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Evaluation of Location of Canalis Sinuosus in the Maxilla Using Cone Beam Computed Tomography

SUMMARY

Background/Aim: *The aim of this study is to evaluate the prevalence of a canalis sinuosus (CS) in the anterior maxilla.* ***Material and Methods:*** *CBCT images of 673 patients (322 females and 351 males) were examined retrospectively with regard to age, gender, location of CS and relation to impacted canines. The age of the patients ranged from 14 to 82 years; the mean age of the female patients was 43.54 years and that of the males was 45.75 years. IBM SPSS 22 for Windows was used for statistical analysis of the results. Statistical comparisons between two categorical variables were conducted using chi-square tests. Significance was set at (p< 0.05).* ***Results:*** *It was observed that 8.17% of the patients in this study exhibited accessory canals (AC) of CS (n= 55). There was no significant difference in CS prevalence between ages, age groups, and location in our study (p> 0.5). There was significant difference in CS prevalence between the genders (p< 0.5).* ***Conclusions:*** *It is important to take into consideration the presence of AC of the CS during surgical procedures in the anterior maxilla. It was also found that CBCT is more helpful than other techniques in detecting accessory canals in the region of interest.*

Key Words: Accessory Canal, Canalis Sinuosus, Anterior Alveolar Superior Nerve, Maxilla, CBCT

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Introduction

The anterior superior alveolar nerve (ASAN) is a part branch of the infraorbital nerve, which follows an intraosseous path in the canalis sinuosus (CS) to innervate the central and lateral incisors and canines[1]. The ASAN is generally much thicker than the middle and posterior superior alveolar nerves[2]. Canalis sinuosus is a little known structure of the anterior maxilla[3,4]. The insertion point is anterior to the incisive canal, where the CS shows anatomical variations commonly called accessory canals (ACs) in the anterior palate[4].

This anatomical structure has nerve and blood vessels that leave the infraorbital nerve from the posterior part of the infraorbital foramen and laterally pass through a bone canal approximately 2 mm in diameter next to the nasal cavity[5]. The CS is a branch of the nerve of the infraorbital canal, through which the anterior superior alveolar nerve passes. It follows the lower margin of the nasal aperture and opens to the side of the nasal septum in front of the incisive canal. Subsequently, it bends between the nasal cavity and the maxillary sinus, reaching the premaxilla in the canine and incisor region[6,7]. The infraorbital nerve is the direct extension of the maxillary nerve and is responsible for the sensitivity of the skin and mucosa of the middle third of the face[8]. In addition Valcu *et al*. have described the anastomosis of the ASAN and the greater palatine nerve located in the canalis sinuosus, showing a distribution of the ASAN to the palatine mucosa[9].

This canal, which is very important for surgical procedures, is relatively unrecognized amongst clinicians unless they confront complications, such as paresthesia or hemorrhage. Additionally, the CS and ASAN have been inadequately described in the surgical and radiological literature and their course has been portrayed as variable in anatomical textbooks[1,3]. Placement of dental implants, surgical removal of impacted or supernumerary teeth in the anterior maxillary region, periodontal surgery, endodontic surgery, orthognathic surgery, and cyst treatment are some of the surgical procedures performed in the anterior maxillary region[10]. However, manipulation of tissues in the anterior region can cause irreversible damage to the patient. Iatrogenic complications may occur especially in the area where the CS is located[6]. Therefore, this canal is one of the structures in which the damage can accompany bleeding and neurological symptomatology[11]. Olenczak *et al.* reported that the ASAN is particularly susceptible to injury after mid-face fractures because its course is entirely intraosseous within the CS[1]. Some studies have shown that the presence of a CS can mimic a periapical lesion and lead the dentist to the wrong treatment plan as a result of a misdiagnosis, causing nerve damage during dental implant surgery, or causing paresthesia after surgery[6,12,13]. If there is bleeding and pain during or after a surgical operation, the neurovascular content of the CS or related anatomic variations should be considered damaged[14].

