# Assessment of the Canalis Sinuosus Using CBCT in Pathological Lesions

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**Objective:** *To assess the canalis sinuosus (CS) in pathological lesions located in the anterior maxilla using CBCT.*
**Methods:** *In total, 104 lesions in the anterior maxilla were assessed. The localisation of CS termination points on the alveolar crest was evaluated. Subsequently, the consistency of the CS and CS–lesion relationships were determined based on the maximal diameter of the lesion and the presence of a cortical perforation.*
**Results:** *Of the 104 lesions, 82 (78.8%) exhibited at least one CS. The presence of CS was statistically significantly different based on the diameter of the lesion ($P < 0.001$). When the presence of CS was investigated in relation to cortical perforation status, a significant difference was observed ($P < 0.05$). Anatomically, CS was most common in the central incisor and ended most frequently near the crest apex vertically and in the palatal region horizontally. Among the instances of CS, 55.3% were lesion-related, 22.3% were in contact and 23 (22.3%) were unrelated to the lesion.*
**Conclusion:** *The incidence of CS was high in anterior maxillary pathological lesions and even higher in small-sized pathological lesions. Most CSs were located within or next to the surgical margin of the pathological lesion.*
**Keywords:** *canalis sinuosus, CBCT, maxilla, oral surgery, pathological lesion*
*Chin J Dent Res 2025;28(2):131–137; doi: 10.3290/j.cjdr.b6260624*

The nasopalatine canal in the anterior maxilla is considered highly important by dental clinicians because of its potential clinical impacts.[1] Nevertheless, most clinicians are unaware of the canalis sinuous (CS) and lack knowledge regarding its diagnosis.[2] The CS is a branch of the infraorbital canal enclosing the anterior superior alveolar neurovascular structure, and the termination point of this intraosseous canal is in the anterior maxilla.[3-5] The neurovascular bundle within the CS innervates the anterior maxillary teeth, the floor of the nasal cavity and the maxillary sinuses. In the anterior maxilla, several procedures are conducted, including dental implant surgery, orthognathic surgery, extraction of impacted or supernumerary teeth, periodontal and endodontic surgery and cyst treatments.[6] A lack of anatomical knowledge about CS can cause pain, local infection and even paraesthesia.[4] Thus, preventing injury during local anaesthesia and maxillofacial surgery requires a comprehensive understanding of key anatomical reference points and areas in the oral and maxillofacial regions, particularly regarding the CS.[7]

Individuals diagnosed with anterior maxillary intraosseous pathological lesions (IPLs) are likely to require surgical intervention, and the surgical risks related to the CS apply to these patients as well. Multiple studies on the prevalence of CS conducted in different countries using CBCT have acknowledged the clinical significance of the CS; however, none have assessed IPLs in the anterior maxilla as yet.[1,6,8-14] Thus, adequate anatomical and clinical information regarding the CS in the anterior maxilla with pathological lesions is lacking. The present study aimed to determine the clinical importance of the CS through CBCT images of patients diagnosed with anterior maxillary IPLs. Moreover, using the collected clinical data, the present authors aimed to identify and mitigate potential risks and complications before surgery for pathological lesions in the anterior maxilla.

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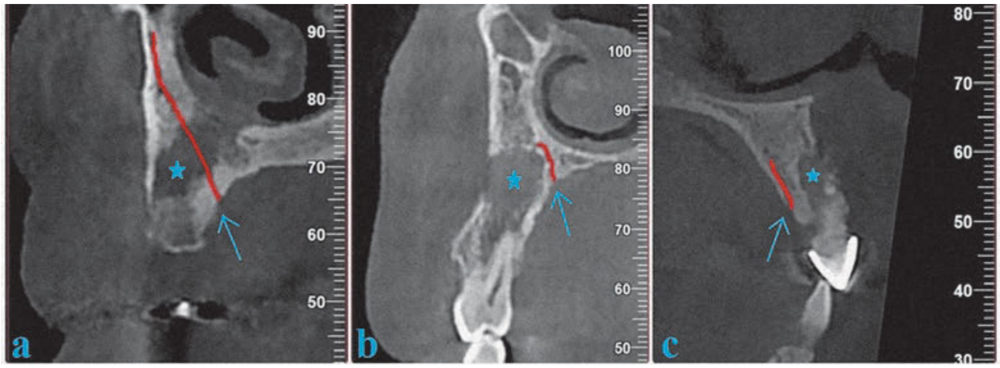



**Fig 1a to c** CSs that were related to **(a)**, in contact with **(b)** and not associated with the bony tissue lesion **(c)** (star, IPL; arrow, ending of CS).

