Assessment of Vidian canal morphology in axial section and its associated structures using cone beam computed tomography: A descriptive study

Eswari Solayappan, Karthikeya Patil, Sanjay C J, Varusha Sharon Christopher

Department of Oral Medicine and Radiology, JSS Dental College and Hospital, JSS Academy of Higher Education and Research, Mysuru - 570015 Karnataka, India

SUMMARY

The Vidian Nerve (VN), a branch of the trigeminal nerve, passes by the Vidian Canal (VC), located at the base of the skull. The VC branches into the greater petrosal nerve and the VN in the pterygopalatine fossa, where the greater petrosal nerve carries parasympathetic fibers to the lacrimal glands and nasal mucosa, and the VN carries sensory fibers from the nasopharynx, nasal cavity, and palate. In this study, 60 subjects of both sexes who underwent cone beam computed tomography (CBCT) were selected by a convenient sampling technique. The data were subjected to statistical analysis following the examination of the various parameters in the axial sections. Among the various morphological characteristics appraised in the axial section, there was no significant sexual dimorphism, except for the angle between the VC and the medial wall of the maxillary sinus, which shows statistical significance. The present study aims to investigate morphometric analysis and its associated structures, offering insightful information about the complex structure of the Vidian canal (VC), which provides adequate knowledge for surgeons to plan with more caution complex skull base procedures, and eventually to lower the therapeutical risks associated with it.

Key words: Vidian canal – Axial section – Cone Beam Computed Tomography – Anatomy – Endoscopic endonasal surgery

INTRODUCTION

The inferior part of the skull that provides structural and functional support for the brain is referred to as the base of the skull, or cranial base. Because it protects important components like the brain, spinal cord, primary blood vessels, and cranial nerves, it acquires its utmost significance. These complex structures arise from certain foramina, or apertures. These foramina are essential for supporting many bodily processes, including sensory perception and muscular control (Rengasamy et al., 2021).

Corresponding author:
Dr. Karthikeya Patil. Department of Oral Medicine and Radiology, JSS Dental College and Hospital, JSS Academy of Higher Education and Research, Mysuru - 570015 Karnataka, India. Phone: +91 94498 22498. E-mail: dr.karthikeyapatil@jssuni.edu.in - ORCID: 0000-0002-7941-2467

Submitted: April 18, 2024. **Accepted:** May 5, 2024

https://doi.org/10.52083/VATZ4874

The Vidian canal, also known as the Pterygoid canal (PC), acts as a vital anatomical feature located at the base of the skull. The Vidian nerve and artery, which are essential components of the cranial nerve system, pass via this canal. Furthermore, it is crucial for supplying blood to different parts of the head and face regions. The identification and delineation of anatomical features to facilitate diagnosis and treatment is a fundamental goal of radiological imaging. Since computed tomography (CT) is the best method for defining the skeletal structure, it is frequently used in conjunction with magnetic resonance imaging (MRI) (Chong et al., 2004). However, because of the resolution impairment, preoperative CT is essential for assessing the connection between the VC and surrounding structures, such as the sphenoid sinus (Yeh et al., 2013). Because of its exceptional spatial resolution, Cone Beam Computed Tomography (CBCT) is one modality that has been increasing recently. It is an example of the manner in which technical developments like three-dimensional imaging continue to improve the accuracy in analyzing skull morphology (Kau et al., 2009).

By utilizing CT and MRI, several researchers have assessed different characteristics of the Vidian canal and its components. However, a review of scientific literature found that limited research has been undertaken to investigate the VC by utilizing CBCT. Therefore, the purpose of the study was to evaluate and compare the Vidian canal based on age and gender, in addition to analyzing the anatomical composition and morphometric proportions of the canal in 3D axial section using CBCT.

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 CBCT was estimated, and samples were retrieved from the archives between April 2022 and April 2023, following the eligibility criteria. All volumetric images were made using Planmeca ProMax 3D Mid with large and medium view modes.