CS is a risk factor for Le Fort I fractures, which are frequently applied during orthognathic surgery. Orthognathic surgery involves the risk of damaging the CS and other neurovascular bundles, such as the nasopalatine artery, postero-superior alveolar artery, descending palatine artery, and internal maxillary artery[4].

Periapical and panoramic radiography are widely used in dentistry by clinicians as valuable diagnostic methods. These radiographic techniques have multiple limitations, such as superimpositions, low image quality, magnifications and distortions. Therefore, 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[15]. Recognition of these anatomical variations has become easier with the widespread use of the conical beam computed tomography (CBCT) in dentistry. It offers advantages to clinicians thanks to its facility for providing detailed views, angular and linear measurements, and multi-plane reconstruction feature. It also makes possible cross-sectional examination before implant surgery[16] .

It is stated in the literature that anatomical variations in the maxillary bone are rare, and that the majority of these are associated with the nasopalatine canal. It is also important to be aware of other anatomical variations in the maxilla, which ensures success in surgical operations[7,17]. In the literature, there are studies evaluating the presence and variations of the CS. Most of these studies were performed using CBCT images. Ghandourah *et al.* evaluated CS frequency, location and width with 269 CBCT images in two groups of adolescents and adults[13]. Kurrek *et al.* dissected 35 human cadavers and evaluated the ASAN by taking images with CBCT[18]. Orhan *et al.* examined images for the CS presence, accessory canal presence, location and number[3]. Studies evaluating the CS are limited in Turkish population, so further studies are needed in this area.

The research's null hypotheses was that anatomical variations in the maxillary bone are rare. The aim of this study was to use CBCT to evaluate the prevalence of CS and its variations with regard to age, gender, location, relationship to the impacted canines in a Turkish sample.

Material and Methods

Cone beam computed tomography (CBCT) scans of patients admitted to the Faculty of Dentistry, Oral and Maxillofacial Radiology Department for dental complaints (e.g., a missing tooth, orthodontic or implant planning, or periodontal or temporomandibular disorder) from 2014 to 2019 were reviewed retrospectively. The CBCT images of 673 patients (322 females and 351 males) were assessed. Any canal with about 1 mm diameter in the anterior maxilla region was evaluated with CBCT. The nasopalatine canal was excluded. The Sidexis XG software program (Sirona, Bemshein, Germany) was used to reconstruct and evaluate the projections and these were analyzed with sagittal, coronal and axial sections (Figure 1).

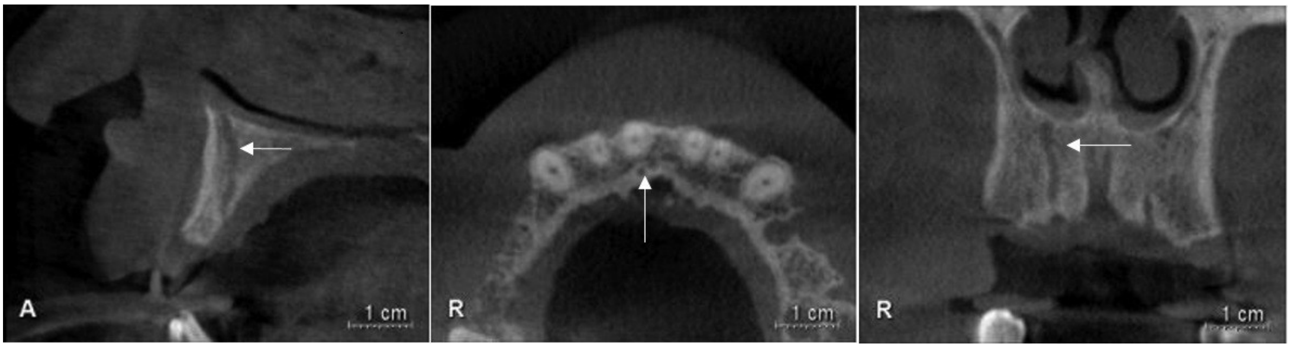

Figure 1. Example of accessory canal in the region of tooth 11 in the sagittal, axial and coronal views

Patients were excluded according to the following criteria; bony lesions in the anterior maxilla region, a history of dentofacial surgery, the presence of artefacts and low-quality imaging of the region of interest. Informed consent was obtained from the patients who participated in the study. The study was approved by the Ethical Committee (the study protocol: 2019/28-10).