## Materials and methods

This study was approved by the university's scientific research and publication ethics committee (2023/4846).

### *Study population*

A total of 104 IPLs in the anterior maxilla of 83 patients were evaluated cross-sectionally. IPLs in the anterior maxilla were assessed using CBCT. In the images of the patient's anterior maxilla, when the normal bone tissue was disrupted and replaced by a hypodense appearance, it was considered an intraosseous pathology. The inclusion criteria were as follows:

- intraosseous lesions between the maxillary right and left premolar regions;
- extensive intraosseous lesions between the anterior and posterior maxilla;
- intraosseous pathologies presenting a lesion centred in the posterior maxilla and extending to the anterior premolar region.

The exclusion criteria were as follows:

- individuals with cleft lip and palate;
- individuals with plates or miniscrews in the anterior maxilla resulting from trauma or other factors;
- individuals with dental implants in the anterior maxilla;
- individuals having undergone grafting procedures or surgical operations;
- individuals with low quality CBCT records (caused by beam hardening and movement);
- individuals with conditions and medications that impact bone metabolism.

### *CBCT technique*

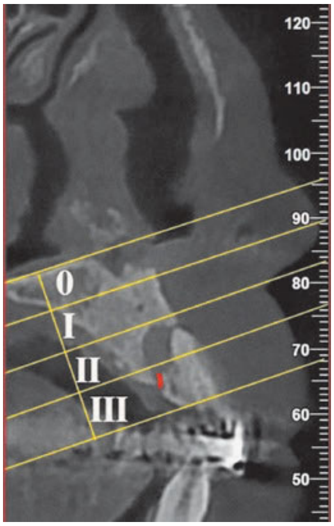
Images acquired using a NewTom 5G CBCT device (Verona, Italy) were used in this study, and NNT software (NewTom) was employed for evaluation. The patients were placed in a supine position while being scanned on the device, which incorporates a gantry. The exposure parameters were 110 kv, 1-20 mA, with a scan time of 18 seconds and exposure time of 3.6 seconds.

### *Image assessment*

The presence of CS was analysed in axial, coronal and sagittal sections in multiplanar reformat (MPR) images with voxel values of 0.3, 0.25 and 0.2 mm and cross-sections with a thickness of 0.3, 0.25 and 0.20 mm. Subsequently, measurements were taken and other evaluations were conducted on cross-sections with a thickness of 0.3, 0.25 and 0.2 mm. All evaluations were performed by a clinician (ND) with 12 years of experience in CBCT.

The CS begins at the infraorbital foramen and orbital base, extending medially and inferiorly. It then proceeds from the front of the maxillary sinus to the lateral and inferior border of the nasal cavity, before reaching the anterior maxilla and ending at the accessory foramen (AF), continuing from the lateral aspect of the nasal septum and the front of the incisive canal.[1]

In the present study, when a pathological lesion was situated on the right or left side, the CS was assessed between the midline and the second premolar. The presence of CS was assessed between the right and left second premolars in patients with bilaterally extending pathological lesions. In scenarios with more than one lesion on one side of the anterior maxilla, CS was investigated between the midpoint of the intact bone and the second premolar and midline between the two lesions. The presence of CS was recorded separately for men and women. CSs were categorised into three groups based on their relationship with the pathologic lesion: CS in direct relation with the pathology, CS in contact with the lesion but with cortical bone separating the CS and the lesion, and CS not associated with the le-



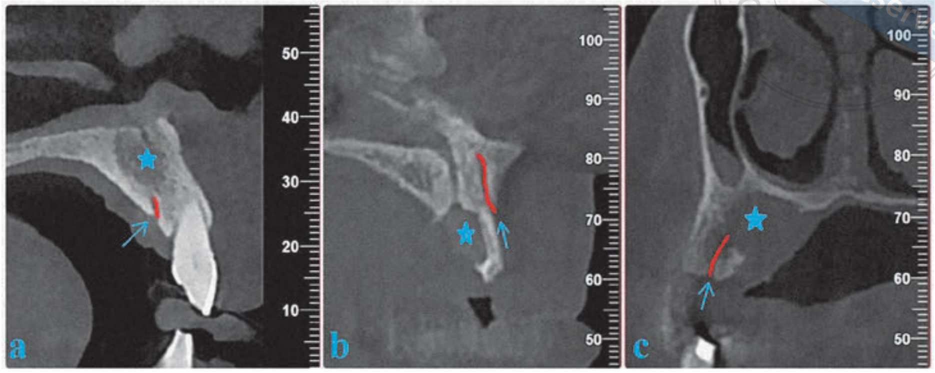




**Fig 2 (left)** Vertical orientation of the CS from the base of the nasal cavity to the apex of the crest apex was shown with a numerical value ranging from 0 to III.

