

Research Article**Anatomical variations of Sphenoid Sinus based on Computerized Tomography (CT)**Ekanayake LSB¹¹ Consultant ENT and Head & Neck Surgeon, Provincial General Hospital Badulla, Sri Lanka**Abstract**

Objectives. Currently in Sri Lanka otorhinolaryngologists are vastly involved in functional endoscopic sinus surgery (FESS), while transsphenoidal approach to sellar lesions is becoming popular among neurosurgeons. There is a possibility of endoscopic supra sellar, lateral skull base and clival surgery to take off in near future although no sufficient database is available about the anatomical variations of the sphenoid sinuses of Sri Lankans. This research is aimed at filling this deficit.

Design and Methods. A cross sectional retrospective study of 200 CT scans of 0.5mm intervals of the ‘nose, paranasal sinus and brain’ of Sri Lankans who were seen at district general hospital Trincomalee were analyzed. Details were collected regarding pneumatization, sellar bulge, protrusion and dehiscence of the walls of maxillary nerve (MN), optic nerve (ON), vidian nerve (VN) and internal carotid artery (ICA) and the different types and attachment of the sphenoid sinus septum.

Results. We found no conchal pneumatization but 100% of the study population to have presellar area of the sphenoid body pneumatization, 87% to have sellar and 39.5% to have post sellar area of the sphenoid bone pneumatization. Superior extension of pneumatization into anterior clinoid process (ACP) was found among 13.5% and extension in to posterior clinoid process (PCP) in 4.5%. Lateral extension in to opticocarotid recess was found in 60% and pneumatization in to greater wing of sphenoid (GWS) was found in 42% while 13.5% had pneumatization of lesser wing of sphenoid (LWS). Anterior pneumatization extended in to vomer and ethmoid bones and was 25% and 19% respectively. Posterior extension in to clivus was 34.5% while pneumatization extended inferiorly in to pterygoid process in 54.5%. The sellar bulge was well defined in 75.5% and not so in 24.5%. The Intersinus septum was absent in 0.5% while single Intersinus septum was present in 86.5% and 8% had a transverse septum. 29.5% had multiple Intrasinus septum while 64.5% had accessory septa. Occurrence of protrusion and dehiscence in optic nerve, maxillary nerve, vidian nerve and internal carotid artery were, 54%, 8.5%, 24.5% and 79% and, 23%, 7%, 14% and 57.5% respectively

Conclusions. The sinus anatomy has a racial difference and regional anatomy varies randomly. Posterior, inferior and lateral extensions of pneumatization could make orientation and relative positioning of vital structures confusing. Septal attachments to vessels and nerves are much higher than appreciated previously. Individual study with greater attention to detail in CT scans is recommended prior to surgery to minimize complications.

Keywords. Anatomy, pneumatization, Bulge, protrusion, dehiscence, sphenoid sinus

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Introduction

The sphenoid bone, located deep within the skull base has a variable anatomy, which is best studied using computerized tomography. It occupies a central position, in the skull anatomically, as well as in skull base surgery and sphenoid sinus acts as a safe passage to the sellar turcica, optic nerve, planum sphenoidale, tuberculum, and the sellar orbital junction for various skull base, sellar, suprasellar lesions and cerebrospinal fluid leak repairs [1]. The level of intervention in sphenoid sinus varies from wide sphenoidotomy in sinusitis, for improvement of drainage and ventilation to liberal removal of inter/intra sphenoidal bone for access in neuro endoscopic surgery. Completion of the postnatal development of the sphenoid sinus, which different authors offer different age limits, falls in to a period, from a young age of 12 to an age of 16 years [1], [8]. On top of the existing diversity in anatomy the highly variable and unpredictable nature of pneumatization, could place the surgeon in a precarious and dangerous situation due to the proximity to surrounding vital structures such as the optic, vidian, maxillary, oculomotor, trochlear nerves, brain stem, cavernous sinuses and the internal carotid arteries [1]. All these factors demand the understanding of subtle variations in sphenoid anatomy for safe and successful sphenoidal sinus surgery.

