VOLUME 9 | ISSUE 4

ORIGINAL ARTICLE Head and neck Imaging

Coronal Assessment of Vidian Canal Morphometrics and its Associative Structures Using Cone Beam Computed Tomography: A Descriptive Study

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SUBMISSION: 27/03/2024 - ACCEPTANCE: 7/07/2024

ABSTRACT

Purpose: The Vidian Canal (VC) is a small canal located at the base of the skull that carries the Vidian Nerve (VN), a branch of the trigeminal nerve. The VC runs from the posterior region of the sphenoid sinus to the pterygopalatine fossa, where it opens up and divides into two branches: the VN and the greater petrosal nerve. VN carries sensory fibers from the nasopharynx, the nasal cavity, and the palate, while the greater petrosal nerve carries para-sympathetic fibers to the lacrimal glands and nasal mucosa. This study analyzed the anatomical constitution and the morphometric variations of VC in 3D employing cone beam computed tomography (CBCT) in coronal sections, as well as to compare and appraise VC according to age and gender based on the coronal section.

Materials and Methods: This study was performed in the Department of Oral Medicine and Radiology at JSS Dental College and Hospital, JSS Academy Higher Education and Research, Mysuru. This was a retrospective descriptive study comprising 30 males and 30 females who underwent CBCT following consent based on a convenient sampling technique. The data was tabulated and then the necessary statistical analysis was performed.

Results: Among the various morphological characteristics appraised, this study shows a statistically sig-

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nificant difference among genders for the VC to midsagittal plane. Even though there is a positive correlation among other parameters, they were not statistically significant.

Conclusion: This study focuses on examining morphometric data using a reliable methodology, providing valuable insights into the intricacies of the Vidian canal (VC). A thorough analysis of the complex anatomy of the VC enables surgeons to exercise greater caution while planning intricate skull-base surgeries, ultimately reducing the risk of post-surgical complications.

KEY WORDS

Vidian canal; Cone Beam Computed Tomography; Anatomy; Pterygoid canal; Endoscopic endonasal surgery

Introduction

The cranial base refers to the inferior portion of the skull that forms the foundation for the brain and serves as a structural and functional component. It carries immense significance due to its role in protecting vital structures such as the brain, spinal cord, major blood vessels, and cranial nerves. Within this region, there exist intricate anatomical structures that emerge from specific foramina or openings. These foramina play a role in facilitating vital functions, most notably sensory perception and motor control [1].

A notable anatomical structure of interest in the current study is the Vidian canal (VC), also called the pterygoid canal (PC). This canal serves as a conduit for the Vidian nerve and artery, which are essential components of the cranial nerve system. Moreover, it plays a crucial role in providing vascular supply to various regions in the craniofacial entity. To get a comprehensive view of its morphometrics through radiological imaging, 3D imaging modalities in recent advances have been of great interest.

Computed tomography (CT) is ideal for the delineation of the bony anatomy and thus it is often combined with magnetic resonance imaging [2]. However, it is indispensable to evaluate the relationship between the VC and surrounding structures like the sphenoid sinus via preoperative CT due to impairment in resolution [3]. Cone Beam Computed Tomography (CBCT) is one such modality that has attracted attention recently due to its high spatial resolution and has shown how technical advancements like three-dimensional imaging continue to improve and refine the accuracy of analyzing skull morphology [4].

Several researchers have evaluated various aspects of the Vidian canal and its components using CT and MRI. However, scientific literature revealed that there is a lack of research using CBCT as an aid for the exploration of the VC. Thus, the purpose of this study was to analyze the anatomical variability and the morphometrics of the Vidian canal in 3D by employing CBCT, as well as to appraise and compare the Vidian canal based on age and gender under the coronal section.

Materials and methods

the study protocol was approved by the Institutional Ethics Committee [JSSDCH IEC Research Protocol No. 21/2022]. This descriptive retrospective study was performed on 60 subjects, comprising 30 males and 30 females, in a monocentric setting. A convenient sampling method was used, assuming an absolute precision of 5% and a confidence level of 95%. A sample size of 60 CBCTs was estimated and samples were retrieved between April 2022 and April 2023 from the institutional archives, following the eligibility criteria. All volumetric images were analyzed using Planmeca ProMax 3D software in the coronal section.