**Fig 3a to c (top)** On the alveolar ridge, horizontal localisation of CS termination was shown as palatinal **(a)**, buccal **(b)** and crest apex **(c)** (star, IPL; arrow, ending of CS).

sion with bony tissue between the CS and the lesion (Fig 1). The termination point of the CS was considered to be the AF and its diameter was measured. This value was recorded as less than or greater than 1 mm. The anatomical points along the dental arch where the CS termination point was present were categorised based on the Oliveria Santos classification (central incisor, between central and lateral teeth, lateral incisor region, canine region, first premolar, adjacent to the incisive foramen; posterior/anterior/lateral).[8] Nonetheless, CSs in the second premolars were also deemed as premolars because of the lesion expansion phenomenon. The vertical position of CS termination in the alveolar crest was categorised using the classification developed by Khojastepour and Akbarizadeh.[12] The alveolar ridge was divided into four equal parts, extending from its highest point at the crest to the floor of the nasal cavity. Each section, from the base of the nasal cavity to the apex of the crest, was labelled with a numerical value from 0 to III (Fig 2). The section that contained the CS opening was recorded. Additionally, the palatal, buccal and crest apex termination of the CS in the alveolar ridge in the horizontal direction were recorded (Fig 3).[6]

The maximum diameters of the pathological lesions were measured. Moreover, lesions were sorted into 0 to 10, 10 to 20, 20 to 30, 30 to 40 and > 40 mm groups based on their maximum diameter, and CS presence was assessed according to these groupings. Subsequently, cortical perforation in pathological lesions was examined, and CS presence was assessed based on the perforation status.

### *Statistical analysis*

Descriptive analysis and chi-square tests were used to compare categorical independent variables across groups. A Bonferroni corrected Z test was used to analyse multiple comparisons of proportions. Maximum diameters of pathological lesions and CS termination diameters were remeasured for 40% of the data 2 weeks later to analyse intraobserver agreement using a Kappa test. The level of statistical significance was set at $P < 0.05$.

## Results

This study assessed 104 pathological lesions in the maxilla of 83 patients. In total, 66 patients had one lesion, 13 had two lesions and 4 had three lesions. Of these 83 patients, 49 (59%) were male and 34 (41%) were female (Table 1). Of the 104 pathological lesions assessed, 60 (57.7%) were observed in men and 44 (42.3%) in women. Regarding the distribution of pathological lesions, 33 (31.7%) were present on the right side, 44 (42.3%) on the left, and 27 (26%) on both sides (Table 1). At least one CS was detected in 82 (78.8%) of the 104 lesions, and in 47 (57.3%) men and 35 (42.7%) women (Table 1). Additionally, the presence of at least one CS did not reveal a statistically significant difference between sexes ($P = 0.881$). Overall, 63 pathological lesions had one CS, 17 had two and two had three, to give 103 CSs in total (Table 1). The Kappa values for intraobserver agreement on the maximum diameter of the pathological lesion and CS diameter were 0.96 and 0.88, respectively.

**Table 1** Number of IPLs and CSs according to patient, sex and side.

| Variable | Number | | | Total |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| Patient | 66 | 13 | 4 | 83 |
| IPL | 66 | 13 | 4 | 104 |
| CS | 63 | 17 | 2 | 103 |
| | | | | |
| Sex | Female | Male | | Total |
| Patient | 34 | 49 | | 83 |
| IPL | 44 | 60 | | 104 |
| At least one CS | 47 | 35 | | 82 |
| | | | | |
| Side | Right | Left | Bilateral | Total |
| IPL | 33 | 44 | 27 | 104 |

**Table 2** Comparison of CS presence according to perforation of pathological lesions (chi-square test).

| Cortical status of IPL | CS | | *P* value |
|---|---|---|---|
| | Presence | Absence | |
| Cortical perforated lesion | 51 (72.9%) | 19 (27.1%) | 0.032 |
| Cortical intact lesion | 31 (91.2%) | 3 (8.8%) | |

Cortical perforation was confirmed in 70 (67.3%) pathological lesions, whereas intact cortical borders were detected in 34 (32.7%) lesions. Cortical perforation was associated with CS in 51 (72.9%) pathological lesions, whereas CS without cortical perforation was observed in 31 (91.2%) lesions. A statistically significant difference ($P = 0.032$) was observed when the presence of cortical perforation in pathological lesions was compared based on the presence of CS (Table 2).

