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Original Article

Radiology Section

Assessment of Normal Intracranial Parameters of the Sellar Region in Healthy Subjects of South Indian Population: A Retrospective Study

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ABSTRACT

Introduction: There is a significant degree of anatomical variation at the level of the sphenoid sinus and sella turcica and a wide range of these values have been reported in literature and ethnic variation has also been found to contribute to this. Thus preoperative imaging of the central skull base with a knowledge of the normal anatomy and measurements in a specific population is imperative to identify these variations and prevent avoidable intraoperative complications.

Aim: To assess the normal intracranial measurements of the intercarotid distance, pituitary fossa width, optic chiasm height, optic chiasm width and the pituitary to optic chiasm distance in healthy subjects of the South Indian population aged between 10 to 80 years and to establish normal reference ranges across the various age groups.

Materials and Methods: This retrospective study was conducted in the Radiology Department at SRM Medical College Hospital and Research Centre, Chennai, Tamil Nadu, India, from July 2021 to December 2021. The study included normal Magnetic Resonance Imaging (MRI) brains of 700 healthy subjects (378 males and 322 females) in the age range of 10 to 80 years. Subjects were divided into seven groups of 100 subjects for each decade. The variables that were measured included the intercarotid distance, pituitary fossa width, optic chiasm height, optic chiasm width and the pituitary to optic chiasm distance. RStudio version 1.2.1093 was used for statistical analysis and p-value <0.05 was considered statistically significant. Association between age and outcome variables were assessed by Pearson's correlation coefficient at 95% confidence interval.

Results: The overall mean age was 45.4 years. The overall mean intercarotid distance was 16.2±3.7 mm, optic chiasm width was 13.1±1.6 mm, optic chiasm height was 2.18±2.7 mm, pituitary width was 12.1±2.3 mm, pituitary to optic chiasm distance was 5.7±1.84 mm. The overall pituitary fossa width and pituitary to optic chiasm distance was found to be higher in males (p-value <0.001; p-value=0.03, respectively) than females while there was no significant difference between genders in the rest of the parameters. A low and positive correlation was found between age and the pituitary width, age (r-value=0.175, p-value <0.001) and the pituitary to optic chiasm distance (r-value=0.342, p-value <0.001) and pituitary width and optic chiasm width (r-value=0.236, p-value <0.001). A strong and positive correlation was found between the pituitary width and the intercarotid distance (r-value=0.736, p-value <0.001).

Conclusion: Establishment of normal reference values across various age groups of the South Indian population may prove useful for future reference and improving diagnostic accuracy.

Keywords: Brain, Carotid artery, Magnetic resonance imaging, Measurement, Pituitary gland

INTRODUCTION

The endoscopic endonasal trans-sphenoidal approach to the central skull base is a minimally invasive surgical modality for treating pathologies of the sellar region with decreased postoperative complications and improved patient comfort [1]. A substantial degree of anatomical variation is known to exist at the level of the sphenoid sinus and sella turcica. The Internal Carotid Arteries (ICA), optic nerves, cavernous sinuses and surrounding cranial nerves are all vulnerable during this approach. Moreover, anatomical variations at this level have been reported with respect to gender and ethnicity and thus preoperative imaging is important to identify this [2,3]. The cavernous segment of the ICA is an important landmark during these procedures and injury to the ICA may contribute to patient mortality and morbidity [4]. The internal carotid arteries can be quite tortuous and the distance separating the medial margin of the internal carotid artery from the lateral surface of the pituitary gland has been reported to vary from 1 to 3 mm [5]. Preoperative imaging of the central skull base is thus important to recognise these anatomical variations [1].

The optic chiasm is also an important landmark for interpreting Magnetic Resonance Imaging (MRI) examinations of brain. A small or large chiasm can be an indicator of several disorders [4]. Gender and ethnic variation have also been found to affect the pituitary and optic nerve morphology [6]. These variables have not been described among the South Indian population. Hence, this study aimed to assess the normal intercarotid distance, pituitary fossa width, optic chiasm width, height and the pituitary to chiasm distance across various age groups in the South Indian population. A knowledge of these parameters will be important and useful for future reference and contribute to diagnosis.

MATERIALS AND METHODS

This retrospective study was conducted in the Radiology Department at SRM Medical College Hospital and Research Centre, Chennai, Tamil Nadu, India, from July 2021 to December 2021. Analysis was done from January 2022 to February 2022. The study was approved by Institutional Review Board (IRB No. 3151).

