



Morphometric Assessment of Optic Canal: A Comparative Study Between Dry human Skull and Computed Tomography with its Clinical Implications

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ABSTRACT

Objective – The main objective of this research is to study the morphometry of the optic canal and the surrounding bony structures in adult human dry skulls and compare it with the parameters obtained from computer tomography (CT) scan.

Methodology –The optic canal of 90 adult dry skull were examined by digital vernier caliper and 110 CT scans were observed by thin layer CT scan images in coronal and axial plane using high resolution matrix and bone algorithm. 3D reconstruction images were also used. The height, width and length of medial wall and lateral wall of the optic canal were measured. The distance between optic canal and apex of petrous part of temporal bone, distance between optic canal from midline, distance between optic canal and tip of anterior clinoid process, and distance between both optic canals were also calculated. The data was tabulated and analysed statistically.

Result – The mean height of optic canal (OC) in CT and dry skull was 3.96 ± 1.35 mm and 4.90 ± 1.04 mm respectively. The mean width in CT and dry skull was 3.97 ± 1.45 mm and 4.30 ± 0.93 mm. The mean length of medial wall and lateral wall in CT and dry skull was 9.10 ± 2.01 mm, 8.10 ± 1.93 mm and 5.89 ± 1.39 mm, 4.41 ± 1.35 mm respectively. The mean distance of OC to the apex of petrous temporal bone in CT and dry skull was 24.73 ± 2.98 mm and 24.64 ± 2.88 mm whereas the mean distance

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between both the OC in CT and dry skull was 14.45 ± 2.69 mm and 16.70 ± 1.90 mm respectively. The mean distance of OC to the apex of anterior clinoid process in CT and dry skull was 10.14 ± 1.86 mm and 9.25 ± 1.85 mm and the mean distance of optic canal from midline in CT and dry skull was 7.22 ± 1.35 mm and 6.39 ± 1.11 mm respectively.

Conclusion – We found significant difference in morphometric parameters between the optic canal and the surrounding parasellar region in dry skulls and CT scans. It will help neurosurgeons in their clinical practice

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INTRODUCTION

Optic canal is the opening or foramina which connects middle cranial fossa to the orbit¹. The detail knowledge of the morphometry of optic canal and its surrounding bony landmarks are very important in diagnosis/management of pathological condition in the parasellar region or middle cranial fossa through imaging techniques². With the advancement of technology, the imaging techniques also become so advanced that it become easy to diagnose any abnormality or alterations in the normal anatomy in any part of the body due to pathology or trauma^{2,3}.

The optic canal is present in between the anterior and posterior root of the greater wing of sphenoid bone and it gives passage to optic nerve with meninges, ophthalmic artery and branches of periarterial sympathetic plexus⁴. Any trauma in the region of optic canal or visual pathway led to visual defect. Knowledge of neuro-arterial relation, gross feature and normal morphometry of parasellar region and optic canal are of immense important for the surgeons treating the vascular lesions in this area⁵. Orbital apex disorder, tumor surrounding the greater and lesser wing of sphenoid and in the posterior part of orbit such as angioma, malignant tumor, meningioma, neuroma, pneumosinus can be operated at optic canal, posterior part of orbit or the superior orbital fissure^{6,7,8}.

Optic canal and the associated osseous structures like anterior clinoid process (ACP), optic strut (OS) and the petrous temporal bone are the important anatomical structures due to their central locations and critical

function, which are often included in the neurosurgical operations⁹.

It is of immense important for the radiologist, anatomist, neurosurgeons and ophthalmologist to know the normal anatomy of cranial fossa and the variation in the position of cranial foramina for better diagnosis².

Even though the success of CT in diagnosing bony lesions is unquestionable, majority of authors have not mentioned the correlation between the findings of CT with the actual anatomical bony structures. In the present study, the morphometric parameters of optic canal (height, width, length of medial wall, length of lateral wall) and the distance between optic canal and the associated bony structures like anterior clinoid process, petrous temporal bone are evaluated in CT and dry skull. Parameters of optic canal in male and female CT scan are also evaluated and compared. An attempt has made to observe the normal anatomy of optic canal and associated osseous structures by comparing the findings of CT and actual dry skull.