The pathological lesions were categorised according to their maximal diameters: 0 to 10, 10 to 20, 20 to 30, 30 to 40 and > 40 mm. CS was identified in all 29 lesions (100%) in the 0 to 10 mm group, 32 (84.2%) of 38 lesions in the 10 to 20 mm group, 11 (61.1%) of 18 lesions in the 20 to 30 mm group, 8 (80%) of 10 lesions in the 30 to 40 mm group, and 2 (22.2%) of 9 lesions in the > 40 mm group. The groups, categorised based on lesion diameter, exhibited statistically significant differences in terms of CS presence ($P < 0.001$). Significant differences were observed between the 0 to 10 mm and 20 to 30 mm, 30 to 40 mm and > 40 mm, 10 to 20 mm and > 40 mm groups (Table 3).

The mean diameter of the AF was 0.667 mm with a minimum of 0.2 mm, a maximum of 1.6 mm and standard deviation of ± 0.298 mm. Eleven patients (10.7%) had an AF diameter > 1 mm. CS termination regions were present in the central incisor for 36 (35%) patients, between the central and lateral incisor for 8 (7.8%), lateral incisor for 18 (17.5%), canine for 17 (16.5%) and premolar for 24 (23.3%).

The localisation evaluation in the vertical orientation and apical-incisal direction revealed that the termination occurred in 9 (8.7%) cases of Type 0, 14 (13.6%) of Type I, 32 (31.1%) of Type II, and 48 (46.4%) of Type III. In the horizontal orientation, 87 (84.5%) of the CSs ended in the palatal direction, 6 (5.8%) in the buccal direction and 10 (9.7%) transversely.

In the present study, 57 (55.3%) of the CSs were related to the lesion, 23 (22.3%) were in contact and 23 (22.3%) were not related.

## Discussion

Differentiating the CS using conventional, two-dimensional, panoramic and periapical radiography techniques commonly employed in dentistry is highly challenging. CBCT is highly effective in assessing the CS and enables 3D evaluation of the path of the canal in the anterior maxilla across axial, coronal and sagittal sections.[15] In the present study, CBCT was used to assess the CS. Furthermore, thin cross-sections aside from axial, coronal and sagittal sections were examined. The recommended slice thickness for CBCT evaluation of the CS is 0.5 to 1 mm.[11] The present authors employed a more meticulous evaluation method by examining CBCT values with lower voxel sizes, namely 0.3 to 0.25 and 0.2 mm.

The presence of CS in the anterior maxilla is common; however, its proximity to surgical sites may cause pain and bleeding during and after surgical proced-

**Table 3** Comparison of CS presence according to maximum diameter of IPLs (chi-square test).

| Lesion max diameter, mm | CS | | *P* value |
|---|---|---|---|
| | Presence number (%) | Absence number (%) | |
| 0–10 | 29 (100%)[a] | 0 (0.0) | < 0.001 |
| 10–20 | 32 (84.2%)[ab] | 6 (15.8) | |
| 20–30 | 11 (61.1%)[bc] | 7 (38.9) | |
| 30–40 | 8 (80.0%)[abc] | 2 (20.0) | |
| > 40 | 2 (22.2%)[c] | 7 (77.8) | |

a-c, there was no difference between diameters with the same letter.

ures.[1] Thus, the use of CBCT for identifying CSs prior to surgical procedures is crucial in preventing accidents and complications, such as dental implant failure, sensory disturbances and bleeding.[16,17] Moreover, nerve injury can be avoided by accurately determining the location of CSs through CBCT prior to implant surgery.[4] Research employing CBCT technology in patients with impacted canines scheduled for surgical intervention found the mean distance between the CS and the impacted teeth to be approximately 5.27 mm, with the shortest measured distance being 0.75 mm.[14] In the present study, 55.3% of the CSs were directly related to pathological lesions, whereas 22.3% were in close contact; thus, most CSs were located within or near the surgical margins of the pathological lesions. However, no clinical studies discussing whether these pathological lesions can lead to bleeding or paraesthesia during or after surgery were found in the literature.