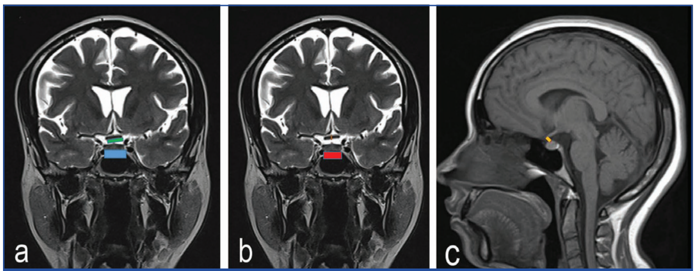
Inclusion and Exclusion criteria: Healthy subjects aged 10 to 80 years with normal MRI brain findings were included in the study. The main indication for these MRI brain studies was for complaints of headache. Any significant findings on the MRI brain were excluded from the study. Adult patients who were pregnant, had a history of endocrine disturbances or were on drug therapy were also excluded from the study.

Out of the 700 subjects, 378 were males and 322 were females. All MRIs were performed on a 1.5 T Siemens machine and the study variables were measured as mentioned in [Table/Fig-1].

Study variable	MRI
Intercarotid distance- shortest distance between the cavernous portion of the internal carotid arteries [Table/Fig-2a].	T2W coronal section
Optic chiasm width- maximum dimension of the optic chiasm [Table/Fig-2a].	T2W coronal section
Pituitary fossa width- maximum width of the pituitary fossa [Table/Fig-2b].	T2W coronal section
Optic chiasm height- maximum height of the optic chiasm at the mid portion [Table/Fig-2b].	T2W coronal section
Pituitary to chiasm distance- shortest distance from the pituitary gland to the optic chiasm [Table/Fig-2c].	T1W sagittal section

[Table/Fig-1]: Intracranial measurements on MRI.

The MRI protocol included coronal T2 weighted (TR:8870 TE:142 ST:3 mm) and sagittal T1 weighted sections (TR:500 TE:9 ST:5 mm) of the brain. [Table/Fig-2a-c] illustrates how the variable was measured.



[Table/Fig-2]: a) T2W coronal images shows measurement of the optic chiasm width (green line) and intercarotid distance (blue line); b) T2W coronal images shows measurement of the optic chiasm height (brown line) and pituitary width (red line); c) T1W sagittal section showing the measurement of the pituitary to optic chiasm distance (orange line).

All the measurements were obtained and interpreted by two radiologists with five and seven years experience. Pituitary width, optic chiasm width, optic chiasm height, intercarotid distance and pituitary to optic chiasm distance was considered as outcome variables. Age group and gender was considered as explanatory variable.

STATISTICAL ANALYSIS

Mean, standard deviation, minimum and maximum was used to describe the outcome variables. Independent t-test was used to compare mean between two groups. One way Analysis of Variance (ANOVA) along with Tukey's Honest Significant Difference (HSD) posthoc test was used to compare mean between more than two groups. Association between age and outcome variables was assessed by Pearson correlation coefficient at 95% confidence interval. Similarly, association between outcome variables were also assessed by Pearson coefficient at 95% confidence interval. A p-value <0.05 was considered statistically significant and was calculated by Independent sample T-test and ANOVA. RStudio version 1.2.1093 was used for statistical analysis.

RESULTS

A total of 700 individuals were included in the study (100 in each age group). The mean age among 11 to 20 years age group was 16.03 years. In 21 to 30 years age group it was 25.96 years, in 31 to 40 years age group it was 35.25 years, in 41 to 50 years it was 45.89 years, in 51 to 60 years it was 55.85 years, in 61 to 70 years it was 64.41 years and in 71 to 80 years it was 74.18 years respectively. The overall mean age was 45.4 years. Among 700 individuals, 378 (54%) were males and 322 (46%) were females.

The mean values of the pituitary width, optic chiasm width and height, intercarotid distance and pituitary to optic chiasm distance across all the age groups were 12.1±2.3, 13.1±1.6, 2.18±0.27, 16.2±3.7 and 5.70±1.84, respectively [Table/Fig-3].

	Measurement	
Variables	Mean±SD	Range
Pituitary width (mm)	12.1± 2.3	5-20
Optic chiasm width (mm)	13.1±1.6	9-18
Optic chiasm height (mm)	2.18±0.27	1.2-2.9
Intercarotid distance (mm)	16.2±3.7	3-27
Pituitary to optic chiasm (mm)	5.70±1.84	1.0-12.0

[Table/Fig-3]: Descriptive statistics of outcome variables in the study population (N=700).

