatomical Analysis. In Schweizerische Zahnärzte-Gesellschaft SSO; 2015 [cited 2023 Sep 20]. Available from: https://boris.unibe.ch/78498/
6. von Arx T, Lozanoff S, Sendi P, Bornstein MM. Assessment of bone channels other than the nasopalatine canal in the anterior maxilla using

limited cone beam computed tomography. Surg Radiol Anat SRA. 2013 Nov;35(9):783–90.
7. Allareddy V, Vincent SD, Hellstein JW, Qian F, Smoker WRK, Ruprecht A. Incidental findings on cone beam computed tomography images. Int J Dent. 2012;2012:871532.
8. Tomrukçu DN, Köse TE. Assesment of accessory branches of canalis sinuosus on CBCT images. Med Oral Patol Oral Cir Bucal. 2020 Jan;25(1):e124–30.
9. Machado V de C, Chrcanovic BR, Felippe MB, Júnior LRCM, Carvalho PSP de. Assessment of accessory canals of the canalis sinuosus: a study of 1000 cone beam computed tomography examinations. Int J Oral Maxillofac Surg. 2016 Dec 1;45(12):1586–91.
10. Ghandourah AO, Rashad A, Heiland M, Hamzi BM, Friedrich RE. Cone-beam tomographic analysis of canalis sinuosus accessory intraosseous canals in the maxilla. GMS Ger Med Sci. 2017 Dec 19;15:Doc20.
11. Sekerci AE, Cantekin K, Aydinbelge M. Cone beam computed tomographic analysis of neurovascular anatomical variations other than the nasopalatine canal in the anterior maxilla in a pediatric population. Surg Radiol Anat SRA. 2015 Mar;37(2):181–6.
12. Yeap CW, Danh D, Chan J, Parashos P. Examination of canalis sinuosus using cone beam computed tomography in an Australian population. Aust Dent J. 2022 Sep;67(3):249–61.
13. Altan Şallı G, Öztürkmen Z. Evaluation of Location of Canalis Sinuosus in the Maxilla Using Cone Beam Computed Tomography. Balk J Dent Med. 2020 Nov 9;25.
14. Orhan K, Gorurgoz C, Akyol M, Ozarslanturk S, Avsever H. An anatomical variant: evaluation of accessory canals of the canalis sinuosus using cone beam computed tomography. Folia Morphol. 2018;77(3):551–7.
15. de Oliveira-Santos C, Rubira-Bullen IRF, Monteiro SAC, León JE, Jacobs R. Neurovascular anatomical variations in the anterior palate observed on CBCT images. Clin Oral Implants Res. 2013 Sep;24(9):1044–8.
16. Shah PN, Arora AV, Kapoor SV. Accessory branch of canalis sinuosus mimicking external root resorption: A diagnostic dilemma. J Conserv Dent JCD. 2017;20(6):479–81.
17. Shelley AM, Rushton VE, Horner K. Canalis sinuosus mimicking a periapical inflammatory lesion. Br Dent J. 1999 Apr 24;186(8):378–9.
18. Manhães Júnior LRC, Villaça-Carvalho MFL, Moraes MEL, Lopes SLP de C, Silva MBF, Junqueira JLC. Location and classification of *Canalis sinuosus* for cone beam computed tomography: avoiding misdiagnosis. Braz Oral Res. 2016 Apr 26;30:e49.
19. Arruda JA, Silva P, Silva L, Álvares P, Silva L, Zavanelli R, et al. Dental Implant in the Canalis Sinuosus: A Case Report and Review of the Literature. Case Rep Dent. 2017;2017:4810123.
20. Aoki R, Massuda M, Zenni LTV, Fernandes KS. Canalis sinuosus: anatomical variation or structure? Surg Radiol Anat SRA. 2020 Jan;42(1):69–74.
21. Wanzeler AMV, Marinho CG, Alves Junior SM, Manzi FR, Tuji FM. Anatomical study of the canalis sinuosus in 100 cone beam computed tomography examinations. Oral Maxillofac Surg. 2015 Mar;19(1):49–53.