MATERIAL AND METHODS

The present study was conducted on normal CT scan of head region of 110 patients (63 male and 47 female) between the age group of 20-50 years and 90 adult dry skulls during Feb 2021-March 2022 among North Indian Population. Ethical clearance was taken from the Institutional ethical committee (F.No. SU/2021/092[27]).

The CT scan sections of the skull were taken by 64 slice CT scanner (Phillips Brilliance 64). The sections were 0.5-1mm thin taken in axial plane parallel to infraorbitomeatal line. The

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coronal plane was perpendicular to axial plane. High resolution matrix and bone algorithm were used for multiplanar CT and 3D reconstruction were also done.

A total of 196 CT scan of head and paranasal sinuses were reviewed retrospectively from the department of Radiology, G.S. Medical College and Hospital, out of which 83 were excluded due to fracture and abnormality in middle cranial fossa, and 3 were excluded due to internal carotid artery calcification.

The height and width of optic canal were measured using coronal reconstructed images (fig-1a) and medial and lateral wall diameter were measured using axial reconstructed images (fig-1b) using bone algorithm. The distance between the optic canal to apex of petrous temporal bone, distance of medial margin of optic canal from midline, distance between optic canal and tip of anterior clinoid process (ACP) and distance between both the optic canals were measured using 3D reconstructed images (fig- 1c).

Total 107 adult dry skulls of both the sexes were reviewed from department of Anatomy as well as the students of different medical colleges of North India, out of which 17 were excluded due to damage in parasellar region or in the middle cranial fossa and rest 90 skulls were analysed. The morphological features were observed. The morphometric

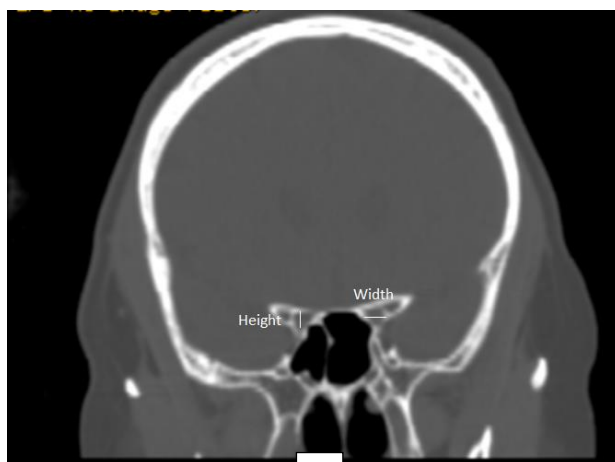
parameters were measured with the help of digital vernier calliper and 2 point divider. The following measurements were taken in adult human dry skulls (fig – 1d):

Optic canal (OC)

- **Height:** It is the maximum vertical distance of the optic canal.
- **Width:** the maximum transverse distance of the optic canal.
- **Length of medial wall**
- **Length of lateral wall**
- Distance between the medial margin of the cranial opening of optic canal and tip of anterior clinoid process (fig 1D).
- Distance between both the optic canal (medial margin of both optic canal)
- Distance between the medial margins of optic canal from the midline (mid sagittal plane).
- Distance between the optic canals (medial margin) to apex of petrous temporal bone.

The data were tabulated in excel sheet – mean and standard deviation of each parameter were calculated and comparison between two category data were done using t-test. The p-value of <0.05 was considered statistically significant.

