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Research Article

# Anatomical Variant Types of Pituitary Fossa (Sella Turcica) Floors in Relation to Pons (Brain Stem) - Observed on Magnetic Resonance Imaging of Pituitary Tumors During TNTS (Trans-Nasal Trans-Sphenoidal) Micro-Decompression

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## Abstract

**Objective:** The importance of quick and direct access to the sella turcica floor in pituitary adenomas for micro/endo-decompression via TNTS route is crucial for good outcome. However there are several types of anatomical variations in the positions of pituitary floor which have not been studied earlier. Establishing an accurate pre-operative anatomical relationship between the various positional types of pituitary (sellar) floors and the fixed pons (brain stem) resting on the clivus in mid-sagittal MR-images shall help better surgical results.

**Material and Methods:** This retrospective observational study was carried out on cranio-cerebral MR (magnetic resonance) sagittal imaging of 342 cases of operated pituitary adenomas via trans-nasal trans-sphenoidal (TNTS) route from Jan, 2014 to Dec, 2023 (10 years). On T1, T2 weighted mid-sagittal images, identification and measurements of pons, pontine line, mid-point of pons, mid-pontine perpendicular line (MPL) and floor of pituitary fossa (sellar floor) were carried out to assess the *high*, *medium* and *low* variant types of sellar floors. The statistical law of variance was applied wherever necessary.

**Results:** The analysis of imaging measurements of 342 pituitary tumor patients, operated for the tumor micro-decompression via TNTS route, revealed that 153 (44.73%) patients had high type sellar floor, 115 (33.62%) patients had medium type sellar floor and 74 (21.63%) patients had a low type sellar floor. There were 17 (4.97%) children, 167 (48.83%) male patients and 158 (46.19%) females. The youngest male was 10 years and the oldest 80 years. The youngest female was 12 years and the oldest 72 years.

**Conclusion:** The precise preoperative anatomical knowledge about the position of pituitary (sellar) floor in relation to the fixed pons in a particular patient, whether high, medium or low type, shall be of significant surgical value during TNTS procedures to access and decompress the pituitary tumors endoscopically or/and microscopically with minimum time and better outcome.

**Keywords:** Pituitary Fossa Floor; Anatomical Variant types; Pons (Brain Stem); Sagittal-MRI

## Introduction

The pituitary Fossa (*sella turcica* - Turkish-saddle) is a saddle-shaped depression in the body of the sphenoid bone that houses the pituitary gland [1]. The word clivus in Latin means slope [2]. The synchondrosis of sphenoid and basilar occipital bones forms the clivus with superior basilar and inferior pharyngeal surfaces. The clivus is just behind the sphenoid sinus [3]. The surgical importance of clivus lies in the extended endoscopic endonasal approaches for its benign and malignant lesions [4]. The anatomical relation of floor of pituitary fossa (sellar floor) to the mid-point of pons (brain stem), resting and fixed on the clivus, is a vital surgical milestone during TNTS procedures for the correct surgical trajectory to access the pituitary fossa tumors. The vertical depth/height of the pituitary floor of each patient varies in relation to pons (brain stem). The lateral view cranial radiographs depict the bony sella and the clivus closely related antero-posteriorly, however high resolution Cranial CT with 3D reconstruction reveals better surrounding structural positions and relations with different densities. But the sagittal MR T1, T2 weighted images are the best to accurately identify structural and tissue morphology in clear dimensions with different intensities. The observations in the present retrospective study revealed variations in the anatomical relation between the type of floor height of pituitary fossa (containing tumors) and the pons (brain stem) on mid-sagittal (vertical) MR planes of different patients.