In the recent past the extended transsphenoidal (ETS) approach attracted vast attention owing to two main reasons. First one is the successful introduction of the endoscope. The second reason was the popularity gained by easy access in to sphenoid via bilateral nasal passages, due to the ever-expanding extensive knowledge of the sphenoid anatomy and recent availability of intraoperative navigation. Yuntao Lu et al. who published about **pneumatization of sphenoid sinus in Chinese and the differences from Caucasians**, revealed different pneumatization rates, tracks and futures between ethnicities. ‘This might indicate the need for more careful use of intraoperative technological devices for the ETS approach in the Chinese population’ state Yuntao Lu et al. hinting the necessity for attention to inter racial variations in anatomy among different races [3]. Surprising variations exist in literature in the past; for rates of pneumatization [4], rates of optic nerve protrusion and dehiscence, as well as internal carotid artery (ICA) protrusion and dehiscence among different ethnic groups. [5]. Unfortunately, there is no data relevant to the Sri Lankan population and the global availability of similar information is relatively sparse [7].

The purpose of our study is to make the endoscopic journey safe for the surgeon and patients, by arming the surgeon with detailed and a complete study of sphenoid sinus in a high-resolution computer tomography as we believe the Sri Lankans sphenoid anatomy differs from others where pneumatization, sellar bulge, complexity of intersinus septum, bulging and dehiscence of the coverings of vital structures are concerned. Attempts were made to describe the patterns of the pneumatization of sphenoid sinus as well as the variability of the sinus septum, regarding which little work has been done in the past [7].

Methodology

A retrospective cross sectional study of 200 high-resolution “Para nasal, nose and brain ” CT images at 0.5mm intervals and the multi-planar reconstruction of the sphenoid sinus in adults above sixteen years, of Sri Lankan patients attending District General Hospital Trincomalee, Sri Lanka, between January 2016 and January 2017 were studied for collection of relevant data. Patients lower age limit was kept at 16 years because, according to Gray, sphenoid sinus does not reach its full development until this age [8]. No Consent was obtained due to the retrospective nature but ethical clearance was obtained. The below mentioned exclusion criteria for subject selection were used in selecting subjects for the research,

- a. Images exhibiting sphenoid ethmoid frontal or maxillary sinus pathology.
- b. Intracranial tumours.
- c. Craniofacial anomalies.

- d. Previous surgery of the sphenoid sinus region.
- e. Sino-nasal tumours.
- f. Nasal polyposis.
- g. Younger than 16 years.
- h. Head and Neck injury.

All CT Scans were examined by the investigator him self using PACS system in the District General hospital of Trincomalee.. (Software iNtuition version4.4.6.74) and the following variables were collected.

Pneumatization

Below this theme, the extension of pneumatization of sphenoid sinus in relation to sellar was analyzed; and classified as presellar (pneumatization anterior to a plane passing along the anterior wall of sellar turcica), sellar (pneumatization anterior to a plane passing anterior to the posterior wall of sellar turcica) and postsellar (Figure 4) (pneumatization extending posterior to posterior wall of sellar turcica and limited anterior to clivus)[1]. Also extension of sphenoid sinus in to pterygoid process (Pterygoid process pneumatization is recognized if pneumatization extend below a horizontal line crossing the vidian canal) [6], anterior and posterior clinoid process, and greater wing of sphenoid, (pneumatization of greater wing of sphenoid was recognized when pneumatization extends beyond a vertical plane crossing the maxillary canal)[6], pneumatization in to ethmoid, vomer, clivus, nasal septum and in other bones of skull base were also studied.

Prominence of the Pituitary Bulge

The impression of the sellar on the sphenoid sinus roof on sagittal CT scan cuts were analysed and was categorized as ill defined or well defined bulge according to the impression it made on sphenoid roof.

Attachment of Sphenoid Septum

An extensive collection and analysis of this important feature was anticipated in this research. As transverse septum and attachment of septum to internal carotid artery and optic nerve are known risk factors for iatrogenic injuries during surgery; we aimed to find the statistics of those as well as new relationships that could exist with the different arrangement of the sphenoid septum [17]. Data were collected about absent septum, single intersphenoidal septum (single intersphenoidal septum, which attached to sellar floor and sphenoidal sinus floor) and its attachment, single transverse septum (attached to lateral walls on one or both sides), multiple intrasphenoidal septum (complete or incomplete septum that at least has one attachment to an intersphenoidal septum or an attachment to posterior end of nasal septum) and accessory septa (complete or incomplete septum that at least has one attachment to lateral or posterior sphenoidal wall away from intersphenoidal septum and that attached to anterior wall of sphenoid away from posterior end of nasal septum).

Protrusion of vital structures in to the sinus.