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A



B

Parameters		Mean (mm)	SD (mm)	Range (mm)	P-value
Height	CT	3.96	1.35	1.7 – 7.1	<0.05
	Dry skull	4.90	1.04	2.5 – 7.1	
Width	CT	3.97	1.45	1.5 – 7.5	<0.05
	Dry skull	4.30	0.93	2.3 – 6.5	
Length of medial wall	CT	9.10	2.01	5.4 – 13.9	<0.05
	Dry skull	5.89	1.11	3.2 -9.7	
Length of lateral wall	CT	8.10	1.93	5.1 – 13.2	<0.05
	Dry skull	4.41	1.35	1.6 – 7.1	

C

D

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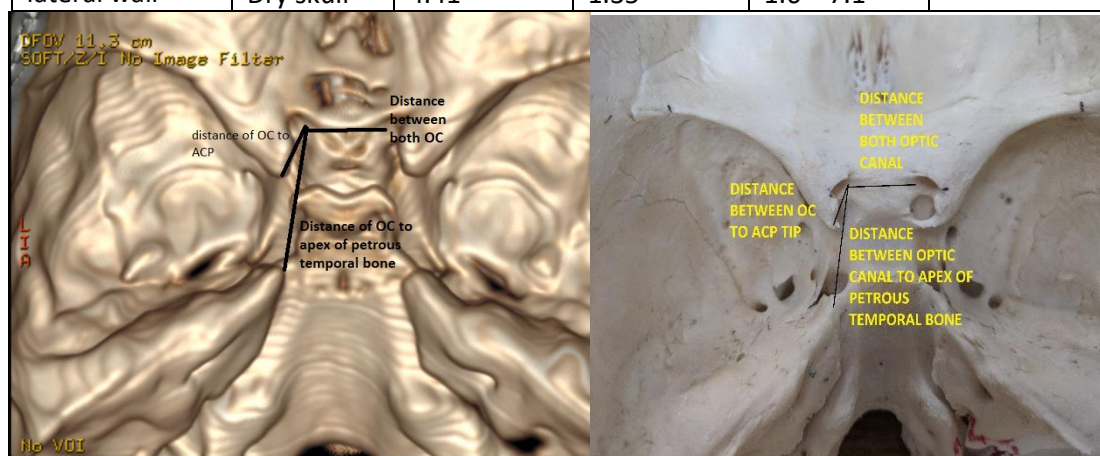


Fig – 1: Measurement of optic canal in CT scan – (A) coronal section (B) Axial Section (C) 3D reconstructed image (D) Measurements in dry skull

RESULT

CT – computed tomography SD – Standard deviation

Parameters		Mean (mm)	SD(mm)	Range (mm)	P-value
Distance between OC to apex of petrous temporal bone	CT	24.73	2.98	19.5 – 32.3	>0.05
	Dry skull	24.64	2.88	18.6 – 30.3	
Distance of OC from midline	CT	7.22	1.35	4.3 – 10.3	<0.05
	Dry skull	6.39	1.11	4.1 – 8.6	
Distance between OC to tip of ACP	CT	10.14	1.86	5.3 – 14.8	<0.05
	Dry skull	9.25	1.85	5.3 – 13.3	
Distance	CT	14.45	2.69	8.8 – 20.4	<0.05

between OC	both	Dry skull	16.70	1.90	12.5 – 20.1	
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CT – Computed tomography OC – Optic canal ACP – Anterior clinoid process
 SD – Standard deviation

Parameters			Mean	SD	Range	t-value	p-value
Height	Dry skull	Right	4.96	1.05	2.5 – 7.1	0.76	>0.05
		Left	4.84	1.02	2.7 – 6.8		
	CT	Right	4.03	1.42	1.7 – 7.1	0.69	>0.05
		Left	3.89	1.28	1.7 – 6.9		
Width	Dry skull	Right	4.37	0.92	2.3 – 6.5	1.07	>0.05
		Left	4.22	0.93	2.4 – 6.3		
	CT	Right	4.07	1.40	1.5 – 7.5	0.89	>0.05
		Left	3.87	1.49	1.4 – 7.2		
Length of medial wall	Dry skull	Right	5.96	1.33	3.2 – 8.5	0.64	>0.05
		Left	5.82	1.44	3.4 – 9.7		
	CT	Right	9.21	2.01	5.7 – 13.9	0.65	>0.05
		Left	9.01	2.02	5.4 – 14.1		
Length of lateral wall	Dry skull	Right	4.51	1.33	1.9 – 7.1	1.05	>0.05
		Left	4.30	1.37	1.6 – 7.1		
	CT	Right	8.20	1.91	4.9 – 13.4	0.66	>0.05
		Left	8.01	1.96	5.3 – 13.1		