Inclusion Criteria:

- CBCT images of male and female subjects between the age group of 11 to 70 years
- Ideal CBCT images with optimum diagnostic quality.
- CBCT images clearly show base of the skull, especially VC.
- Images were made for the assessment of oral and

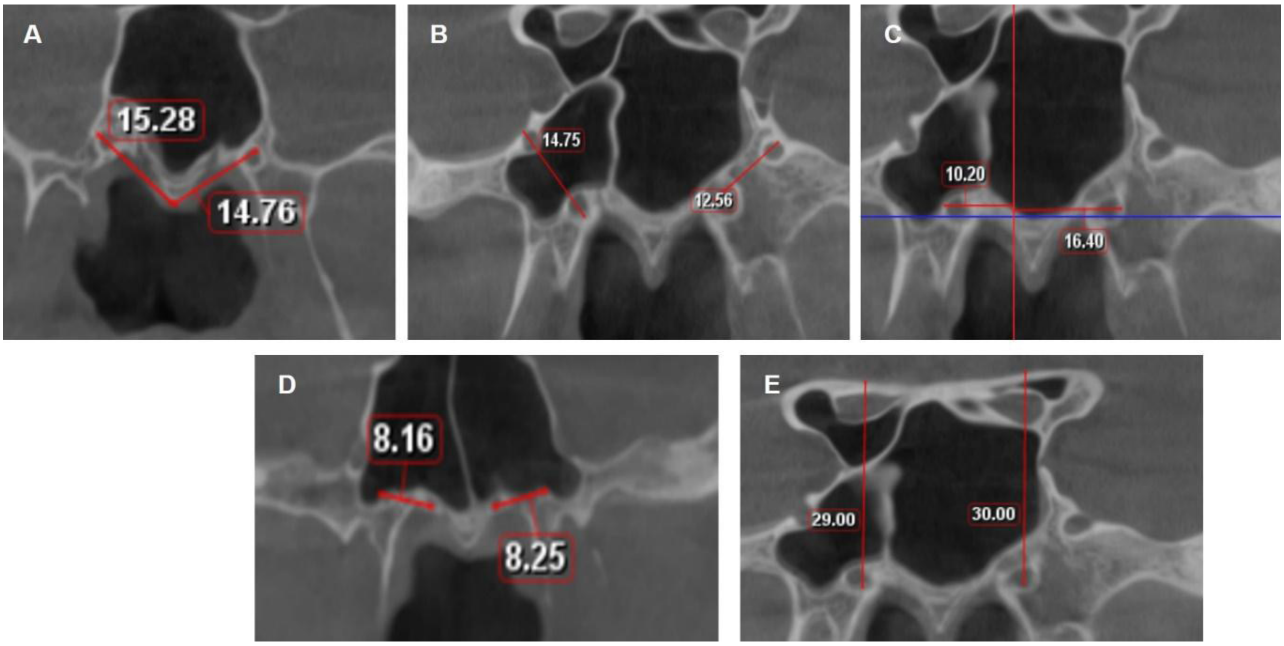

***Figure 1A:** Depicts VC to vomerine crest, **1B**- Depicts VC to FR, **1C**- Depicts VC to midsagittal plane, **1D**- depicts VC to PSC, **1E**- depicts VC to superior wall of SS*

maxillofacial trauma or pathology not involving the base of the skull.

Exclusion Criteria:

- Partial images or presence of artifacts in the base of the skull.
- CBCT of coronal section images with any pathology or developmental defects of the base of the skull.
- Image with any evidence of previous surgery, fracture, or healed fracture in the base of the skull.

Images satisfying the inclusion criteria were subjected to analysis for the following landmarks in coronal sections in 3D-rendered images of Planmeca Romexis 5.3 (3D software):

- **VC to vomerine crest:** The left and right nasal cavities are divided by vomerine crest with a bony ridge that runs down the middle of the nasal cavity and distance is measured from VC to vomerine crest (Figure 1a).
- **VC to Foramen rotundum (FR):** The FR is a round opening in the sphenoid bone and is measured from VC (Figure 1b).
- **VC to Midsagittal Plane:** The midsagittal plane is an imaginary line that divides the body into left and right halves. The distance between the VC and midsagittal plane is measured (Figure 1c).
- **VC to the palato-sphenoidal canal (PSC) distance:** The pterygopalatine fossa is connected to the nasal cavity by the PSC, a tiny canal that passes through the palatine bone and is measured from the VC (Figure 1d).
- **VC to the superior wall of the sphenoid sinus (SS):** The superior wall of SS is a bony structure that separates the sphenoid sinus from the middle cranial fossa; it was identified as a dense, radiopaque line on the coronal image and was measured to VC (Figure 1e).
- **Pneumatization of VC,** which was defined according to Lee et al. (2011).
  - > Type 1: VC located within the bony floor of the sphenoid sinus (Figure 2a).
  - > Type 2: VC partially protruded into the sphenoid sinus (Figure 2b).
  - > Type 3: VC totally protruded into the sphenoid sinus (Figure 2c).
- **Association of VC and medial pterygoid plate (MPP):**
  - > Type A: VC located medially to the medial