The mean pituitary width was found significantly higher in males as compared to females (p-value <0.001). The mean pituitary to optic chiasm distance was also found to be significantly higher in males as compared to females (p-value=0.03) [Table/Fig-4].

Variables	Males Mean±SD (Range)	Female Mean±SD (Range)	p-value (Independent sample T-test)
Pituitary width (mm)	12.6±2.2 (7-20)	11.7±2.3 (5-19)	<0.001
Optic chiasm width (mm)	13.2±1.6 (9-18)	13±1.5 (9-18)	0.114
Optic chiasm height (mm)	2.16±0.27 (1.2-2.9)	2.2±0.27 (1.5-2.9)	0.059
Intercarotid distance (mm)	16.0±3.9 (3-27)	16.2±3.4 (8-26)	0.056
Pituitary to optic chiasm (mm)	5.83±1.82 (1.0-11.0)	5.4±1.86 (1.0-12.0)	0.03

[Table/Fig-4]: Comparison of outcome variables between male (n=378) and female (n=322).

Tukey HSD posthoc test showed that mean pituitary width was statistically significantly higher in the age group 51-60 years, 61-70 years and 71-80 years as compared to the age group 11 to 20 years, 21 to 30 years and 31 to 40 years respectively (p-value <0.001). The mean pituitary to optic chiasm distance was found statistically significantly lower in the age group 11 to 20 years as compared to the age group 31 to 40 years, 41 to 50 years, 51 to 60 years, 61 to 70 years and 71 to 80 years respectively (p-value <0.001) [Table/Fig-5].

Among individuals aged 21 to 40 year, 41 to 60 years and 61 to 80 years, male were found to have statistically significantly higher pituitary width in each age group as compared to females (p-value <0.05). Among individuals aged 41 to 60 years, females were found to have statistically significantly higher optic chiasm height as compared to males (p-value=0.019) whereas males were found to have statistically significantly higher OC width as compared to females (p-value=0.047) [Table/Fig-6].

There was no statistically significant difference in the intercarotid distance and pituitary to optic chiasm distance between males and females across the individual age groups [Table/Fig-7].

[Table/Fig-8] shows that the correlation between age and Optic Chiasm (OC) width and height and the intercarotid distance was found to be statistically insignificant (p-value >0.05). There was low and positive correlation between age and the pituitary width (r-value=0.175; p-value <0.001) as well as the pituitary to optic chiasm distance (r-value=0.342; p-value <0.001). [Table/Fig-9-11] shows the measurement of the variables in few cases of study.

Between the variables, there was a positive correlation between pituitary width and optic chiasm width (r-value=0.236, p-value <0.001), optic chiasm width and inter-carotid distance (r-value=0.259, p-value <0.001) and the pituitary width and intercarotid distance (r=0.736, p-value <0.001) [Table/Fig-12].

Variables	11 to 20 years Mean±SD (Range)	21 to 30 years Mean±SD (Range)	31 to 40 years Mean±SD (Range)	41 to 50 years Mean±SD (Range)	51 to 60 years Mean±SD (Range)	61 to 70 years Mean±SD (Range)	71 to 80 years Mean±SD (Range)	p-value (ANOVA)
Pituitary width (mm)	11.9±2.4 (5-20)	11.2±2 (6-15)	11.7±2.3 (6-16)	12.2±2.5 (6-18)	12.6±2.2 (8-18)	12.6±2.2 (7-17)	12.6±2.2 (7-19)	<0.001
Optic chiasm width (mm)	13.0±1.5 (10-16)	13.0±1.3 (10-16)	13.4±1.5 (9-17)	13.4±1.5 (10-18)	13.1±1.6 (10-17)	13.0±1.7 (9-18)	12.8±1.6 (9-18)	0.053
Optic chiasm height (mm)	2.26±0.29 (1.7-2.9)	2.19±0.28 (1.4-2.8)	2.18±0.22 (1.5-2.8)	2.17±0.25 (1.6-2.8)	2.20±0.26 (1.2-2.7)	2.15±0.29 (1.5-2.8)	2.11±0.28 (1.6-2.8)	0.057
Intercarotid distance (mm)	16.7±3.5 (9-24)	16.6±3.6 (9-26)	16.5±3.2 (9-25)	16.7±3.7 (8-27)	15.8±3.9 (3-24)	15.2±3.5 (8-24)	16.2±4.2 (7-24)	0.067
Pituitary to optic chiasm (mm)	4.50±1.38 (1.6-8.2)	4.97±1.73 (1.4-9.5)	5.79±1.92 (2.2-12.0)	5.80±1.68 (1.0-9.8)	6.10±1.86 (1.0-9.6)	6.21±1.70 (1.0-11.0)	6.54±1.76 (2.9-9.6)	<0.001