Radiographs were taken through a CBCT (Sirona Galileos Comfort Plus- Bemshein, Germany, at 98kV, 6mA, and a voxel size of 0.25 mm). The field of view (FOV) of the images assessed in this study was 15 × 15cm. The Sidexis software was used to convert the original digital imaging and communication in medicine (DICOM) format. The evaluation of the images was performed on the monitor screen (Asus PRO A4310-BB158M All In One, ASUSTeK Computer Inc., Beitou District, Taipei, Taiwan). The data obtained was recorded in the Microsoft Excel program to determine the frequency with regard to age group, gender, presence of CS, location in relation to the adjacent teeth and the impaction of canine teeth.

Two oral and maxillofacial radiologists evaluated the radiological images in a dark, quiet room. The data of 673 patients was analyzed. SPSS 22 for Windows (Statistical Package for Social Sciences IBM, New York, USA) was used for statistical analysis of the results. Comparisons between two groups were made using chi-square tests. Wilcoxon's matched pairs signed rank test was used to determine intra-examiner reliability and inter-examiner reliability was assessed using the intraclass correlation coefficient (ICC) and the coefficient of variation (CV). Significance was set at $p < 0.05$. Intra-observer and intra-observer calibration were provided based on anatomical diagnoses from the CBCT images, and were assessed for data reliability. Observers evaluated the same images twice, with an interval of one week between evaluations.

Results

Our study consisted of images of 673 patients who complied with the criteria. There were 322 female patients (47.84%) and 351 male patients (52.15%). The age of the patients ranged between14 and 82 years, and the mean ages for the female/male patients were 43.54 years and 45.75 years respectively. Overall, it was found that 8.17% of the patients in this study exhibited AC of CS (*n*= 55). A total of 62 AC were found in different location in 55 patients. While there was no AC in 618 patients (91.8%) in the study group, the number of patients with one AC was 55 (8.17%), and the number of patients with two AC was seven (1.04%). There was a significant difference between the genders concerning AC of the CS occurrence. The distribution of CS among genders is shown in Table 1.

Table 1. Distribution of CS among genders

CS	Male	Female	Total
(-) n (%)	315 (89.7%)	303 (94.1%)	618 (91.8%)
(+) n (%)	36 (10.3%)	19 (5.9%)	55 (8.2%)
n	351	322	673

($p < 0.05$)

Of the patients with AC in this study (*n*= 55), seven were aged between 14 and 25 years, 11 were between 26 and 35 years, 12 were between 36 and 45 years, and 25 were over 60 years old. There was no statistical relationship between age and AC prevalence (Table 2).

Table 2. Distribution of CS among age groups

Age Groups	Male n (%)	Female n (%)	Total n (%)
14-25	4(11.1%)	3(15.7%)	7(12.7%)
26-35	4(11.1%)	7(36.8%)	11(20%)
36-45	8(22.2%)	4(21.1%)	12(21.8%)
46 +	20(55.6%)	5(26.4%)	25(45.5%)

($p > 0.05$)

AC was most common in the regions of tooth 12 and tooth 22 followed by the regions of tooth 11 and tooth 23. Moreover AC openings were detected close to the incisive foramen (IF). The distribution of ACs close to the incisive foramen is shown in Table 3.