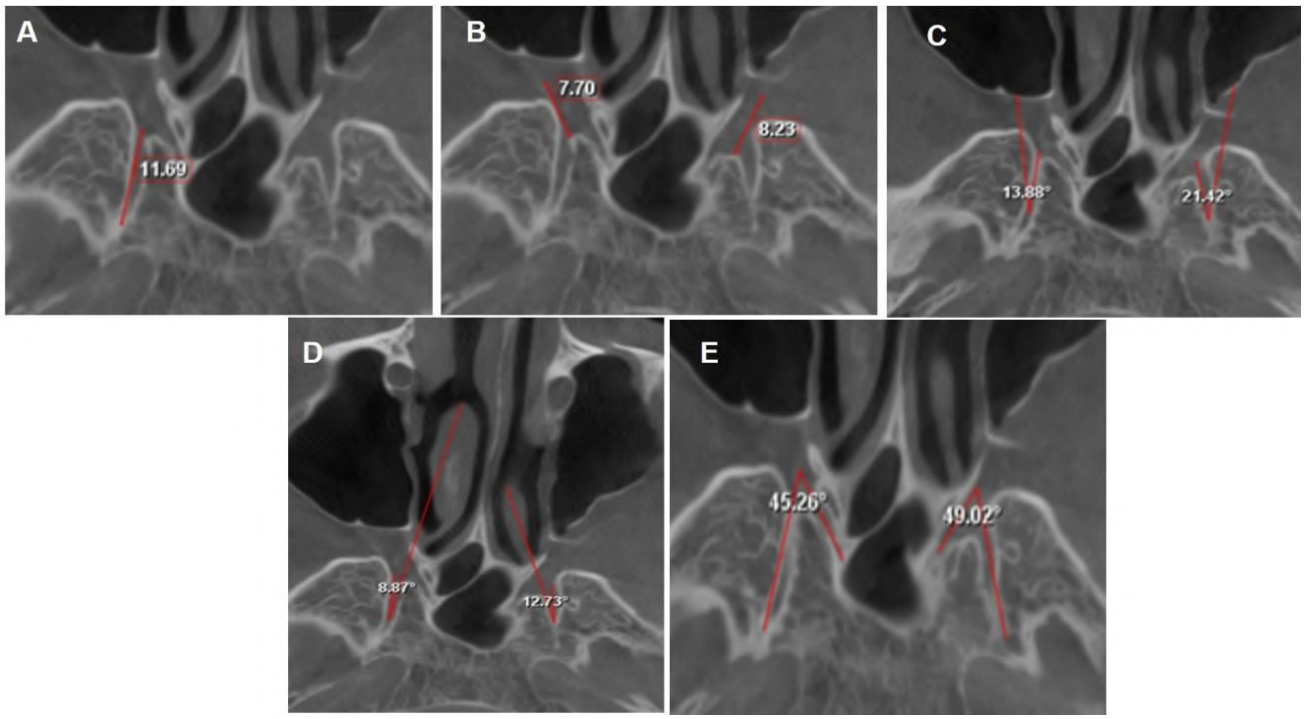

Fig. 1.- A: depicting length of VC. **B**: depicts VC to PPF. **C**: depicts angle between VC and medial wall of maxillary sinus. **D**: depicts angle between VC ad middle turbinate. E: depicts angle between VC and Palato-sphenoidal canal.

Inclusion Criteria

- CBCT images of male and female subjects between the age group of 11-70 years.
- Ideal CBCT images with optimum diagnostic quality.
- CBCT images that clearly show the base of the skull, especially the VC.
- Images that were made for the assessment of oral and maxillofacial trauma/ pathology not involving the base of the skull.

Exclusion Criteria

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

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

Length of VC: the VC appears as a tunnel-shaped radiolucent area in the lateral wall of the sphenoid sinus, and the length is measured from anterior opening to another end of VC (Fig. 1a).