According to CBCT studies conducted on maxillae with no pathological lesions, the occurrence of CS ranges from 15.7% to 100%.[1,8-15,18,19] The present study, the first in the literature in this field, examined anterior maxillae with IPLs, including those < 1 mm in diameter. The frequency of CS was determined to be 78.8%, which aligned with the results reported in previous studies. Moreover, the present study showed that the frequency of CS was 100% in lesions < 10 mm in diameter, but this frequency decreased to 22% in lesions > 40 mm in diameter. Based on this, it can be inferred that a CS may be resorbed and subsequently lost once the lesion diameter reaches a considerable size. To the best of the present authors' knowledge, the present study is the first to reveal that there is a higher likelihood of CSs in small anterior maxillary pathological lesions. Additionally, although the frequency of CSs was found to be higher in patients with cortical perforation than in those without, the underlying reason could not be elucidated. Thus, further studies on this subject are needed.

A study conducted to assess CS terminations in a vertically orientated apical-incisal direction reported that type 0 near the nasal cavity floor accounted for 3.94%, type I for 38.15%, type II for 52.63%, and type III near the crest apex for 5.26%.[12] The vertical terminations of CS in the present study were determined as types III, II, I and 0, in decreasing order, from the crest apex to the nasal cavity floor. Unlike in the previous study,[12] the present authors evaluated CSs in the maxilla with IPLs. The vertical position of the CS must be understood to facilitate surgical intervention and avoid potential complications. Because most CSs open close to the crest, they should be considered during surgical planning for patients with IPLs.

A study reported CS terminations as 91% palatal, 5.1% buccal, and 3.8% transversal.[7] Yeap et al[1] found that the palatal region was the most common CS endpoint. Another study reported that all CSs ended in the palatal region.[10] In the present study, most CSs (84.5%) ended in the palatal region, aligning with previous literature.

A previous study reported that the mean (minimum–maximum) diameter of the CS was 1.30 ± 0.44 (0.57–2.88) mm.[9] In the present study, the mean diameter was 0.667 ± 0.298 (0.2–1.6) mm. The prevalence of CS with a diameter > 1 mm was reported as 20% by Machado et al,[7] 15.7% by Oliveira-Santos et al[8] and 3.4% by Aoki et al.[15] The present results show a prevalence rate of 10.7% for CS with a diameter > 1 mm. Although the exact correlation between the diameter of the CS and the occurrence of clinical complications is unclear, an increase in diameter is expected to exacerbate bleeding because of the correlation between canal and vessel diameters.[1] Regardless of the fact that CSs measuring > 1 mm in diameter can cause noteworthy complications, vessels with smaller diameters can also contribute to substantial bleeding.[8]

The distribution of CSs based on sex was investigated by Tomrukçu and Köse,[9] Aoki et al[15] and Machado et al,[7] and all concluded that CSs were more prevalent in men. According to Şekerci et al[20] and Anatoly et al,[11] however, the prevalence of CS was higher among women. Studies conducted by Beyzade et al,[10] Von Arx et al[6] and Oliveria Santos et al[8] did not yield statistical significance based on sex. In the present study, although more CSs were observed in men, this difference was not statistically significant.

With regard to the termination points of CSs in the dental arch, 35% were in the central incisor, 23.3% in the premolar, 17.5% in the lateral, 16.5% in the canine and 7.8% in the central-lateral incisor region. Aoki et al[15] observed the highest prevalence of CSs in the central incisor region, whereas the premolar region showed no CSs. Tomrukçu and Köse[9] and Beyzade et al[10] observed the most significant number of CSs in the central incisor region, with the premolar region having the lowest number of CSs. In the present study, the central incisor region exhibited the highest percentage of CS terminations, followed by the premolar region. Considering the potential anatomical displacement of the CSs caused by pathological lesions, the present study could have detected an increased prevalence of CSs in the premolar region.

Sun et al[21] found 502 CSs among 1,002 patients in their study. Of these patients, 259 had one CS, 147 had two, 80 had three, 10 had four, 2 had five, 2 had six, 1 had seven and 1 had eight.[21] Conversely, most of the lesions in the present study had a single CS and none of the pathological lesions had > 3 CSs.

The present study has the limitation of lacking clinical data support. It is imperative to conduct controlled clinical studies to determine whether CSs diagnosed with preoperative CBCT lead to intra- or postoperative complications. A further limitation is the absence of histopathological confirmation to determine whether the lesions were malignant or benign for the definitive diagnosis of the analysed IPLs.