Table 3. Distribution of CS among Region of Interest

Location of CS	n	%
11	7	11.29
11-12	3	4.84
12	8	12.90
12-13	0	0.00
13	3	4.84
13-14	0	0.00
21	4	6.45
21-22	6	9.68
22	8	12.90
22-23	1	1.61
23	7	11.29
23-24	2	3.23
Anterior of IF	7	11.29
Posterior of IF	2	3.23
Right to IF	0	0.00
Left to IF	4	6.45

IF: Incisive foramen

The greatest number of AC openings was observed anterior to the incisive foramen (n= 7, 11.29%). AC was not found in the regions between tooth 12 and tooth 13 and between tooth 13 and tooth 14; also, it was not found right to the incisive foramen (IF).

AC was found in at least two locations in some patients. Where two ACs were found in the same patient, the locations were: in the region of teeth 22-23 and tooth 23, in the region of tooth 12 and tooth 22, in the region of tooth 12 and teeth 23-24, in the region of tooth 11 and teeth 21-22, the region of tooth 23 and anterior of the IF. Two different patients had the same AC location in the regions of tooth 12 and tooth 22.

The presence of impacted canine teeth was also registered. One canine impaction was found located on the left side. The results showed intra-examiner reliability between the observers ($p > 0.05$), with the ICCs between the two observers ranging from 0.911 to 0.930. The high ICC and low CV showed that the CBCT assessment process was standardized between observers and that there was high inter-examiner agreement.

Discussion

The anterior maxilla is generally considered an extremely safe surgical area. Therefore, during surgical procedures in this area, surgeons have often only paid attention to the nasopalatine canal or nasal floor. Recently, more awareness has been raised of the thinner neurovascular structures in the anterior maxilla[19]. The ASAN is the largest of the superior alveolar nerves and originates from the infraorbital nerve. On the orbital floor, it passes laterally to the infraorbital canal in the CS[20]. Recent research has shown bone canals in the anterior maxilla related to CS and these accessory canals generally reach the apices of the anterior teeth[2,3,21]. In addition, it has been reported that superimposition of the lower portion of the CS onto the anterior maxillary teeth may mimic periapical lesion[5].

In the literature, cases of severe hemorrhage have been reported associated with an accessory foramen with a diameter of <1 mm during dental implant placement. Volberg *et al.* presented a case showing trigeminal neuralgia related to damage of the CS after immediate implant placement[22]. Therefore, in cases requiring surgical procedures (such as implant placement, impacted tooth surgery), it is important to consider how to optimize preoperative preparation and prevent complications. In addition, careful preoperative imaging analysis of the neurovascular ducts in the jaws should be performed based on macroscopic and microscopic anatomical knowledge[19,21].

Two-dimensional (2D) images, such as panoramic and periapical radiography, provide visualization of limited quality. Due to superimpositions or artefacts, CS is recognized with difficultly. Furthermore, many clinicians identify this structure as a pathology. Cone beam computed tomography (CBCT) is a safe method commonly used in dentistry to obtain three-dimensional images of the jaw. It is especially useful for CS research, as it can provide high resolution images and detailed three-dimensional scans[3,23]. Anatoly et al reported that the best visualization for detecting CS was achieved with 0.5 mm and 1 mm slice thickness slices[11].

In 2012 de Oliveira Santos *et al.*[20] demonstrated that additional palatine foramina at least 1mm in diameter were found in around 16% of patients of both genders and different age groups. In 2017 Ghandourah *et al.*[13] assessed the frequency, location and width of ACs of the CS using CBCT. In 2018, Orhan *et al.*[3] evaluated the presence or absence of CS with regard to age, sex, location in relation to the adjacent teeth and impaction of canine teeth.

In the present study, the age of the patients ranged from 14 to 82 years and the age groups were 14-25 years old, 26-35 years old, 36-45 years old and 46 or more years old. There was no statistical relationship between age or age groups and AC of the CS prevalence. This result is in agreement with the results of research by de Oliveira Santos, Orhan, von Arx and Machado *et al*.[2,3,20,21].