VC to Pterygopalatine Fossa (PPF) length: a small space located behind the maxillary sinus and medial to the infratemporal fossa (Fig. 1b).

Angle between VC and medial wall of maxillary sinus: a line from the midpoint of the VC to the midpoint of the medial wall of the maxillary sinus; it measures the angle formed by the intersection of these two lines (Fig. 1c).

Table 1. Axial section parameters - descriptive statistics.

PARAMETERS	GENDER	SIDE	MEAN	STANDARD DEVIATION	MINIMUM	MAXIMUM
Length of vidian canal	MALE	RIGHT	13.388	2.575	8.880	18.820
		LEFT	12.875	2.491	8.040	17.270
	FEMALE	RIGHT	12.850	2.774	5.230	18.400
		LEFT	12.560	2.715	4.670	17.760
Vidian canal to pterygopalatine fossa	MALE	RIGHT	9.620	1.780	6	12.500
		LEFT	9.806	2.449	5.570	19.680
	FEMALE	RIGHT	8.525	2.130	3.600	12.350
		LEFT	8.867	2.432	4.800	15.760
Angle between vidian canal and medial wall of maxillary sinus	MALE	RIGHT	25.567	1.888	20.540	28.970
		LEFT	25.213	2.228	18.600	28.900
	FEMALE	RIGHT	21.030	3.007	12.140	25.110
		LEFT	20.879	4.796	12.080	30.400
Angle between vidian canal and middle turbinate	MALE	RIGHT	11.011	3.848	3.560	22.110
		LEFT	11.925	6.599	1.830	39.900
	FEMALE	RIGHT	9.628	3.956	4.030	22.060
		LEFT	9.648	3.758	1.610	18.690
Angle between vidian canal and palato-sphenoidal canal	MALE	RIGHT	51.521	11.791	15.260	68.010
		LEFT	50.061	11.609	23.170	72.930
	FEMALE	RIGHT	44.856	13.445	23.540	87.430
		LEFT	48.562	15.122	26.960	98.160

Angle between VC and middle turbinate: the middle meatus is a space in the nasal cavity that is located between the middle and inferior nasal turbinates. By locating the VC, the angle formed by the intersection of these two lines was measured (Fig. 1d).

Angle between VC and palato-sphenoidal canal (PSC): the PSC appears as a tunnel-shaped radiolucency in the axial section medial to the VC. It is located posteriorly to the maxillary sinus and anteriorly to the foramen lacerum. The angle is measured by drawing a line along the axes of VC and PSC (Fig. 1e).

Statistical analysis

The demographic data were 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 below 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. They belonged within the age range of 11 to 70 years. The mean, standard deviation, and standard error mean were estimated with descriptive statistics depicted in Table 1.

Paired sample t test was done to evaluate any morphometric difference in the bilateral aspect for all the parameters. However, only the distance from VC to the medial wall of the maxillary sinus showed statistically significant differences among them, whereas length of VC, VC to PPF, the ngle between VC to middle turbinate, and the angle between VC and PSC were not statistically significant.

Independent t test was conducted to check whether the morphometrics show any dimorphic characters between genders. It was concluded that none of the parameters were statistically significant, like the length of VC, VC to PPF, the angle between VC and the medial wall of the maxillary sinus, angle between VC and the middle turbinate, and the angle between VC and PSC (Table 2).

DISCUSSION

Early nineteenth century anatomist Johann Nepomuk Vidian has been credited with identifying VC. The Vidian nerve (VN), a branch of the posterior lateral nasal nerve that transports sensory and parasympathetic fibers, is one of the anatomical components that passes via the VC. The innervation of the pharynx, the lacrimal gland, and the nasal cavity is significantly influenced by the VN. The pterygopalatine fossa is where the VN departs after coursing through the VC in the base of the skull. The fossa is the source of the branches that supply sensory innervation to the nasal

Table 2. t Test analysis.