[Table/Fig-5]: Comparison of outcome variables according to age group.
p-value <0.05 was considered statistically significant

Age group	Pituitary width (mm)		p-value	OC width (mm)		p-value	OC height (mm)		p-value (Independent sample T-test)
	Male (Mean±SD)	Female (Mean±SD)		Male (Mean±SD)	Female (Mean±SD)		Male (Mean±SD)	Female (Mean±SD)	
11 to 20 years	12.9±1.92	12.31±2.46	0.179	13.18±1.58	12.86±1.44	0.291	2.22±0.31	2.29±0.26	0.254
21 to 40 years	12.97±2.17	12.09±2.14	0.005	13.34±1.38	13.13±1.44	0.299	2.21±0.24	2.17±0.26	0.236
41 to 60 years	12.39±2.45	11.55±2.30	0.013	13.48±1.48	13.04±1.62	0.047	2.15±0.27	2.23±0.24	0.019
61 to 80 years	12.0±2.02	11.32±2.23	0.041	12.89±1.75	12.88±1.50	0.954	2.12±0.26	2.14±0.33	0.651

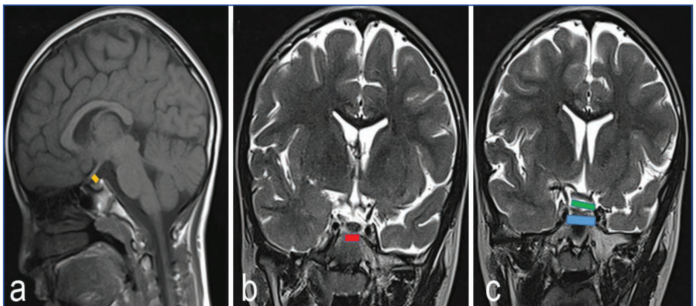
[Table/Fig-6]: Difference in pituitary width, OC width and OC height between males and females according to age group.
p-value <0.05 was considered statistically significant

Age group	Intercarotid distance		p-value	Pituitary to Optic chiasm		p-value (Independent sample T-test)
	Male (Mean±SD)	Female (Mean±SD)		Male (Mean±SD)	Female (Mean±SD)	
11 to 20 years	16.43±3.77	16.98±3.26	0.435	4.47± 1.37	4.52±1.39	0.851
21 to 40 years	16.40±3.59	16.61±3.24	0.668	5.57±1.77	5.24±1.93	0.222
41 to 60 years	16.04±4.17	16.58±3.34	0.311	5.84±1.73	6.08±1.82	0.349
61 to 80 years	15.54±3.94	16.02±3.79	0.418	6.48±1.76	6.15±1.66	0.208

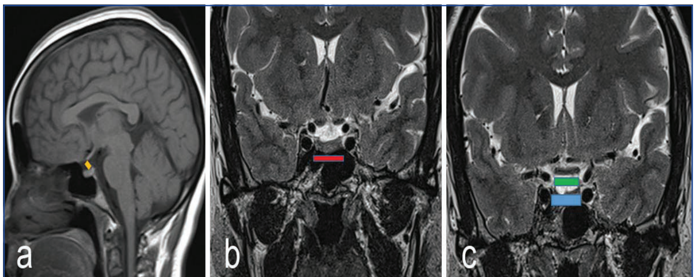
[Table/Fig-7]: Difference in the IC distance and Pituitary to OC distance between males and females according to age group.
p-value <0.05 was considered statistically significant

Correlation with age	Correlation coefficient (95% CI)	p-value
Pituitary width	0.175 (-0.246,-0.102)	<0.001
Optic chiasm width	-0.052 (-0.125,0.023)	0.172
Optic chiasm height	-0.143 (-0.215,-0.070)	0.183
Intercarotid distance	-0.089 (-0.162,-0.015)	0.081
Pituitary to optic chiasm	0.342 (0.275,0.406)	<0.001