Protrusion of internal carotid artery, optic nerve, maxillary branch of trigeminal nerve and vidian nerve in to sphenoid sinus was studied and compared with current available data as internal carotid artery, optic ,nerve, maxillary nerve and vidian nerve are in the close proximity to the sinus wall making it a ever present threat to encounter accidently during surgery. Finding any amount of bulging of the structures in to sinus cavity was considered as a positive finding for protrusion of internal carotid artery and optic nerve, and as for diagnosis of protrusion for maxillary nerve and vidian nerve, the presence of air density at least in a section of coronal CT cut around the relevant structure [6].

Dehiscence in the wall of the bony canal.

Any absence in the bony canal of the vital structures in the sinus, putting them at risk during surgery or other pathological processes was studied. Dehiscence is defined as absence of visible bony density separating the sinus from the structure under investigation, and dehiscence of the walls of internal carotid artery, optic nerve, maxillary nerve and studied this way [6].

Analysis of Data

Data was analysed statistically by using Chi square test and contingency coefficient C. P value was taken as 0.05.

Results

Pneumatization Pattern of the Sphenoid sinus in 200 Sri Lankan subjects

	Right	Left	Bilateral
Conchal	0(0%)	0(0%)	0(0%)
Presellar	0(0%)	0(0%)	200(100%)
Sellar	0(0%)	0(0%)	174(87%)
Postsellar	1(0.5%)	0(0%)	79(39.5%)
Opticocarotid Recess	22(11%)	23(11.5%)	75(37.5%)
Pterygoid Plates	22(11%)	18(9%)	75(37.5%)
Anterior Clinoid Process	11(5.5%)	8(4%)	8(4%)
Posterior Clinoid Process.	0(0%)	5(2.5%)	4(2%)
Greater Wing of Sphenoid.	10(5%)	15(7.5%)	59(29.5%)
Lesser Wing of Sphenoid	7(3.5%)	10(5.0%)	10(5.0%)
Vomer	1(0.5%)	1(0.5%)	48(24%)
Ethmoid Bone	7(3.5%)	5(2.5%)	26(13%)
Clivus	14(7%)	7(3.5%)	48(24%)

Table 1

Pneumatization of the Body of Sphenoid and the directional extensions.

[Table 1](#) shows pneumatization patterns of sphenoid sinus. Pneumatization of the anterior clinoid process was encountered in 27 patients (13.5%). bilateral pneumatization was observed in 8 (4%) while unilateral pneumatization was observed 11 (5.5%) in the right and 8 (4%) on the left, whereas 9 (4.5%) had posterior clinoid process pneumatization. Though there were no conchal pneumatization, body of the sphenoid bone showed 200(100%) presellar, 174(87%) sellar and 80(40%) had postsellar pneumatization. In lateral extension, had 84 (42%), 27(13.5%), 120(60%) pneumatization in greater wing of sphenoid, lesser wing of sphenoid and opticocarotid recess respectively. The inferolateral extension of pneumatization was 115 (57.5%) in to pterygoid processes while posterior extension was 69(34.5%) extending in to clivus. We did not find any statistical significance in type of pneumatization and its representation, as the Chi value was 0 and p value was 1.

Prominence of the Pituitary Bulge.

Ill defined	51(25.5%)
Well defined	149(74.5%)

Attachment of Sphenoid Septum.

No septum 1	Sellar floor	Optic Nerve	Internal Carotid Artery
Single intersphenoidal Septum	159(79.5%)	22(11%)	63(31.5%)
Transverse Septum	3(1.5%)	0(0%)	13(6.5%)
Multiple Intrasphenoidal Septa	27(13.5%)	11(5.5%)	14(7%)
Accessory Septa	60(30%)	7(3.5%)	68(34%)

Table 2

to

Septation patterns are listed in [Table 2](#). When analyzing the statistics for orientation of sphenoid septum there was only 1(0.5%) that had no septum separating the sinus in to two. The commonest septal attachment was the single Intersinus septum, which was 173(86.5%) resulting in separation of the sinus cavity in to two halves. Out of the latter group 159(79.5%) of them were attached to the sellar floor, 22(11%) attached to optic nerve, while 63(31.5%) had an attachment to internal carotid artery. 16 patients had transverse septum and out of them 13 had attachments over internal carotid artery while 3 attached to sellar floor. Out of the study population of 200, 59(29.5%) had multiple Intrasinus septa, which attached by the following figures of 27(13.5%), 11(5.5%), 14 (7%) to sellar floor, optic nerve and internal carotid artery respectively. Accessory septa were present in 135(67.5%), out of them 60(30%) were attached to sellar floor while 7(3.5%) to optic nerve and 68(34%) to internal carotid artery. The septal attachment and its 'deviations' had a Chi value 9.587 and a p value of 0.148 and didn't show a significant association between different types of septa to their attachments

Figure 1.