PARAMETERS	SIDE	T VALUE (GENDER)	P VALUE	T VALUE (SIDE)	P VALUE
Length of vidian canal	RIGHT	1.630	0.108	-0.779	0.439
	LEFT			-0.469	0.641
Vidian canal to pterygopalatine fossa	RIGHT	-0.934	0.354	-2.160	0.035
	LEFT			-1.491	0.141
Angle between vidian canal and medial wall of maxillary sinus	RIGHT	0.652	0.517	-6.998	**<0.001**
	LEFT			-4.489	**<0.001**
Angle between vidian canal and middle turbinate	RIGHT	-0.826	0.412	-1.373	0.175
	LEFT			-1.642	0.106
Angle between vidian canal and palato-sphenoidal canal	RIGHT	-0.773	0.443	-2.042	0.046
	LEFT			-0.431	0.668

cavity through the sphenopalatine ganglion and the pharyngeal plexus, which supplies sensory innervation to the pharynx. Moreover, the VC is traversed by the Vidian artery, a branch of the pterygopalatine portion of the maxillary artery, and the vein goes through the canal (Nturibi et al., 2022).

By analyzing the associated structures, it is beneficial for preoperative risk assessment, intraoperative navigation, and postoperative care to comprehend the link between the neighboring structures of VC and their structural modification. Since the VC is a key structure for accurately recognizing the petrous part of the internal carotid artery, it acts as a marker for the identification and protection of the VN during endoscopic endonasal approaches (EEA) in skull base surgeries (Pinheiro-Neto et al., 2012). Internal carotid artery (ICA) was superior to VC in most cases, and certain metrics showed association between the VC and its surrounding components (Gong et al., 2023).

Length of VC

The length of the VC is one important element that determines the depth of the bone that has to be penetrated during endonasal surgery. In the current study, the average VC length showed no statistically significant difference between gender and side. This is in line with the observation made by Bahşi et al. (2019), which revealed that there was no discernible statistically significant gender or side difference in the mean VC length. The average length of VC in male and female patients was 14.00±3.35 mm and 12.51±3.42 mm, respectively, according to Gong et al., which is consistent with the findings of Vuksanovic-Bozaric et al. and Wang et al., which show statistical differences among genders (Gong et al., 2023, Vuksanovic-Bozaric et al., 2019, Wang et al., 2014)**.** This gender difference is not consistent with our study, which can be attributed to the ethnic differences among the study population.

VC and pterygopalatine fossa

The anterior opening of the VC can only be reached by opening the Pterygopalatine fossa during an EEA. Hence, the distance between the VC and the pterygopalatine fossa is crucial. In this study, there was no statistically significant difference in the mean PPF length between the genders or between sides. This impression is consistent with the study conducted by Kurt et al., who reported that there was no significant gender difference in the mean PPF length, which was 9.32 ± 1.96 mm on the left and 9.29 ± 1.81 mm on the right (Bahşi et al., 2019). The PPF length from VC varied from 6.7 to 7.1 mm on both sides (Kassam et al., 2008, Mato et al., 2015). The average distance from VC to PPF was 6.7 mm on the right and 6.7 mm on the left with no statistical difference between gender and side (Mato et al., 2015).

Angle between Vidian canal and maxillary sinus

In order to minimize hazards and unify surgery for the maxillary sinus region, it is important to determine and evaluate the angle formed by the VC and maxillary sinus. The current investigation shows statistical significance while comparing the right and left sides. However, there was no statistically significant gender difference. This finding of no gender difference agrees with the study by Gong et al., who documented the relative connection for the first time, which was not statistically significant either by gender or side. More studies with a larger sample among various ethnic groups are essential for establishing the fact of differences in side among the same individual (Gong et al., 2023).