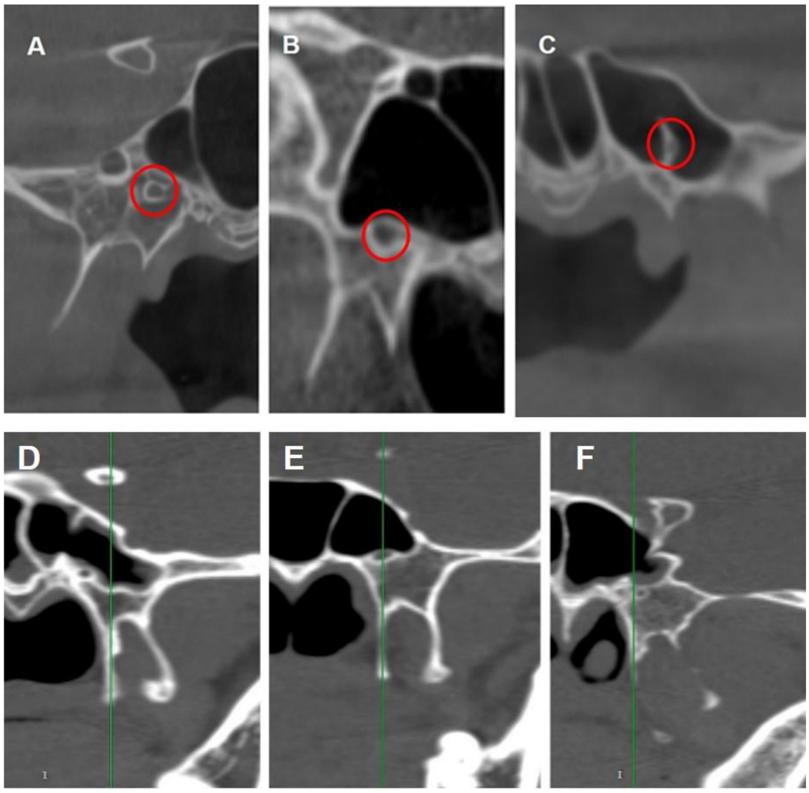

Figure 2a- *Type 1 (VC within sphenoid bone),* ***2b***- *Type 2 (VC partially projected into SS),* ***2c***- *Type 3 (VC completely protruded into SS);* ***2d***- *Type A (VC medial to MPP),* ***2e***- *Type B (VC same line to MPP),* ***2f***- *Type C (VC lateral to MPP)*

pterygopalatine plate (Figure 2d),

> Type B: VC located on the same line as the medial pterygopalatine plate (Figure 2e),

> Type C: VC was located laterally to medial pterygopalatine plate (Figure 2f)

Statistical analysis

The demographic data was evaluated using the mean, median, and standard deviation. The statistical analysis was carried out with a 95% confidence level using the paired sample t-test and independent t-test. Significant P values ($P<0.05$) were defined as those that are less than 0.05. The SPSS software Version 23.0 was used to analyze the data.

Results

A total of 60 participants, comprising 30 (50%) males and 30 (50%) females, were examined who belonged to the age range of 11 to 70 years. The mean, standard deviation, and standard error mean were estimated with the descriptive statistics depicted in Table 1.

A paired sample t-test was done to evaluate for any morphometric difference in the bilateral aspect for all the parameters. However, only VC to midsagittal plane showed a statistically significant difference among them, whereas VC to vomerine crest, VC to FR, VC to PSC, and VC to the superior wall of the sphenoid sinus were not statistically significant.

An independent t-test was conducted to check if the morphometrics showed any dimorphic characters among genders. It was concluded that VC to FR, VC to right midsagittal plane, and VC to right superior wall of sphenoid sinus were statistically significant, whereas VC to vomerine crest, VC to left midsagittal plane, VC to PSC, and VC to left superior wall of sphenoid sinus were not statistically significant (Table 2).