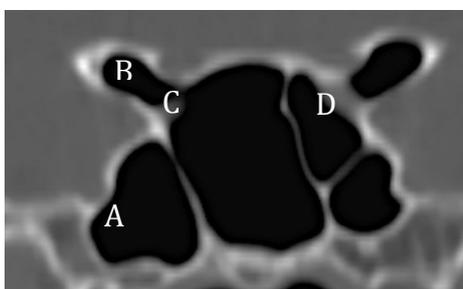


Figure 1
Coronal CT scan showing, A. pneumatization of right greater wing of sphenoid., B. pneumatization of anterior clinoid process , C. pneumatization of opticocarotid recess, D. optic nerve protrusion with both Intersinus septum and accessory septum attaching to internal carotid arteries left and right respectively.

Protrusion of Vital Structures to Sphenoid

	Right	Left	Bilateral
Maxillary Nerve	1(0.5%)	4(2%)	11(5.5%)
Vidian Nerve	16(8%)	8(4%)	23(12.5%)
Optic Nerve	16(8%)	55(27.5%)	37(18.5%)
Internal Carotid Artery	39(19.5%)	23(11.5%)	48(24%)

Table 3

In our research ([Table 3](#)) we found 11(5.5%) with bilateral protrusion of maxillary nerve in to the sinus and 1(0.5%) of patients had right side protrusion while 4(2%) had left sided protrusion. Meanwhile 23(12.5%) had bilateral protrusion of vidian nerve; there were 16(8%) with protrusion of right side vidian nerve, while 8(4%) had protrusion on left. Total Optic nerve protrusion was 108(54%). There were 110(55%) internal carotid artery protrusions, among them 48(24%) were bilateral while 39(19.5%) had right and 23(11.5%) had left side isolated unilateral Internal carotid artery protrusion. There was no significant association between protrusion of the structures and their sidedness. (P value=1

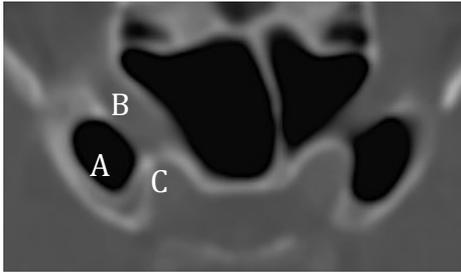


Figure 2.
Axial CT scan showing A. pneumatized opticocarotid recess with B. bilateral optic nerve and, C carotid artery protrusion.

Dehiscence in The Wall of the Bony Canal.

	Right	Left	Bilateral
Maxillary Nerve	5(2.5%)	6(3%)	3(1.5%)
Vidian Nerve	11(5.5%)	7(3.5%)	10(5%)
Optic Nerve	19(9.5%)	27(13.5%)	0(0%)
Internal Carotid Artery	20(10%)	15(7.5%)	80(40%)

Table 4

Out of the 200 subjects there were 3(1.5%)with bilateral dehiscence (Table 4) in the wall of maxillary nerve, and 5(2.5%) with right and 6(3%)with only left side unilateral dehiscence; while 10(5%) of the vidian nerves showed bilateral dehiscence and had 11(5.5%) unilateral dehiscence in right side and 7(3.5%) in left side of the bony covering of the latter. In our research we didn't find any patients with bilateral Optic nerve dehiscence, but 19(9.5%) had right sided and 27(13.5%) had left sided unilateral dehiscence in optic nerve. Internal carotid artery had 20 (10%) right and 15(7.5%) left unilateral dehiscence (Figure 3) while 80(40%) had bilateral dehiscence. We didn't find any significant relationship between dehiscence of structures and their sidedness. (Chi value was 7.157 and p value was 0.3065.)

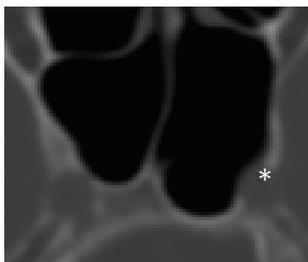


Figure 3.
Axial cut of CT scan illustrating * showing dehiscence in the wall of the left internal carotid vessel wall.