## Material and Methods

This observational study of cranio-cerebral mid-sagittal MR (magnetic resonance) imaging of 342 cases of operated pituitary adenomas via TNTS (trans-nasal trans-sphenoidal) route from Jan., 2014 to Dec., 2023 (over a period of 10 years) was carried out retrospectively in the department of neurosurgery (Table 1). All patients had absolute lateral basal cranial radiographs, CT brain with 3D reconstruction and MRI brain with standard pituitary protocol. Based on the fixed position of the pontine brain stem, resting on the dorsal surface of the clivus and serving as a reference point, the positions of pituitary fossa floors were assessed in relation to the mid-point of the pons on mid-sagittal MR images and categorized as high, medium and low sellar floors. Most prominent part of the brainstem, the pons is about 26 to 30 mms in height (length) on sagittal image and approximately 38 mms in transverse (width) on coronal image. The pons is about 16mm antero-posteriorly in axial view. The pituitary fossa (sella turcica) typically measures 5 to 16 mm in antero-posterior length, 4 to 12 mm in vertical height (depth) and 9 to 21 mm in width. The size of the sella turcica appears to increase with age and stabilizes by 18 years of age [5]. The pituitary gland usually has a height of 6 to 10 mm and a total volume of 400 to 500 $mm^3$. Analysis of a morphometric study on 400 patients found that the mean antero-posterior diameter, length and depth of sella turcica were 10.13 mm, 9.51 mm and 7.39 mm respectively [6]. However, authors reported the overall midpoint height of the sella turcica was 6.59 mm (SE = 0.13), overall length was 9.06 mm (SE = 0.15) and the overall volume of 845.80 $mm^3$ (SE = 288.92) [1]. The pituitary gland tumors usually reach the floor of the pituitary fossa, inside the *sella turcica*, leaving no potential space between the dura and the bone, thus compressing the dura against the bony floor of the fossa, lamina dura, which forms a part of the roof of sphenoid sinus (Figure 1).

| Age group in yrs./Sex | 10-20 | 21-30 | 31-40 | 41-50 | 51-60 | 61-70 | 71-80 | Total |
|---|---|---|---|---|---|---|---|---|
| Males | 09 | 28 | 41 | 43 | 28 | 24 | 03 | 176 (51.46%) |
| Females | 08 | 21 | 43 | 58 | 30 | 05 | 01 | 166 (48.53%) |
| Total | 17 (4.97%) | 49 | 84 (24.56%) | 101 (29.53%) | 58 (16.95%) | 29 | 04 | 342 |

**Table 1:** Age(years) and Sex distribution of 342 cases of Operated Pituitary Tumors.

*Youngest; male -10 yrs and female -12 yrs

*Oldest; male -80 yrs and female – 72 yrs.

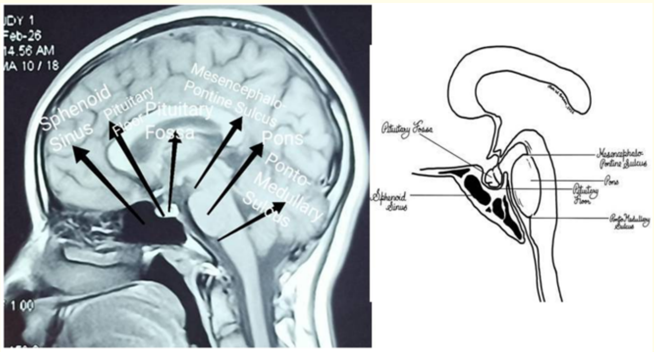


**Figure 1:** T1W image of MR brain sagittal view and the Sketch diagram shows related structures Sphenoid bone, Sphenoid sinus, Sella turcica, Pituitary gland, Clivus and Brain stem at the Base of Skull.

### Technical assessment of pituitary Fossa floor position

In the present retrospective study, on a Mid-Sagittal MR image, a Pontine Line was drawn on the pons from the ponto-mesencephalic sulcus to the ponto-medullary sulcus (Figure 2). The Mid-Point of the pons was fixed on the middle of this Pontine Line (Figure 3). Then a perpendicular (horizontal) line, called Mid-Pontine Perpendicular Line (MPL), was drawn forwards anteriorly across the sphenoid bone from the Mid-Point of the pons (Figure 4). The MPL was marked as the reference line for the assessment of the type of position of the sellar floor in the mid-sagittal image. When the pituitary fossa floor (tip) reached to the Mid-Pontine Perpendicular Line (MPL), it was called as the medium type of pituitary fossa. The pituitary fossa with its floor above this line in millimeters (mm) was grouped as high type and below the line in mm as low type pituitary fossa floor (Figure 5 - 11). The pituitary fossa floors in the high and low type groups, which were at different distances above or below the MPL (mid-pontine perpendicular line) were re-grouped as, upto 6mm, 7-10 mm and more than 10 mms high type (above the MPL) or low type below the MPL (Table 2 / Figure 5 – 11). All measurements were carried out in the mid sagittal plane on MR images. The observations were analyzed, compiled and inferences drawn. The statistical law of variance was applied wherever necessary. The patients who presented with recurrences after the primary decompression of pituitary tumors via TNTS were excluded from the study, for the apprehensions of developing false pituitary floors. All other tumors and lesions of sellar and parasellar region, except pituitary adenomas, like craniopharyngiomas, Rathke's cleft cyst, aneurysms and Empty sella syndrome etc., were excluded. The patients of pituitary adenomas with craniofacial anomalies, spina bifida, Down's syndrome and Seckel's syndrome (dwarfism with severe microcephaly), due to the possible influence of these anomalies on the shape and structure of sella turcica, were also excluded from the study.