Discussion:

VC is named after the anatomist Johann Nepomuk Vidian, who described it in the 19th century. The anatomical elements that traverse the VC are the Vidian nerve (VN), which is a branch of the posterior lateral na-

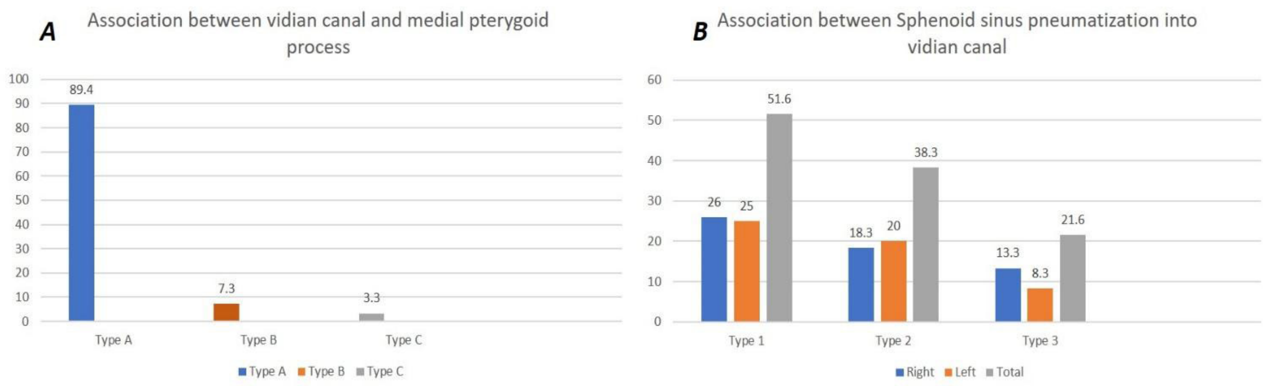

Figure 3a: *shows the association between the Vidian canal and the medial pterygoid plate, and 3b: shows the association between sphenoid sinus pneumatization and the Vidian canal.*

sal nerve that carries sensory and para-sympathetic fibers. The VN plays an important role in the innervation of the nasal cavity, lacrimal gland, and pharynx. The VN courses through the VC in the skull base and exits through the pterygopalatine fossa. In the fossa, it gives off branches to the sphenopalatine ganglion, which provides sensory innervation to the nasal cavity, and to the pharyngeal plexus, which provides sensory innervation to the pharynx. In addition, the Vidian artery, a branch of the pterygopalatine part of the maxillary artery, also passes through the VC [5].

Understanding the relationship between the adjacent structures of VC and their anatomical variation is of great value for preoperative risk assessment, intraoperative navigation, and postoperative care. The VC serves as a landmark for the identification and protection of VN during endoscopic endonasal approaches (EEA) since it is a crucial structure for correctly identifying the petrous portion of the internal carotid artery [6]. In the majority of patients, the internal carotid artery (ICA) was superior to the VC, and there was a correlation found in some measures between the VC and its surrounding components [7].

VC to Vomerine Crest

A bony ridge that differentiates the nasal chambers and is located close to the roof of the nasal cavity is called the vomerine crest. The VC often runs along the inferolateral portion of the sphenoid sinus, medial to the vomerine crest [8]. Its relationship to the VC is significant because, during surgical procedures such as Vidian neurectomy, the intra-sphenoid septum, which is located between the VC and the vomerine crest, could hinder vision. In our study, there was absolutely no statistically significant similarity between gender and sides. This is in accordance with the study conducted by Acar et al., who found no gender or side differences [9]. Bidarkotimath and Acar et al. reported a distance range of 12 to 18 mm with a mean distance of 16 mm, which is similar to this study [9,10].

VC to Foramen Rotundum

The foramen rotundum is a circular opening in the sphenoid bone of the skull. The opening of VC lies 8-9 mm below and medial to the foramen rotundum. According to Kassam et al., the VC-FR distance was essential to the EEA [11]. In our study, the mean VC-FR distance was statistically insignificant between the genders. However, there was a difference in the mean distance between the left and right sides, which was statistically significant at 8.99 ± 1.48 and 9.12 ± 1.57 mm, respectively. In accordance with our study, Yeh et al. reported the difference in mean VC-FR distance as statistically significant between the left and right sides. However, there was no statistically significant difference among genders [3]. Yazar et. al. reported the mean distance from FR to VC as 7.2mm and it was not statistically significant either by gender or side [12]. This can be explained by the fact that there may be a possible difference due to the difference in the ethnic population studied. Many studies have mentioned the mean VC-FR distance between 4 and 8.5 mm [3, 10, 12, 13, 14, 15].