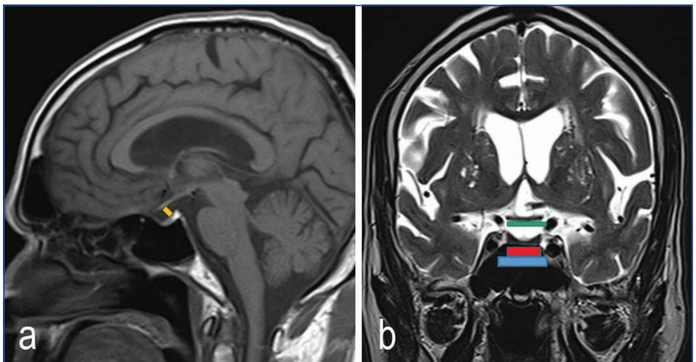
[Table/Fig-8]: Correlation between age and outcome variables.
p-value <0.05 was considered statistically significant



[Table/Fig-9]: Shows the measured variables in a 11-year-old female.
Orange line- pituitary to optic chiasm distance, red line- pituitary width, green line- optic chaism width, blue line- intercarotid distance



[Table/Fig-10]: Shows the measured variables in a 35-year-old female.
Orange line- pituitary to optic chiasm distance, red line- pituitary width, green line- optic chaism width, blue line- intercarotid distance



[Table/Fig-11]: Shows the measured variables in a 70-year-old male.
Orange line- pituitary to optic chiasm distance, red line- pituitary width, green line- optic chaism width, blue line- intercarotid distance

DISCUSSION

The Intercarotid Distance (ICD) was measured in the present study as the narrowest distance between the medial walls of the cavernous segments of the ICA on both sides. This study found the mean intercarotid distance to be 16.2 mm±3.7 mm with a range of 3-27 mm across all age groups with no significant difference between males and females. This is in keeping with the majority of reported studies who found no significant difference between genders [5,7-9]. Few studies however did report that the intercarotid distance was found to be higher in males than females [9,10].

There was a statistically no significant correlation of age with the ICD. Farimaz M et al., had also found no significant correlation of

Variables	Pituitary width		Optic chiasm width		Optic chiasm height		Intercarotid distance		Pituitary to Optic chiasm distance	
	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value
Pituitary width	NA	NA	0.236	<0.001	0.073	0.055	0.736	<0.001	-0.054	0.152
Optic chiasm width	0.236	<0.001	NA	NA	0.091	0.016	0.259	<0.001	0.047	0.217
Optic chiasm height	0.073	0.055	0.091	0.016	NA	NA	0.048	0.207	0.013	0.736
Intercarotid distance	0736	<0.001	0.259	<0.001	0.048	0.207	NA	NA	-0.066	0.082
Pituitary to optic chiasm distance	-0.054	0.152	0.047	0.217	0.013	0.736	-0.066	0.082	NA	NA

[Table/Fig-12]: Correlation between the outcome variables.
NA: Not applicable

the intercarotid distance with age however there was a negative correlation of the inter-cavernous distance with age in the Turkish population, which was also reported by Polat SO et al., [7,8].

The mean values for the intercarotid distance at the sellar region in healthy individuals reported in the literature have a wide range, varying from 12 mm to 18 mm [3,11-13]. This may be related to the method used to measure the distance and the ethnical differences between the study populations. Nunes CF et al., found the mean intercarotid distance at its horizontal portion at the sellar region was 19.41±3.00 mm with a statistically significant difference between males and females (males=21.17 mm, females=17.26±2.52 mm; p-value= 0.0014) [12]. Gupta T, found the mean intercarotid distance measured 13.7 mm with a minimum inter carotid distance of 7.63 mm [4]. A study done by Polat SO et al., on 292 subjects in the Turkish population found the intercavernous distance to be 14.1 mm in females and 13 mm in males with a negative correlation with age [7]. Farimaz M et al., also reported a mean intercavernous distance of 14.1±2.8 mm in females and 13.0±2.8 mm in males with no statistically significant difference between males and females and they found the ICD decreases with age [8]. Dao Trong P et al., found that the ICD was up to 2.4 mm smaller in the Caucasian cohorts as compared to African American/Asian cohorts which indicate that racial disparities regarding the sellar anatomy should be considered in patients undergoing pituitary surgery [14]. Comparison of measured ICD is shown in [Table/Fig-13] [15-26].