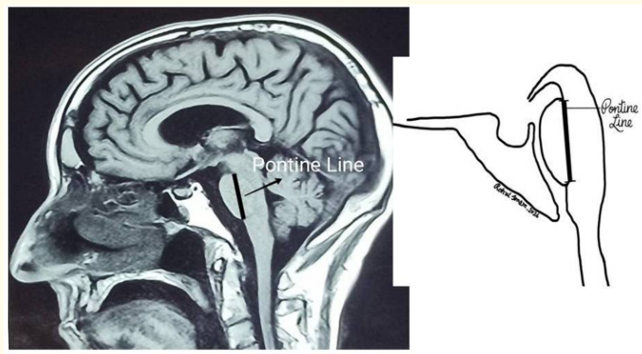


**Figure 2:** Sagittal MRI brain and the Sketch diagram depicts the Pontine Line drawn between Mesencephalo-Pontine Sulcus and Ponto- Medullary Sulcus.

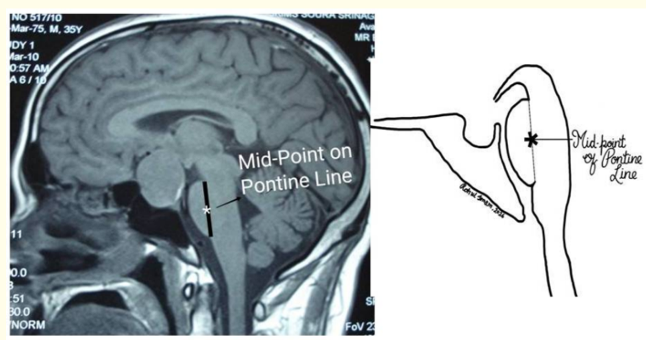


**Figure 3:** The Mid-Point on Pontine Line is shown in the Sagittal MRI Brain and in the Sketch diagram.


**Figure 4:** Mid-Pontine Perpendicular Line (MPL) drawn from the Mid-Point on the Pontine Line across Pons, Clivus and Sphenoid Sinus as shown on Sagittal MRI Brain and in the Sketch diagram.