Relationship Between Pneumatization Of Anterior Clinoid Process (ACP) And Internal Carotid Artery (ICA) Protrusion.

	ICA protrusion	No ICA protrusion
ACP pneumatization	27	1
No, ACP pneumatization	83	89

Out of the total 110 patients who had internal carotid artery protrusion 27 patients had Anterior Clinoid process pneumatization. Chi square test suggested significant association between ACP pneumatization ICA protrusion ($p < 0.05$) and contingency coefficient C showed significant association.

Relationship Between Pneumatization Of Anterior Clinoid Process (ACP) And Optic Nerve (ON) Protrusion.

	ACP pneumatization	NO,ACP pneumatization
ON protrusion	22	86
No ON Protrusion	6	86

Contemporaneous occurrence of a pneumatized anterior clinoid process and a protruding optic nerve was confronted on the 22(78.5%) of the pneumatized 28 anterior clinoid processes. Chi-square test did not suggest significant association between ACP pneumatization and ON protrusion ($p > 0.05$).

Relationship Between Pneumatization of greater wing of (GWS) And Maxillary Nerve (MN) Protrusion

	GWS pneumatization	No GWS pneumatization
MN protrusion	15	1
No MN protrusion	69	115

Parallel existence of a pneumatized great wing of sphenoid and a protruding maxillary nerve was found on 15(16.6%). Chi-square test didn't indicate significant association between great wing of sphenoid pneumatization and maxillary nerve protrusion ($p > 0.05$).

Relationship Between Pneumatization Of Pterygoid Plates (PP) And Vidian Nerve (VN) Protrusion.

	PP pneumatization	No, PP pneumatization
VN protrusion	5	42
No VN protrusion	143	10

Contemporaneous existence of a pneumatized pterygoid plate and a protruding vidian nerve was seen in 5(3.3%) patients. Chi square analysis indicated significant association between PP pneumatization and VN protrusion ($P < 0.05$) and contingency coefficient C showed significant association.

Pneumatization of Opticocarotid Recess and Optic Nerve and Internal Carotid Artery Protrusion.

	ON protrusion	ICA protrusion
OCR pneumatization	67	64
No, OCR pneumatization	41	46

We found;120(60%) positive results of OCR pneumatization, among 64(32%) and 67(33.5%) had simultaneous internal carotid artery and optic nerve protrusions respectively and did not show any significant association between pneumatization of OCR and ON, ICA protrusion.

Sphenoidal Septal Variations and its Associations with Other Variables.

	MN		VN		ON		ICA	
	D	P	D	P	D	P	D	P
No septum Total=1.	0(0%)	0(0%)	0(0%)	1(100%)	0(0%)	1(100%)	0(0%)	1(100%)
Intersinus septum. Total =173.	11(6%)	5(2.8%)	1(.57%)	42(24.2%)	7(4%)	82(47.3%)	8(4.6%)	101(58.19%)
Transverse Septum. Total=16.	1(6.25%)	0(0%)	1(6.25%)	1(6.25%)	11(68.75%)	8(50%)	12(75%)	8(50%)
Multiple intrasinus septum. Total=59.	4(6.7%)	3(5.08%)	7(11.86%)	13(22%)	35(59.3%)	22(37.2%)	26(44%)	24(40%)
Accessory septum. Total=129.	8(6.2%)	4(3.1%)	14(10.85%)	22(17%)	40(31%)	45(34.88%)	48(37.2%)	53(41%)

We also analysed different arrangements of the septum and its influence on the dehiscence (D) and protrusion (P) of vital structure in to sphenoid sinus and our research did not show any significant association with different septal arrangements with ON or ICA protrusion or dehiscence.

Discussion.

Pneumatization.