CT – computed tomography SD – Standard deviation

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Parameters			Mean	SD	Range	t-value	p-value
Distance between OC to apex of petrous temporal bone	Dry skull	Right	24.72	2.94	18.6-30.3	0.38	>0.05
		Left	24.56	2.85	19.2-29.6		
	CT	Right	24.70	3.06	19.5-31.9	0.12	>0.05
		Left	24.75	2.92	19.9-32.3		
Distance of OC from midline	Dry skull	Right	6.43	1.07	4.1 - 8.4	0.46	>0.05
		Left	6.35	1.16	4.2 - 8.6		
	CT	Right	7.20	1.29	4.3 – 10.5	0.21	>0.05
		Left	7.25	1.42	4.5 – 10.1		
Distance between OC to tip of ACP	Dry skull	Right	9.42	1.77	5.8 – 12.7	1.23	>0.05
		Left	9.08	1.91	5.3 – 13.3		
	CT	Right	10.12	1.87	5.3 – 14.7	0.11	>0.05
		Left	10.16	1.87	5.6 – 14.8		

CT – Computed tomography OC – Optic canal ACP – Anterior clinoid process
 SD – Standard deviation

90 dry skull and 110 CT-scan (63 male 47 female) was analysed. A total of 180 optic canal in dry skull and 220 (126 male and 94

female) were examined. The mean, standard deviation (SD), and range of all the parameters of optic canal (OC) were



calculated and shown in table 1. The parameters for the distance between the optic canals from the associated osseous

The mean, SD and range of all the parameters of optic canal of right and left side are shown in table 3. There was no significant difference

Parameters		Mean(mm)	SD(mm)	Range(mm)	P-value
Height	Male	4.03	1.43	1.7 – 7.1	<0.05
	Female	3.79	1.56	1.9 – 6.7	
Width	Male	3.42	0.85	1.5 – 7.5	<0.05
	Female	3.16	0.91	1.5 – 6.9	
Length of medial wall	Male	9.38	1.79	5.4 – 13.9	<0.05
	Female	8.95	1.38	4.8 - 13.4	
Length of lateral wall	Male	8.75	2.05	5.1 – 13.2	<0.05
	Female	8.31	1.63	4.6 – 12.3	

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structures are shown in table 2.

Statistically significant differences were noted between the dry skull and CT in all the parameters of optic canal (height, width, medial wall, lateral wall) with $p < 0.05$ (table 1). It was observed that the mean distance between optic canal and the apex of petrous temporal bone was 24.73 ± 2.98 mm in CT and 24.64 ± 2.88 mm in dry skull and no significant difference noted between the dry skull and CT method with $P > 0.05$ (mention not needed) (table 2) whereas the other parameters like distance of the optic canal from midline, distance of optic canal from tip of anterior clinoid process and distance between both optic canal shows significant difference between the dry skull and CT ($P < 0.05$) shown in table 2.

noted in all the parameters measured between the right and left side of optic canal ($P > 0.05$). The mean, SD of the parameters of associated structures from optic canal are shown in table 4 and no statistical difference were noted between the right and left side in dry skull and CT study ($P > 0.05$).

In all the parameters of optic canal in male and female CT scan, the mean, standard deviation (SD), range and p-value was calculated and shown in table 5. We have noted statistically significant difference between the male and female optic canals parameters ($P < 0.05$). The males have higher mean of all the parameters of optic canal as compared to female.