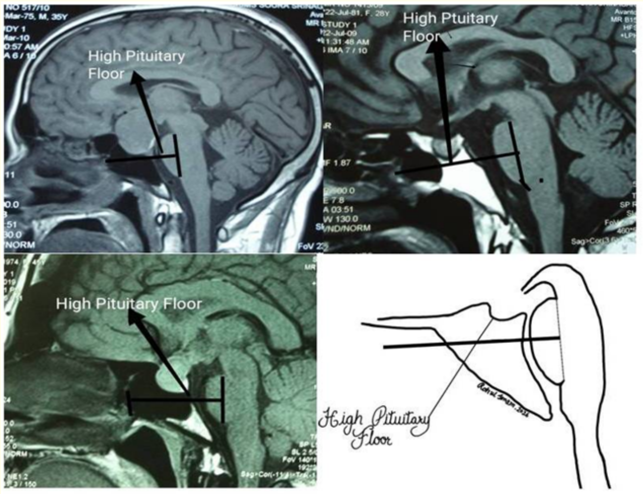


**Figure 5:** MRI Brain and Sketch diagram shows High Type Pituitary Floors up to 6 mms above MPL.

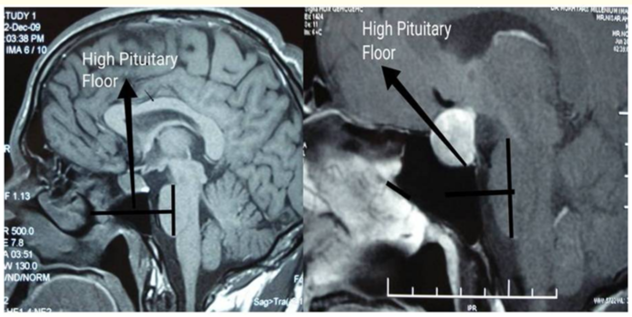


**Figure 6:** Sagittal Planes of T1W images MR Brain reveals as high as 7 to 10 mms Pituitary Floors above Mid-Pontine Perpendicular Line (MPL).

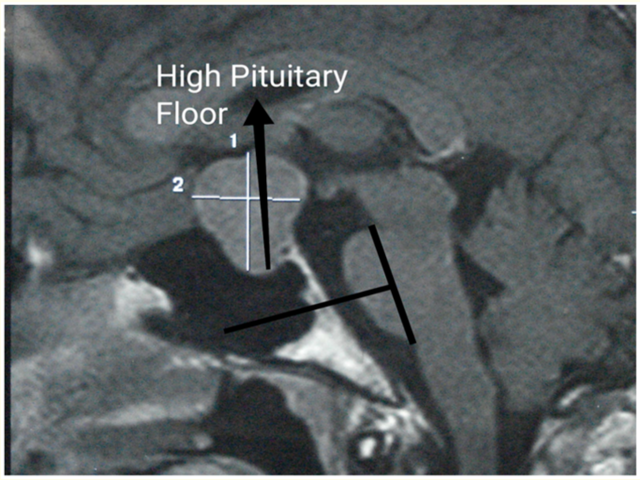


**Figure 7:** Sagittal MRI Brain shows High Type Pituitary Floor, 11 mms above MPL.

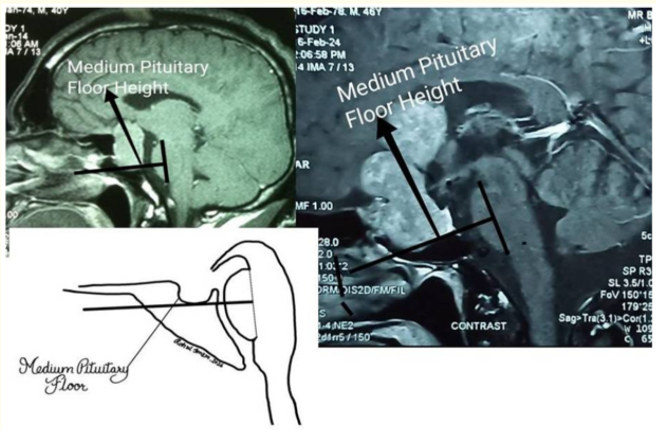


**Figure 8:** Sketch diagram is depicting the Medium Type Pituitary Floors, which are in line with MPL, as shown in the Sagittal MRI Brains of the two Pituitary Adenomas.