In our research we analysed the pneumatic extension within the sphenoid bone, and categorized it as body, superior extension, anterior extension, posterior extension, lateral extension and inferior extension of sphenoid pneumatization. Body of sphenoid included the conchal, presellar, sellar and post sellar; superior extensions including anterior and posterior clinoid processes, anterior extension into ethmoid bone, vomer, palatine bone. Lateral extensions into Greater wing, lesser wing of Sphenoid and opticocarotid recess. Inferior extension in to pterygoid plates and posterior extension into clivus. We found no conchal pneumatization but 100% of the population had presellar area, 87 % had sellar area and 39.5 % had post-sellar pneumatization. Nathan D. Wiebracht et al. found 9% had presellar, 37% sellar and 54% postsellar pneumatization [1]. Yuntao Lu et al. obtained, amid the 200 cases and 400 side CT cuts they studied, conchal in 6%, presellar in 57 cases (28.5%), the sellar type in 65.5% of all cases [3]. Osama Hamid et al. encountered 6(2%) cases with conchal pneumatization, 62 (21%) presellar pneumatization, 162(54.7%) sellar pneumatization, and 66(22.3%)postsellar pneumatization [13]. The difference in the results may be due to racial difference and also to the way we used the final nomenclature, as presellar in our research included all the sinuses that had presellar pneumatization and any other posterior extensions but, others only included pure presellar pneumatization, limited to a line passing anterior to anterior wall of sellar only, and rest which had presellar pneumatization and extensions beyond fell in to sellar or post sellar groups accordingly. In our group we labeled them according to the

degree of pneumatization and all who had sellar pneumatization eventually had some degree of contribution in to presellar pneumatization (as isolated sellar pneumatization did not occur independent of presellar pneumatization) and post sellar pneumatization had sellar and presellar pneumatization .Due to this we had 100%to have presellar pneumatization, 87%of the population to have both pre and sellar pneumatization, 40%to have all pre, sellar and post sellar pneumatization. So the pure presellar only, was 12.5%, pure sellar was 74.5%and pure postsellar was 13% keeping the figures parallel to Osama Hamid et al. The difference with findings of Yuntao Lu et al. may be due to the racial difference, difference in selection of age, taken by them as 18 years instead of 16years and grouping sellar and post sellar as one entity in to single sellar group by them.

Superior extension in to anterior clinoid process and posterior clinoid process were found in 13.5% and 4.5% respectively in our study. Similar figures were reported about anterior clinoid process (ACP) by Bolger et al. which was 13%, of the 202 paranasal sinus CT scans [9], De Lano et al. which was 4%[2], Sirikci et al. in 29.3% of 92 paranasal sinus cuts [10], Birsen et al. encountered in 24% of 260 patients [11], GH Hewaidi et al. reported anterior clinoid process pneumatization in 15.3% among 300 patients [6]. The discrepancy may be attributed to differences among the study population and to the difference in thinness of the CT cuts, as the sensitivity is increased with reduction of thickness. We used 0.5mm thickness cuts; similarly but our figures were anterior clinoid process13.5% and posterior clinoid process 4.5%, the difference, which may be due to the racial difference.

Lateral extension of pneumatization was revealed in the shape of, 42% in greater wing of sphenoid, and 13.5% in lesser wing of sphenoid in our research. Earwaker discovered greater wing pneumatization in 10.7% of his patients [12], GH Hewaidi et al. observed pneumatization of greater wing in 20%[6]. Even though we defined pneumatization of greater wing of sphenoid as extension of pneumatization extending beyond a vertical foramen rotundum, as the other two researches we found somewhat dissimilar results to them emphasizing the difference that could be due to racial difference [6].Optico carotid recess pneumatization was found in 120(60.%) of the study population and we could not find any significant association between presence of pneumatized opticocarotid recess and neither protrusion and dehiscence of internal carotid artery no optic nerve, unlike the results published by Hewaidi et al.[6].

We recognized pterygoid process pneumatization if it extended beyond a vertical plane crossing the vidian canal. With this criterion we found Inferior extension of the sphenoid pneumatization in to pterygoid process in 115(57.5%) of the total study population. GH Hewaidi et al. with the same criteria as us, found a pneumatized pterygoid process in29%of the patients [6]. Bolger et al. identified pterygoid process pneumatization in 43.6%pf patients [9]. Sirikci et al. recognized pterygoid process if pneumatization extends beyond a plane tangential to the most inferior lateral aspect of the maxillary nerve and vidian nerves and found pneumatization in 29.3% [10]. The high value in our results may be due to our definition of GWS pneumatization, as well as racial difference in Sri Lankans and taking the CT cuts at 0.5mm intervals increasing the sensitivity. Posterior extension of pneumatization was found in 69 (34.5%) of our study population extending the pneumatization in to clivus, while Yuntao Lu et al. found 21.4% with posterior extension in to clivus emphasizing the interracial diversity in anatomy here as well.

Prominence Of the Pituitary Bulge.