Angle between VC and middle turbinate

The angle between VC and middle turbinate serves as an important anatomical landmark in various surgical procedures, particularly in EEA. An abnormally prominent or hypertrophic turbinate may jeopardize the outcome of operation during EEA. Though males show higher angle when comparing to females statistically, there was absolutely no dissimilarity either gender or side. A coronal CT analysis found that the surgeries were successful with 30.2 ± 4.9 and 26.4 ± 9.1°, 33.8 ± 4.8 and 44.3 ± 8.1° for the unsuccessful. A smaller angle between them improves the success probability of the surgeries (Acar et al., 2019). Our study shows the lesser angle, which indicates the successful surgeries if needed.

Angle between VC and palato-sphenoidal canal

The sphenoid process of the palatine bone and vaginal process of the sphenoid bone combine to produce the palato-sphenoidal canal hence it is also known as palato-vaginal canal or palato-sphenoidal canal, a bony tube that connects the nasopharynx to the pterygopalatine fossa through which the palato-vaginal or pharyngeal artery and pharyngeal nerve passes through it. The palato-vaginal canal acts as an important anatomical indicator used as a reference point during endoscopic surgery to laterally identify the pterygoid canal, or VC. A thorough understanding of radiologic anatomy and this angle is crucial to identify the angle formed between VC and PSC (Pinheiro-Neto et al., 2012; Bidarkotimath et al., 2012)**.** The current study revealed that males have a higher angle compared to females, although there was no statistically significant difference between gender or side. The average mean angle of VC and palato-vaginal canal angle is 48º and indicated that there was no statistically significant variation between genders or sides. This is in accordance with the results obtained in this study (Pinheiro-Neto et al., 2012).

The following conditions are thought to be associated with the Vidian nerve: crocodile tears, rhinitis, epiphora, cluster and cranial headaches, and corneal ulcerations (Herzallah et al., 2012). Vidian neuralgia is one of the most prevalent VN diseases. Severe facial discomfort, frequently characterized as a crushing or stabbing sensation, is the hallmark of this condition. A number of issues, such as chewing, talking, or even touching the face, can cause the pain, which is usually localized on one side of the face (Yamasaki et al., 2015). Another VN disorder is called Vidian neuropathy, and it can be brought on by a number of underlying conditions, such as infection, inflammation, or nerve damage. It 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 (Wood et al., 2000).

Although damage to the Vidian nerve is rarely the cause of dry eye, when it does occur, keratitis may result. Vidian nerve dysfunction can manifest as dry nose, decreased lacrimation, and corneal desiccation. Another type of pathology found in the Vidian canal are schwannomas, which are a rare type of brain tumor that manifest in various ways. Headaches, facial pain and paresthesia, facial muscle paralysis, and the compression of surrounding tissues or their expansion into other areas are all possible symptoms of Vidian schwannomas (Yamasaki et al., 2015).

Early in the 1960s, Golding-Wood created the Vidian neurectomy technique to treat nasal polyposis, persistent vasomotor rhinitis, and allergic rhinitis (Wood et al., 2000). Before endoscopic sinus surgery became popular, there were a number of established techniques for entering the VN. Hsu et al. (2013) stated that these techniques still carry a considerable risk of postoperative morbidity, which includes catastrophic hemorrhage, oronasal or oroantral fistula, and vision loss.

CONCLUSION

The Vidian canal, which supplies the head and neck region and serves as sensory innervation for the palate and nose, is an essential component of the base of the skull. Although many studies have utilized CT to evaluate the VC and its anatomic associations, this study used CBCT, since it is coupled with a low radiation exposure that lowers the adverse effects of radiation. Randomized controlled trials comparing CT and CBCT images must be carried out. In this investigation, only the VC to maxillary sinus exhibited a statistically significant difference between the sides. This is the second study to evaluate the angle between the VC and the medial wall of MS in scientific literature. To get at the conclusion, further investigation with larger sample size has been advised, nonetheless, given lack of studies in the literature.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The Institutional Ethics Committee authorized the work as a descriptive retrospective study after it was proffered to them. Only subjects' respective masked radiographs were evaluated from the archives maintained in the department; no patients participated actively in the study. Hence, patient consent is not applicable for the study.