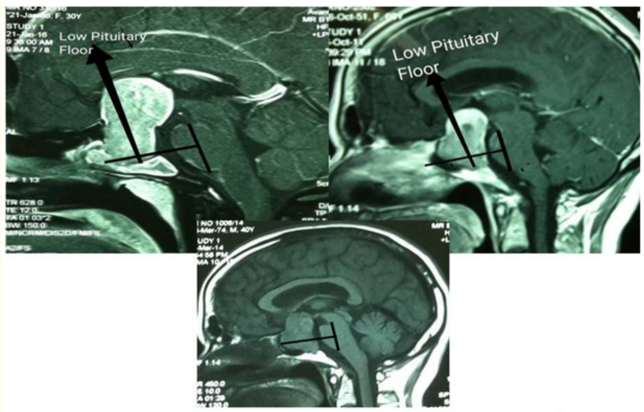


**Figure 9:** Sagittal MRI Brains show Low Type Pituitary Floors, up to 6 mm below Mid-Pontine Perpendicular Line (MPL).

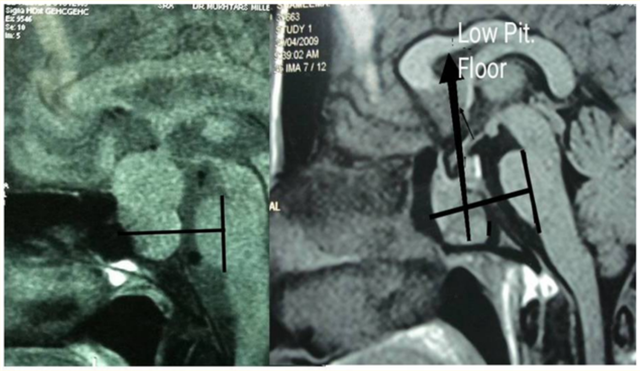


**Figure 10:** Low Type Pituitary Floors, 7 to 10 mms below the Mid-Pontine Perpendicular Line (MPL), are revealed in the two Sagittal Planes of MRI Brain in two patients of pituitary Adenomas.

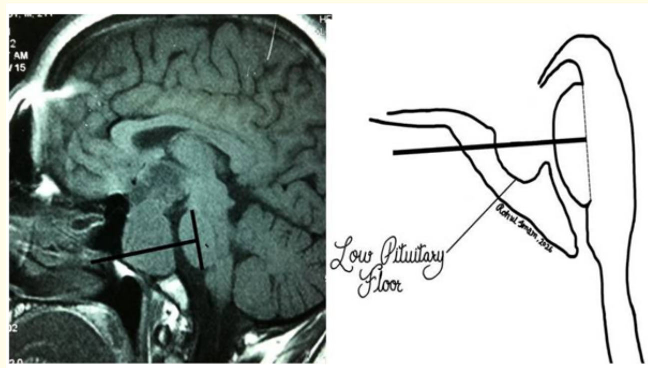


**Figure 11:** Sagittal T1WI MRI Brain and Sketch diagram depicts the Low Type Pituitary Floor, 12 mms below Mid-Pontine Perpendicular Line (MPL).

| **Level of Pituitary floor (mm)** | | **No. and Gender of patients** | | | **Total** | |
|---|---|---|---|---|---|---|
| **Male** | | **Female** | **Children** | | | |
| High Type (above MPL) | Up to 6 mm | 31 | 29 | 4 | 64 | 153(44.73%) |
| | 7-10 mm | 20 | 27 | 5 | 52 | |
| | >10 mm | 16 | 18 | 3 | 37 | |
| Medium Type (In line with MPL) | In line with MPL | 62 | 49 | 4 | 115 | 115(33.62%) |
| Low Type (below MPL) | Up to 6 mm | 18 | 14 | 1 | 33 | 74(21.63%) |
| | 7-10 mm | 12 | 11 | 0 | 23 | |
| | >10 mm | 08 | 10 | 0 | 18 | |
| Total | | 167(48.83%) | 158(46.19%) | 17(4.97%) | 342 | 342 |

**Table 2:** Anatomical Variant Types of Pituitary Fossa Floors in relation to Pons (Mid-Pontine Perpendicular Line - MPL).

*MPL = Mid-Pontine Perpendicular Line

*Youngest; male -10 yrs and female -12 yrs

*Oldest; male -80 yrs and female – 72 yrs.

## Results

The study comprised of assessment of sagittal MR imaging of a total 342 pituitary tumor patients, each operated first time for the tumor decompression via TNTS route. There were 167 (48.83%) males, 158 (46.19%) females and 17 (4.97%) children. The age-group most involved, with 71.04% (243/342) patients, was 30 – 60 years and in this age-group there was a predominance of females with 38.29% (131/342) patients. The youngest male patient was a 10 years boy and oldest 80 years, while as the youngest female patient was a 12 years girl and the oldest 72 years. Among 153 (44.73%) patients with high type sellar floor, about 64 (18.71%) had sellar floor up to 6 mm above mid-pontine perpendicular line (MPL), 52 (15.20%) had 7–10 mm above MPL and 37 (10.81%) patients were with a sellar floor more than 10mm above MPL