Studies have shown no statistically significant difference despite the tendency of men to have more ACs than women[2,3,13,21]. Although Manhaes Jr *et al.*[16] and de Oliveira Santos *et al.*[20] reported that they found 99 females to 82 males and 15 females to 13 males with ACs respectively, they also stated that they did not find any statistical differences. In contrast to the literature, in our study, there was a significant difference between the genders in AC of the CS occurrence, with males showing a higher prevalence than females. This result is in agreement with the research of Tomrukçu *et al.*[24] and Aoki *et al.*[10].

In our study, a total of 62 AC of the CS were found in different locations in 55 patients (8.17%). Machado *et al*.[21] found that frequency of the CS was 52.1%, Manhaes Junior *et al.*[16] found the frequency of the CS was 36.2%, de Oliveira Santos *et al.*[20] reported 15.7%, Orhan *et al*.[3] reported 70.8%, Ghandourah *et al.*[13] reported 67.6%, von Arx *et al.*[2] reported 27.8%. These discrepancies may result from differences in voxel size or from selecting different reference values as the channel diameter.

The regions where AC of CS were predominantly observed varies in the literature. Ghandourah *et al.*[13] reported that ACs were found in the adult group mostly in the region of the central incisors, followed by the left and right lateral incisors and canine regions. In the adolescent group, the area of highest prevalence was the left lateral incisor and canine region[13]. Von Arx *et al*.[2] stated that the area where AC were most frequently found was the palatal region to the central incisors. Orhan *et al*.[3] stated that CS were most frequently observed in the maxillary inter-central region. Machado *et al*.[21] stated that the area of greatest prevalence was the palatal side of the anterior maxillary teeth. Manhaes Jr *et al.*[16] reported that it was beside the incisive foramen. De Oliveira Santos et al.[20] reported that it was in the alveolar process near the incisors or canines. Sekerci *et al*.[25] reported that the accessory canals were located most frequently palatal to the left lateral incisor. Anatoly *et al.*[11] reported that CS was most frequently present in the lateral incisor region. Similarly, in our study, AC was most common in the region of the right and left lateral incisors, tooth 12 and tooth 22. In addition, AC openings were most commonly observed anterior to the incisive foramen.

The published literature revealed great variability and differing results in the studies of the CS, highlighting the lack of standardization of the studies, and suggesting that results may depend on the slice thickness of the CBCT. The articles show that CS is an important structure, considering the neurovascular bundle it carries[4,11].

The present study has some limitations - a limited number of samples were used for the study. Further studies are needed on larger cohorts in this area.

Conclusions

It can be concluded that there is no relationship between the CS location or age group. In addition, it was found that there are significant differences in the frequency of the CS concerning gender. Contrary to popular belief, anatomical variations in the maxillary bone are not rare. It is important to take into consideration the presence of AC of the CS during surgical procedures in the anterior region. Clinicians should recognize these anatomical structures with CBCT before surgical operations, to avoid possible complications and prevent inappropriate treatment and injuries.