Parameters	Authors and year of publication	Place of study	ICD
Cadaver	Fujii K et al., (1979) [15]	Florida, USA	17
	Ozcan T et al., (2010) [16]	Turkey	13.33
	Abuzayed B et al., (2010) [17]	Turkey	13.22
	Aktas U et al., (2013) [18]	Turkey	15.33
	Perondi GE et al., (2013) [19]	Brazil	18
	Cebula H et al.,(2014) [20]	Cincinnati, USA	12.15
Magnetic Resonance Imaging	Scotti G et al., (1988) [21]	Italy	16.60
	Knappe UJ et al., (2009) [22]	Germany	17.8
	Zada G et al., (2011) [23]	Los Angeles, USA	16.2
	Sasagawa Y et al., (2013) [24]	Japan	19.4
	Present study	South India	16.2
Computed tomography angiography	Zhang Y et al., (2012) [25]	China	20.6
	Carrabba G et al., (2013) [26]	Italy	16.65
	Farimaz M et al., (2016) [8]	Turkey	16.5

[Table/Fig-13]: Comparison of the measured ICD.

There was statistically no significant difference in the mean OC width and mean OC height between males and females (p-value >0.05). There was also no significant difference in the mean OC width and mean OC height across age groups (p-value >0.05). These findings were in keeping with previously reported studies [6,7,9].

In the study by Polat SO et al., the means of the optic chiasm height and width values were found to be 2.80±0.7 mm and 13.13±1.37 mm respectively in healthy males and 2.80±0.49 mm and 12.82±1.27 mm respectively in healthy females of the Turkish population [7]. They found no significant difference in these values between the genders or across various age groups [7]. Bilal D et al., found the mean of width of the optic chiasm was 13.32±1.28 mm and the mean of the optic chiasm height was 2.53±0.18 mm in the Sudanese population with the maximum value seen in the sixth decade and no significant difference in gender or across different age groups [6]. A study on the American population showed the mean optic chiasm width was 14±1.68 mm across age groups 18 to 82 years with a decrease in width with increasing age however no significant difference between genders [27].

The pituitary width has been found to have a positive correlation with the intercavernous distance as reported by Polat SO et al., [7]. There was a low and positive correlation of age with the pituitary width, that is, with an increase in age there was a mild increase in the pituitary fossa width as reported in literature [28]. Chauhan P et al., found a mean width of 8.4 mm in females and 7.3 mm in males of the North Indian population with a statistically significant difference between the genders [28]. They found the size of the sella in the older age group was larger than the younger population, in keeping with our study. A study on 73 subjects of the Nepalese population found that the sella turcica had a mean length of 8.375 mm, anteriorposterior diameter of 7.029 mm, and depth of 10.13 mm [29]. They found the dimensions of the sella turcica increased with age till the age of 80 years and then decreased and the length and depth of sella turcica were higher in males compared to the females, similar to present study findings [29]. The increase in the pituitary fossa width with age was attributed to age related atrophic changes and similar results were also reported in other plain radiograph studies of the sella in Indian and other populations [30-32].

The pituitary to optic chiasm distance has not been well described. Knowledge of the normal reference values for this entity may help in improving diagnostic accuracy. This distance may be increased in conditions such as empty sella or decreased in conditions such as pituitary hyperplasia, pituitary tumours, meningiomas, gliomas. The optic chiasm may be in normal location, prefixed or postfixed [33].

Authors found a low and positive correlation between age and the pituitary to optic chiasm distance, that is, as the age increased the distance also increased (p-value <0.05). This could be attributed to atrophy of the brain with increase in the CSF spaces and sulci with increasing age. Between the variables there was found to be good correlation between the pituitary width and intercarotid distance, ie, as the pituitary width increased, the intercarotid distance also was found to increase which has also been described in literature [7] and a low and positive correlation between the pituitary width and the optic chiasm width.

The current study was unique in the fact that authors were able to compare many of the intracranial parameters related to the sella and establish certain reference values across the age groups in the South Indian population which has not been described previously in literature and which may aid in diagnosis and preoperative management.

Limitation(s)

This was a retrospective study with relatively small sample size across the age groups hence the results may not be accurately generalisable to the entire population. There is scope for further research with larger sample sizes with inclusion of the other populations of India.

CONCLUSION(S)

Present study was able to establish certain reference values in the South Indian population for the various intracranial parameters which may help in image interpretation and improving diagnostic accuracy, however the wide range of normal values and difference between genders must be kept in mind.

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