(Figure 5, 6, 7). However 115 (33.62%) patients had medium type sellar floor which were positioned in line with the MPL (Figure 8). While 74 (21.63%) patients had a low type sellar floor, of which 33 (9.64%) had a sellar floor up to 6mm below MPL, 23 (6.72%) patients with sellar floor 7-10mm below MPL and 18 (5.26%) had sellar floor more than 10mm below the Mid-Pontine Perpendicular Line (Figure 9, 10, 11). Overall the most, 116 (33.91%), of the patients with high type sellar floors had floors up to 10 mm above MPL while as fewer, 37 (10.81%), had pituitary floors more than 10 mm above MPL. Similarly low type sellar floors up to 10 mm below MPL were found in 56 (16.36%) while pituitary floors more than 10mm below MPL were found in 18 (5.26%) patients. The high type sellar floor was most common type, existing in a little lesser than half of all the patients while as the medium sellar floor was found in about one-third of all the pituitary tumors (Table 2).

## Discussion

This observational retrospective study was carried out on the sagittal images of 342 patients of pituitary adenomas, including 17 (4.97%) children, operated via TNTS route in the department of neurosurgery under a standard protocol over a period of 10 years. It revealed high, medium and low type positional variations in the floor of pituitary fossa. Some authors undertook a systematic review and meta-analysis involving 18,364 patients, reporting four sella turcica shapes in which the most commonly occurring variants are the normal ST (sella turcica) 55.56%, the U-shaped 73.58%, the circular type 42.29% and non-bridging 55.64% sella turcica. Authors assert that various morphometric characteristics of the ST may be applied in clinical practice to evaluate its shape, dimensions, and normal or pathological variants [1]. The present study measured the level of position of the sellar (pituitary) floors in the sphenoid bone in relation to the mid-pontine perpendicular line (MPL) from the pons and found three types of sellar floor variations. The authors of a study noted atypical sella shapes such as J-shaped, deep and flattened dorsum sellae in individuals with craniofacial syndromes including Down syndrome, William's syndrome and Axenfeld–Rieger syndrome [7]. The authors linked these anomalies to disrupted sphenoid ossification and neural crest migration, which is supported by the embryological models from a histological study [8]. In a CT-based study it was found that most pneumatizations originated from the sphenoid sinus (81.8%), while pneumatization of the anterior clinoid process was noted in 9.2% individuals and some extending from the ethmoid sinus (10.9%) [9]. The present study found high type sellar floors in 153 (44.73%), medium type in 115 (33.62%) and low type sellar floors in 74 (21.63%) patients. All the operated patients of pituitary adenomas via TNTS route with recurrences, patients with abnormal craniofacial syndromes or with disproportionate features of base of skull were excluded from the study. A morphometric study was conducted on 2726 skulls and found clinically relevant middle clinoid processes in 42% of specimens and classified these into three categories. These were Incomplete (69% of all middle clinoid processes), Carotico-clinoid Ring (27%) where middle clinoid processes join the anterior clinoid process without forming a true ring and Contact (4%) as bony projections [10]. Authors of a study reported on the variations in posterior clinoid processes based on 100 dry human skulls. The posterior clinoid process was classified as normal (78%), elongated (16%) and pneumatized (6%) [11]. The present study revealed that most, 33.91%, of the patients with high sellar floors variations had floors up to 10 mm above MPL while as fewer, 10.81%, had pituitary floors more than 10 mm above MPL. Similarly low sellar floors up to 10 mm below MPL were found in 16.36% while pituitary floors more than 10mm below MPL were found in 5.26% patients (Table 2). It is reported that sellar bridges, which are osseous connections between the clinoid processes of the sphenoid bone and represent important anatomical variants, typically are formed through the ossification of intracranial ligaments and include the Caroticoclinoid Bridge (CCB) and interclinoid bridge (ICB). These bridges host additional foramina that guide neurovascular structures and neurosurgical approaches to the skull base [12]. It is revealed in a study that a statistically significant difference occurs between the linear dimensions of the two genders with significant linear correlation between age and the dimensions of sella turcica below 18 years of age [6]. The study concluded that the results obtained could be utilized as normative data of sella turcica for Indian population. The highest number of persons belonged to the age group 26-40 years, comprising 41.5 % males and 42% females respectively. The youngest male in the study group was aged 2 years and the oldest male in the study group was aged 93 years. The shape of the sella turcica can be classified into three groups- U shape in which the tuberculum and dorsum sellae are at the same height (55%), J shape where the tuberculum is lower than dorsum sella (25%) and shallow (20%) where the