References

1. Olenczak JB, Hui-Chou HG, Aguila DJ, Shaeffer CA, Dellon AL, Manson PN. Posttraumatic Midface Pain. Ann Plast Surg, 2015;75:543-547.
2. von Arx T, Lozanoff S. Anterior superior alveolar nerve (ASAN). Swiss Dent J, 2015; 125:1202-1209.
3. 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 (Warsz), 2018;77:551-557.
4. Ferlin R, Pagin BSC, Yaedú RYF. Canalis sinuosus: a systematic review of the literature. Oral Surg Oral Med Oral Pathol Oral Radiol, 2019;127:545-551.
5. Shelley AM, Rushton VE, Horner K. Canalis sinuosus mimicking a periapical inflammatory lesion. Br Dent J, 1999;186:378-379.
6. Arruda JA, Silva P, Silva L, et al. Dental Implant in the Canalis Sinuosus: A Case Report and Review of the Literature. Case Rep Dent, 2017:2017:4810123.
7. Neves FS, Crusoé-Souza M, Franco LCS, Caria PHF, Bonfim-Almeida P, Crusoé-Rebello I. Canalis sinuosus: a rare anatomical variation. Surg Radiol Anat, 2012; 34:563-566.
8. 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;57:323-334.
9. Vâlcu M, Rusu MC, Mihaela Şendroiu V, Cristiana Didilescu A. Case Reports The Lateral Incisive Canals of the Adult Hard Palate-Aberrant Anatomy of a Minor Form of Clefting? Rom J Morphol Embryol, 2011;52:947-949.
10. Aoki R, Massuda M, Zenni LTV, Fernandes KS. Canalis sinuosus: anatomical variation or structure? Surg Radiol Anat, 2020;42:69-74.
11. Anatoly A, Sedov Y, Gvozdikova E, Mordanov O, Kruchinina L, Avanesov K et al. Radiological and Morphometric Features of Canalis Sinuosus in Russian Population: Cone-Beam Computed Tomography Study. Int J Dent, 2019;2019:2453469.
12. Gurler G, Delilbasi C, Ogut EE, Aydin K, Sakul U. Evaluation of the morphology of the canalis sinuosus using cone-beam computed tomography in patients with maxillary impacted canines. Imaging Sci Dent, 2017;47:69-74.
13. Ghandourah AO, Rashad A, Hamzi BM, Friedrich RE, Heiland M. Cone-beam tomographic analysis of canalis sinuosus accessory intraosseous canals in the maxilla. Ger Med Sci, 2017;15:1-12.
14. McCrea SJJ. Aberrations Causing Neurovascular Damage in the Anterior Maxilla during Dental Implant Placement. Case Rep Dent, 2017;2017:5969643.
15. Baciut M, Hedesiu M, Bran S, Jacobs R, Nackaerts O, Baciut G. Pre and postoperative assessment of sinus grafting procedures using cone-beam computed tomography compared with panoramic radiographs. Clin Oral Implants Res, 2013;24:512-516.
16. Manhäes Jr 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;30:e49.
17. Mraiwa N, Jacobs R, Van Cleynenbreugel J, Sanderink G, Schutyser F, Suetens P et al. The nasopalatine canal revisited using 2D and 3D CT imaging. Dentomaxillofac Radiol, 2004;33:396-402.
18. Kurrek A, Troedhan A, Konschake M. Contemporary CBCT diagnostics - discovery of a new artery with possible impact on surgical planning: the anterior superior palatal alveolar artery. Surg Radiol Anat, 2018;40:1147-1158.
19. Tanaka R, Hayashi T, Ohshima H, Ida-Yonemochi H, Kenmotsu S, Ike M. CT anatomy of the anterior superior alveolar nerve canal: a macroscopic and microscopic study. Oral Radiol, 2011;27:93-97.
20. 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;24:1044-1048.
21. Machado V de C, Chrcanovic BR, Felippe MB, Manhães Júnior LRC, de Carvalho PSP. Assessment of accessory canals of the canalis sinuosus: a study of 1000 cone beam computed tomography examinations. Int J Oral Maxillofac Surg, 2016;45:1586-1591.

22. Volberg R, Mordanov O. Canalis Sinuosus Damage after Immediate Dental Implant Placement in the Esthetic Zone. Case Rep Dent, 2019;2019:3462794.
23. Şallı GA, Özcan İ, Pekiner FN. Prevalence of pneumatization of the articular eminence and glenoid fossa viewed on cone-beam computed tomography examinations in a Turkish sample. Oral Radiol, 2020;36:40-46.
24. Tomrukçu DN, Köse TE. Assesment of accessory branches of canalis sinuosus on CBCT images. Med Oral Patol Oral y Cir Bucal, 2020;25:e124-e130.
25. 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, 2015;37:181-186.

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