REFERENCES

AÇAR G, ÇIÇEKCIBAŞI AE, ÇUKUROVA İ, ÖZEN KE, ŞEKER M, GÜLER İ (2019) The anatomic analysis of the vidian canal and the surrounding structures concerning vidian neurectomy using computed tomography scans. *Braz J Otorhinolaryngol*, 85(2): 136-143.

BAHŞI İ, ORHAN M, KERVANCIOĞLU P (2019) The anatomical and radiological evaluation of the Vidian canal on cone-beam computed tomography images. *Eur Arch Otorhinolaryngol,* 276: 1373-1383.

BIDARKOTIMATH S, VIVEKA S, UDYAVAR A (2012) Vidian canal radiological anatomy and functional correlations. *J Morphol Sci*, 29(1): 27-31.

CHONG V, KHOO J, FAN YF (2004) Imaging of the nasopharynx and skull base. *Neuroimag Clin N Am*, 14(4): 695-719.

GONG W, CAO W, ZHANG W, XIANG R, XU Y (2023) Imaging anatomy of the vidian canal and its clinical significance. *Quant Imaging Med Surg*, 13(12): 8704-8728.

HERZALLAH IR, AMIN S, EL-HARIRI MA, CASIANO RR (2012) Endoscopic identification of the pharyngeal (palatovaginal) canal: an overlooked area. *J Neurol Surg Part B Skull base,* 73(5): 352-357.

HSU C-Y, SHEN P-H, WEITZEL EK (2013) Endoscopic vidian neurectomy assisted by power instrumentation and coblation. *J Chin Med Assoc*, 76(9): 517-520.

KASSAM AB, VESCAN AD, CARRAU RL, PREVEDELLO DM, GARDNER P, MINTZ AH, SNYDERMAN CH, RHOTON AL (2008) Expanded endonasal approach: vidian canal as a landmark to the petrous internal carotid artery. *J Neurosurg*, 108(1): 177-183.

KAU CH, BOZIC M, ENGLISH J, LEE R, BUSSA H, ELLIS RK (2009) Cone-beam computed tomography of the maxillofacial region: an update. *Int J Med Robot*, 5(4): 366-380.

MATO D, YOKOTA H, HIRONO S, MARTINO J, SAEKI N (2015) The vidian canal: radiological features in Japanese population and clinical implications. *Neurol Med Chir (Tokyo)*, 55(1): 71-76.

NTURIBI E, BORDONI B (2022) Anatomy, Head and Neck: Greater petrosal nerve. In: *StatPearls*. StatPearls Publishing.

PINHEIRO-NETO CD, FERNANDEZ-MIRANDA JC, RIVERA-SERRANO CM, PALUZZI A, SNYDERMAN CH, GARDNER PA, SENNES LU (2012) Endoscopic anatomy of the palatovaginal canal (palatosphenoidal canal): a landmark for dissection of the vidian nerve during endonasal transpterygoid approaches. *Laryngoscope*, 122: 6-12.

RENGASAMY VENUGOPALAN S, VAN OTTERLOO E (2021) The Skull's Girder: a brief review of the cranial base. *J Dev Biol*, 9(1): 3.

VUKSANOVIC-BOZARIC A, VUKCEVIC B, ABRAMOVIC M, VUKCEVIC N, POPOVIC N, RADUNOVIC M (2019) The pterygopalatine fossa: morphometric CT study with clinical implications. *Surg Radiol Anat*, 41(2): 161-168.

WOOD B, RICHMOND BG (2000) Human evolution: taxonomy and paleobiology. *J Anat*, 197: 19-60.

YAMASAKI A, SEDAGHAT AR, LIN GC, CURRY WT, SHIH HA, GRAY ST (2015) A rare finding of schwannoma of the vidian canal: a case report. *J Neurol Surg Rep*, 76(1): e48-e51.

YEH IK, WU IS (2013) Computed tomography evaluation of the sphenoid sinus and the vidian canal. *B-ENT*, 9(2): 117-121.