TABLE 1: CORONAL SECTION PARAMETERS- DESCRIPTIVE STATISTICS						
PARAMETERS	**GENDER**	**SIDE**	**MEAN**	**STANDARD DEVIATION**	**MINIMUM**	**MAXIMUM**
Vidian canal to vomerine crest	MALE	RIGHT	16.162	2.500	10.100	21.610
		LEFT	16.385	2.273	11.760	19.680
	FEMALE	RIGHT	15.005	2.424	9.330	20.650
		LEFT	14.742	2.394	10.430	19.870
Vidian canal to foramen rotundum	MALE	RIGHT	10.389	1.604	6.770	13.790
		LEFT	10.567	1.619	6.510	15.680
	FEMALE	RIGHT	7.608	1.331	4.530	10.120
		LEFT	7.682	1.524	3.790	11.680
Vidian canal to midsagittal plane	MALE	RIGHT	15.372	2.672	8.800	19.600
		LEFT	16.011	3.022	7.210	21.200
	FEMALE	RIGHT	8.445	1.799	4.420	12
		LEFT	17.020	2.809	8	23.600
Vidian canal to palate-sphenoidal canal	MALE	RIGHT	6.718	1.515	4.180	9.480
		LEFT	7.253	2.159	3.120	11.640
	FEMALE	RIGHT	6.227	1.313	3.300	8.950
		LEFT	6.893	1.929	2.910	12.710
Vidian canal to superior wall of sphenoid sinus	MALE	RIGHT	25.503	3.157	17.330	33.110
		LEFT	25.084	3.153	17.710	33.960
	FEMALE	RIGHT	22.823	2.530	14.930	29.730
		LEFT	22.705	2.892	12.520	28.910

However, they restricted themselves to descriptive statistics and did not compare between gender and sides [3, 10, 13, 15]. Hence, further studies are needed to compare the genders and bilateral variance.

VC to Midsagittal Plane

The midsagittal plane is a vertical plane that divides the body into right and left halves.

In this study, the mean distance between the VC and midsagittal plane found to be between 8-20 mm showed a p-value less than 0.01, which is statistically significant among genders; however, on comparing the sides, the mean distance showed a p-value less than 0.01, which is statistically significant only on the right side. Osawa et. al. detected the mean distance between the VC and the mid-sagittal plane in a dry skull as 9.0–13.5 mm [16]. The distance measured is comparable to the current study. However, they carried out only descriptive statistics and did not opine on gender or side differences. Interestingly, Cheng et. al. and Vuksanovic-Bozaric et. al. found this distance to be statistically insignificant among genders as well as with sides [17, 18]**.** This could possibly be explained by the difference in ethnic variation.

VC and Palato-sphenoidal Canal:

Despite the existence of various endoscopic anatomical studies describing the pterygopalatine fossa and the VC, the palato-sphenoidal canal, a bony tunnel has remained overlooked endoscopically due to its small size and location. Our study showed that the difference in the mean distance between the VC and the palato-sphenoi-

TABLE 2: T TEST ANALYSIS

PARAMETERS	SIDE	T VALUE (GENDER)	P VALUE	T VALUE (SIDE)	P VALUE
Vidian canal to vomerine crest	RIGHT	0.098	0.922	-1.820	0.074
	LEFT			-2.726	0.008
Vidian canal to foramen rotundum	RIGHT	-0.863	0.392	-7.307	**<0.001**
	LEFT			-7.106	**<0.001**
Vidian canal to midsagittal plane	RIGHT	-6.432	**<0.001**	-11.779	**<0.001**
	LEFT			1.339	0.186
Vidian canal to palate-sphenoidal canal	RIGHT	-2.541	0.014	-1.341	0.185
	LEFT			-0.680	0.499
Vidian canal to superior wall of sphenoid sinus	RIGHT	1.614	0.112	-3.628	**<0.001**
	LEFT			-3.046	0.003

dal canal was statistically insignificant among genders and sides. Herzallah et al. found that the mean distance from the PSC to the VC was 3.78 mm [19]. This distance is comparatively less than the distance obtained in the current study of 6.2 mm. This can be explained as our study used CBCT in place of CT and also because CT slices were relatively thick (2 mm), cuts may have passed the proximal portion of the canal and thus measured the distance between the middle portions of the PC and VC. This warrants further studies to strengthen the evidence for the distance range.