depth is minimum [6]. The present study comprised of 167 (48.83%) males, 158 (46.19%) females and 17 (4.97%) children. The age-group most involved, with 243 (71.04%) patients, was 30 – 60 years and in this age-group there was a predominance of females with 131 (38.29%) patients. The youngest male patient was a 10 years and the oldest was 80 years, while as the youngest female patient was a 12 years and the oldest 72 years. The shapes and sizes of sella have been reported in studies on Saudi and Greek subjects with different skeletal types on lateral cephalometric radiographs. The five morphological variants described include oblique anterior wall, bridging of sella turcica, double contour of the floor, irregularity in the posterior part of the floor and pyramidal shape of the dorsum sella. These studies also found increase in size of sella turcica on lateral cephalometric radiographs in patients leading to an incidental diagnosis of pituitary adenoma [13-15]. Several authors reported that the shape of the sella may be altered in conditions like spina bifida, Down's syndrome and Seckel's syndrome. These abnormalities in shape of sella turcica were detected antenatally in foetuses [16-18]. The present study found that 115 (33.62%) patients had medium type sellar floor which were positioned in line with the MPL (Figure 8). A study reported empty sella syndrome, Rathke's cleft cyst and aneurysms in the vicinity of sellar region, as other causes of enlarged sellar dimensions [19]. However a small sized sella may be seen in or as a consequence of primary hypopituitarism, Sheehan's syndrome (post-partum pituitary necrosis) and other causes of pituitary apoplexy [20]. It is reported that the size of sella turcica on lateral cephalometric radiographs was studied in Norwegian population aged 6-21 years. They found that while the length of the sella turcica was almost constant, the diameter and height increased with age. They did not find any difference between males and females with respect to the depth and diameter of sella turcica. However, length was found to be larger in males [21]. A study on 180 Saudi patients described the shape and size of sella turcica and found that the linear dimensions obtained were 2.02 to 2.73 mm larger than that obtained in the Norwegian group. The report did not find any statistically significant difference between the two genders and found larger sella sizes in older age groups [15,21]. In the present study 153 (44.73%) patients with high type sellar floor, about 64 (18.71%) had sellar floor 3-6 mm above mid-pontine line (MPL) and 52 (15.20%) had 7–10 mm floor above MPL. In a similar study on 184 Greek subjects with age range of 6-17 years, authors provided quantitative data for the objective assessment of shape of the sella turcica in addition to the linear dimensions. Only anterior sella height was found to be significantly different in their study, being larger in females. They also found a statistically significant correlation between age and size of the sella, with size of the sella increasing with age [5]. In South Indian population, a study found average length and depth of sella turcica as 9.15 mm and 7.3 mm but a statistically significant difference in length of sella turcica between males and females [22]. In a recently performed morphometric study of the sella turcica, using computed tomography, the reporters found that the average length was 10.3 mm and the depth 6.3 mm. the computed tomography has higher contrast resolution compared to lateral cephalometric radiographs allowing easier and accurate measurements. Capability of multi-dimensional reconstruction has helped in minimizing the effects of patient position on the plane of image used for the measurement [23]. While 74 (21.63%) patients in present study had a low type sellar floor out of which about 33 (9.64%) had a sellar floor 3-6mm below MPL and 23 (6.72%) patients had a sellar floor 7-10mm below MPL. This study confirmed the reports of the several above studies that the variations in the size and structure of the sphenoid bone containing pituitary (sellar) fossa with its floor are found in the different populations and different ages.

## Conclusion

The morphometry of the sellar (pituitary) floor by the lateral cephalometric radiographs along with 3D-CT and reconstruction has been of immense value in the past but the cranio-cerebral MRI in all planes especially sagittal has increased the significance of these measurements and structural morphologies multifold. The present study explores the accurate pre-operative anatomical relations between the positions of pituitary (sellar) floor and the fixed pons (brain stem) on the clivus, whether High, Medium or Low Types. This shall be of significant value during TNTS procedure of a particular patient to accurately access and decompress the pituitary tumors endoscopically and/or microscopically with significant outcome. The advantage of assessing the depth/height of level of pituitary floor is specific to MR image of a specific patient and not a general rule for all patients. Although the study was limited to only pituitary adenoma patients, a community study may be a future trend.

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