CT – computed tomography SD – Standard deviation

Parameters	Kalthur et al. ⁵ (2015)		Berlis et al. ² (1992)		Present study (2021)	
	CT	Dry skull	CT	Dry skull	CT	Dry skull
Height (mm)	3.6	5.17	3.63	3.70	3.96	4.90
Width (mm)	4.59	5.48	7.64	6.25	3.97	4.30
Medial wall (mm)	10.63	9.1	-	-	9.10	5.89



Lateral wall (mm)	9.2	8.66	-	-	8.10	4.41
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DISCUSSION

The optic canal is an important foramen that connect orbit to the cranial cavity¹⁰ and gives passage to the optic nerve covered with meninges, ophthalmic artery with its sympathetic plexus^{11, 12, 13}. Medially the optic canal is bounded by body of sphenoid, laterally by the anterior clinoid process, superiorly and inferiorly by the anterior and posterior root (OS) of lesser wing of sphenoid⁴.

As the intracranial part of the optic nerve and ophthalmic artery are more susceptible to the injuries and various diseases⁵, the knowledge and understanding of the gross anatomical features of the optic canal and the surrounding osseous structures is necessary for proper diagnosis and prevention of the neurovascular structures during surgeries^{5, 6, 8}. We have compared the different parameters of optic canal in CT scan and dry skull. Our study result is in concurrence with the study done by Kalthur et al.,⁵ but our values is slightly lower than their values and we also found significant difference between the dry skull and CT methods as their study. Our study also concurred the study by Berlis et al.,² but our values for the height of optic canal is slightly higher and width of optic canal is slightly lower as compared to their study (table – 6).

Hart et al.⁸ had conducted a study of optic canal in CT scan and stated that the mean height and width of optic canal was 4.0mm and 6.7mm, and mean length of medial and lateral wall was 14.8mm and 10.5mm respectively which was higher than the values of our study. Zhang X et al.¹⁴ had studied CT scan of 335 patients and observed that the average canal length was 5.61±2.22mm which was much higher than our values.

Gosva et al.⁶ had conducted a study on dry skull (N=318) and found the mean height and width as 4.62mm and 4.70mm whereas the length of medial and lateral wall was 7.61mm

and 6.71mm. Orhan et al.¹⁵ had stated the average height and width of optic canal as 4.35mm and 6.48mm respectively whereas the length of medial and lateral wall was 9.8mm and 9.2mm respectively. Lang and Gehmann¹⁶ studied optic canal in dry skull and observed the average height and width as 3.7mm and 6.25mm whereas a study by Slavin et al.¹⁷ revealed the average height and width as 5.2mm and 5.38mm respectively. Our values of all the parameters are different from their values may be because of the different population.

Ajay K et al.¹⁰ had measured the mean height on left and right side as 3.85± 0.81mm and 5.82± 1.04mm whereas the mean width on left and right side was 3.85± 0.81mm and 3.74± 0.79mm, which is lower than the values of our study. They also measured the mean distance of optic canal to the apex of petrous temporal bone was 26.45±3.02mm on left side and 26.10±2.86mm on right side which is higher than the values of our study, but they also found no significant difference between the right and the left side as in our study.

Purohit and Singh¹⁸ had measured the mean transverse diameter on right side as 5.03±0.72mm whereas on the left side it was 5.02±0.76mm. The value are higher than our values. They also measured the distance between optic canal to the apex of petrous temporal bone and the average was 7.36±1.06mm on right side and 7.20±0.99mm on left side which is lower than the value of our study, and they also did not found any significant difference between the right and left side like our study.

Chou et al.¹⁹ had observed 18 optic canals in dry skull and found the average length of medial and lateral wall as 13.63mm and 8.75mm. Ozturk et al.²⁰ had studied 152 optic canals, the average length of medial and lateral wall was 10.7mm and 9.9mm on right side and 10.5mm and 10.1mm On left side respectively. Akdemir et al.²¹ observed 25 dry skull, the average width on right and left side

was 7.45mm and 7.38mm respectively. Abhinav et al.²² had found the length of optic canal on right and left side as 5.90mm and 6.20mm. Jiang et al.²³ stated the average length of medial and lateral wall was 12.04mm and 7.89mm on right side and 12.06mm and 7.90mm on left side. Our values are less than the values of the above studies and we have not found any significant difference between the right and left side.