## Conclusion

Considering the extensive utilisation of preoperative CBCT in maxillofacial pathological lesions, it is essential to conduct a CS assessment of the obtained images because CSs are prevalent in anterior maxillary IPLs. A higher incidence of CSs was observed when the anterior maxillary pathological lesion was small, whereas the incidence was notably diminished in larger lesions, particularly in cases with pathological lesions > 40 mm in diameter. Moreover, a significant number of CSs were identified within or close to the surgical margin. Thus, more clinical studies are necessary to determine whether these characteristics contribute to complications during or after surgery.

## Conflicts of interest

The authors declare no conflicts of interest related to this study.

## Author contribution

Both authors participated in the data collection process, statistical analysis and writing of this article.

(Received Jun 11, 2024, accepted Jan 21, 2025)

## References


1. 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;67:249–261.
2. Lopes-Santos G, Salzedas LMP, Bernabé DG, Ikuta CRS, Miyahara GI, Tjioe KC. Assessment of the knowledge of canalis sinuosus amongst dentists and dental students: An online-based cross-sectional study. Eur J Dent Educ 2022;26:488–498.
3. Jones FW. The anterior superior alveolar nerve and vessels. J Anat 1939;73:583–591.
4. Neves FS, Crusoé-Souza M, Franco LC, Caria PH, Bonfim-Almeida P, Crusoé-Rebello I. Canalis sinuosus: A rare anatomical variation. Surg Radiol Anat 2012;34:563–566.
5. 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.
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 2013;35:783–790.
7. Machado VC, Chrcanovic BR, Felippe MB, Manhães Júnior LR, de Carvalho PS. 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.
8. de Oliveira-Santos C, Rubira-Bullen IR, Monteiro SA, León JE, Jacobs R. Neurovascular anatomical variations in the anterior palate observed on CBCT images. Clin Oral Implants Res 2013;24:1044–1048.
9. Tomrukçu DN, Köse TE. Assesment of accessory branches of canalis sinuosus on CBCT images. Med Oral Patol Oral Cir Bucal 2020;25:e124–e130.
10. Beyzade Z, Yılmaz HG, Ünsal G, Çaygür-Yoran A. Prevalence, radiographic features and clinical relevancy of accessory canals of the canalis sinuosus in Cypriot population: A retrospective cone-beam computed tomography (CBCT) study. Medicina (Kaunas) 2022;58:930.
11. Anatoly A, Sedov Y, Gvozdikova E, et al. Radiological and morphometric features of canalis sinuosus in Russian population: Cone-beam computed tomography study. Int J Dent 2019;19:2453469.
12. Khojastepour L, Akbarizadeh F. Evaluation of extension type of canalis sinuosus in the maxillary anterior region: A CBCT study. Chin J Dent Res 2023;26:29–34.
13. Sedov YG, Avanesov AM, Mordanov OS, Zurnacheva DD, Mustafaeva RS, Blokhina AV. Visualization features of canalis sinuosus with cone beam computed tomography. Indian J Dent Res 2019;30:656–660.

14. 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.
15. Aoki R, Massuda M, Zenni LTV, Fernandes KS. Canalis sinuosus: Anatomical variation or structure? Surg Radiol Anat 2020;42:69–74.
16. de Oliveira-Neto OB, Barbosa FT, Lima FJC, de Sousa-Rodrigues CF. Prevalence of canalis sinuosus and accessory canals of canalis sinuosus on cone beam computed tomography: A systematic review and meta-analysis. Int J Oral Maxillofac Surg 2023;52:118–131.
17. Lopes Dos Santos G, Ikuta CRS, Salzedas LMP, Miyahara GI, Tjioe KC. Canalis sinuosus: An anatomic repair that may prevent success of dental implants in anterior maxilla. J Prosthodont 2020;29:751–755.
18. Beckenstrater MA, Gamieldien MY, Smit C, Buchanan GD. A cone-beam computed tomography study of canalis sinuosus and its accessory canals in a South African population. Oral Radiol 2024;40:367–374.
19. Ferlin R, Pagin BSC, Yaedú RYF. Evaluation of canalis sinuosus in individuals with cleft lip and palate: A cross-sectional study using cone beam computed tomography. Oral Maxillofac Surg 2021;25:337–343.
20. 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.
21. Sun Z, Li D, Zhang X, Zhang J, Li H, He C. Cone-beam computed tomography of accessory canals of the canalis sinuosus and analysis of the related risk factors. Surg Radiol Anat 2024;46:635–643.