VC and Superior wall of Sphenoid Sinus

The superior wall of the sphenoid sinus is important as it relates to structures like the internal carotid artery and the optic nerve. In this study, the mean distance between the VC and the superior wall of the sphenoid sinus was insignificant among genders. However, the mean distance is statistically significant on the right side. Similar to the current study; Bidarkotimath and Yazar et al. found that the average distance between the VC and superior wall of the sphenoid sinus was 12-28mm, with no statistically significant difference among genders or between sides [10, 12]. Contrarily, Bahsi et al. found statistically significant differences among genders but not statistically significant differences among sides [8]. The differences between the current study and the research conducted by Bidarkotimath, Yazar, and Bahsi et al. can be explained by the differences in sample size, ethnicity, and the equipment used [8, 10, 12].

VC and Medial Pterygoid Plate

The medial pterygoid plate, also known as the medial pterygoid lamina, is a horse-shoe-shaped process that arises from the sphenoid bone. To obtain the best possible exposure of the pterygoid plates during surgeries, it is necessary to ligate the descending palatine artery and sacrifice the greater palatine nerve, which results in anesthesia of the ipsilateral hard palate. However, this impairment is largely tolerated by the patients [6]. Adding to that, Prevedello et al.'s study said that drilling the pterygoid process can be accomplished without disrupting the Vidian nerve [11]. This study observed that the association between the VC and medial pterygoid plate of type A reveals 89.4%, type B shows 7.3% and type C shows 3.3%. These observations are consistent with Yeh and Wu, who reported that the VC was on the medial or the same line in 520 (98.1%) cases and on the lateral in 10 (1.9%) cases, according to the medial plate of the pterygoid process [3]. Our results are also in accordance with Mato et al., who identified 90.9% as medial, 8.7% on the same line and 0.4% lateral of the medial plate of the pterygoid process on the right side and 86.1% as medial, 12.1% on the same line and 1.7% as being lateral of the medial plate of the pterygoid process on the left side [20] (Figure 3a).

Pneumatization of VC in Sphenoid Sinus (SS)

The SS is rarely symmetrical due to the existence of intra-sinus septa and may show varying degrees and directions of pneumatization. In accordance with our study, Liu et al. found type 1 in 53.4%, type 2 in 34.2% and type 3 in 12.5% [21]. Also, concurrent with the current study, Bahsi et al. observed similar findings with type 3, followed by type 1 and type 2 [8]. Though there is some amount of disparity, which may be due to the variations in the population and the differences in the study design (Figure 3b).

The disorders related to the Vidian nerve are believed to be: rhinitis, epiphora, crocodile tears, cranial and cluster headaches, and corneal ulcerations [13]. One of the most common disorders of the VN is known as Vidian neuralgia. This condition is characterized by severe facial pain that is often described as a burning or stabbing sensation. The pain is typically felt on one side of the face and can be triggered by a variety of factors, including chewing, talking, or even touching the face [22]. Another disorder of the VN is known as Vidian neuropathy, which is characterized by a loss of sensation in the face, nose, and throat, as well as a loss of muscle control in the affected areas. This may be caused by a variety of underlying conditions, including infection, inflammation, or nerve damage [23].

Damage to the Vidian nerve is seldom the cause of dry eye, but when it happens, it can lead to keratitis. Corneal desiccation, reduced lacrimation, and a dry nose can also be symptoms of Vidian nerve dysfunction. Other pathologies in the Vidian canal are schwannomas, which are a very uncommon form of cerebral tumor that appear in different ways. Vidian schwannomas can induce headaches, discomfort in the face, paresthesia, facial muscle paralysis, and compression of adjacent tissues or expansion into surrounding regions [24].

Conclusion

The Vidian canal is a crucial part of the base of the skull that supplies the head and neck region, which also provides sensory innervation for the nose and palate. This study employed CBCT because it is associated with a low radiation dosage that reduces the harmful effects of radiation, even though many researchers have used CT to analyze the VC and its anatomic relationships. It is necessary to conduct randomized controlled trials comparing CT and CBCT images. In this study, various parameters were examined, such as VC to FR, VC to the right midsagittal plane, and VC to the right superior wall of the sphenoid sinus, which were all statistically significant, when comparing the right and left sides. Only the VC to midsagittal plane showed a statistically significant difference among genders. However, the paucity of studies in the literature indicates that further study has been recommended in order to conclude. To overcome that, a large sample size is advisable because of the variation in different ethnicities. **R**

Funding
This project did not receive any specific funding.
Acknowledgements
Not Applicable

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