Orhan Magden Kaynak¹⁵ had found the mean height of optic canal on right and left side was 4.35 ± 0.03 mm and 4.36 ± 0.03 mm whereas the mean width was 6.48 ± 0.6 mm on right side and 6.43 ± 0.6 mm on left side. The average medial wall length was 9.61 ± 1.6 mm on right side and 9.84 ± 1.8 mm on left side whereas the average lateral wall length was 9.2 ± 1.3 mm and 9.1 ± 1.3 mm on right and left side respectively. Govsa et al.⁵ measured the mean height of optic foramen as 4.7 ± 0.79 on right side and 4.55 ± 0.65 mm on left side whereas the average width as 4.91 ± 0.49 on right side and 4.71 ± 0.43 mm on left side. The average length of medial and lateral wall was 7.5 ± 1.5 mm and 6.48 ± 1.01 mm on right side whereas 7.72 ± 1.41 mm and 6.94 ± 1.84 on left side respectively. Radunovic et al.²⁴ had found the mean height and width of optic canal as 4.65mm and 4.90mm on right side and 4.55mm 4.85mm on left side, the average length of medial and lateral wall was 13.43mm and 8.36mm respectively. Our values concurred with their studies and we have also not found significant difference between the right and the left side as their studies.

Our study is in concurred with the study by Kalthur et al.⁵, but they have observed a significant difference between the right and left side and we have not found any significant difference both the sides of all the parameters of optic foramen.

Demartini Z Jr, Zanine SC²⁵ had found the average distance between the optic canals as 12.2mm which is lower than our findings.

Our study result of **CT scan** is in concurrence with the study done by Kalthur et al.⁵ as in their study the mean height of **optic canal** was 3.63 mm in male and 3.51 mm in female

whereas the mean width was 4.75 mm in male and 4.24mm in female. The average length of medial wall was 10.86mm in male and 10.11mm in female and that of lateral wall was 9.3mm in male and 8.8mm in female. Our values are slightly lower than their values but we have also found significant difference between the males and females as their study. The difference in the values may be because of population difference.

Hart et al.⁸ stated that the average height of optic canal was 4.1mm in male and 4.0mm in female ($P > 0.05$) whereas the average width was 7.1mm in male and 6.4 mm in female ($P > 0.05$). The mean length of medial wall was 16.1mm in male and 13.9 mm in female ($P < 0.001$) whereas that of lateral wall was 11.3mm in male and 10mm in female ($P < 0.001$). Our values are lower than their values, and we got significant difference between the average height and width of males and females. We also got significant difference between the mean length of lateral and medial wall of males and females as their study.

Most of the previous authors had only analysed the morphometric parameters of optic canal either in CT or in dry skull, but in our study we also measured the parameters of optic canal and the associated osseous structures around the optic canal and compared in CT as well as in dry skull which would be more reliable.

Knowledge of optic canal along with its neurovascular structures is of immense importance for surgeons while dealing with tumors such as meningiomas that have grown through bone, as removal of bony borders without exposing the neural structures is important while dealing with these tumors.^{5,10,26} Bones of the optic foramen is often removed while exposing the aneurysm and tumors in this region. While dealing with the superior hypophyseal and ophthalmic aneurysm, anterior clinoid process and lesser wing of sphenoid is often need to be removed.^{6,8}

So the detailed knowledge of the optic canal and the surrounding parasellar region is of

immense important for the Neurosurgeons while doing surgeries.

Conclusion

All neurosurgeons working on cranial base should carefully study the anatomical description of optic canal and the surrounding osseous structures in parasellar region, especially before performing surgery on meningioma and aneurysm in that area. We have found significant difference among sex groups in both dry skull and CT scan in all the parameters of optic canal and the surrounding parasellar region. A large range of variation exist in CT scan images of all parameters of optic canal. Our study will help neurosurgeons in their clinical practice.

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