In our research 149 had a well-defined pituitary bulge while 51 had an ill defined pituitary bulge in the sagittal cuts of our scans. The sellar bulge was present in 232 scans, whereas this was absent in 64 scans according to Osama Hamid et al [13].

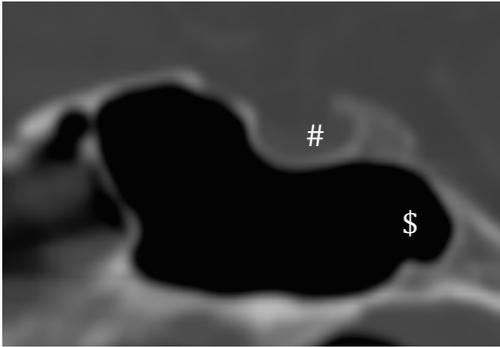


Figure 4.
Sagittal CT scan showing (\$) post-sellar pneumatization and a (#) well-defined pituitary bulge.

Attachment of Sphenoid Septum.

In their publication “Complex Anatomy of the Sphenoid Sinus: A Radiological Study and Literature Review” Wiebracht et al. states septation of sphenoid sinus also influences surgical planning [1]. Kinnman who studied 80 acromegaly patients on plane radiography and found 5% to have no identifiable septum, 41.9% to have a midline septum, 35.5% and 22.4% to have right and left deviations respectively [14]. Ramakrishnan et al. found single septum in 85.5% and 14.2% to have more than one septum [15]. Osama Hamid et al. Who’s work which is considered as a corner stone research in sphenoid sinus, found 10% to be with absent septum, 71.6% to have a single Intersinus septum and 8.7% to have multiple septa. He also found the insertion of the intersphenoidal septum was in the sellar floor in 198 patients (66.9%) while the intersphenoidal septum attached to the carotid canal in 14 patients.. The accessory septum was found in 32 patients (10.8%) and this was attached to the sellar floor in 12 patients and in to carotid canal in 20 patients. Multiple intersphenoidal septa were found in 20 patients (6.8%). All these researches were done on patients with pituitary pathology, which had effects of growth hormone on bone; and also lack ‘much’ emphasis on septal attachment [1]. Although Wiebracht et al. did their study on patients without any pituitary pathology but they could not eliminate the influence of other sinus pathologies affecting their results [1]. They found 4% to have absent septa, 83% to have single Intersinus septa, 3% to have multiple septa and 9% to have diverging septa. The septa terminated 25% lateral to carotids, 34% on the carotids and 48% on the sellar. In our study we found 173 with single inter sinus septum, out of the latter, 159 (79.5%) of our study population had a single intersphenoidal septum (SIS) attaching to sellar floor, 22 (11%) of SIS attaching to optic nerve, 63 (31.5%) to have an attachment to internal carotid artery. Among the 16 (8%) who had a transverse septum 3 (1.5%) were attached to sellar floor, 13 (6.5%) were attached to internal carotid artery (ICA). Out of the 73 patients who had multiple intrasphenoidal septa 27 (13.5%) had them attached to sellar floor, 11 (5.5%) were attached to optic nerve and 14 (7%) were attached to ICA. We also found 129 patients with accessory septa among which 60 (30%) of patients had an attachment to sellar floor, while 7 (3.5%) to optic nerve and a large 68 (34%) to ICA. We found similar results among the latter study and the study done by Osama Hamid (with ours), may be due to the similar selection criteria; further proving his (Wiebracht) point of removing single septum may not be sufficient due to the presence of multiple septa in improving drainage and ventilation of sinus in surgery [1].

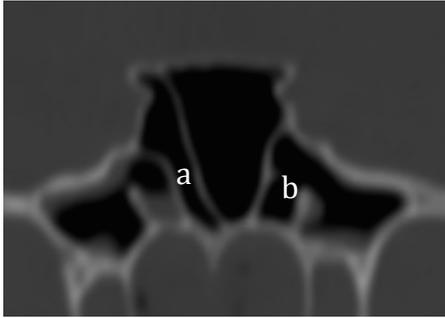


Figure 5.
Coronal CT scan showing a. multiple intrasphenoidal septa and b. bilateral vidian nerve protrusion.

Protrusion of vital structures.

Protrusion of vital structures into the sinus has been a hot topic among the scholars for some time, Sirikci et al and Hewaidi found significant association between same side pterygoid process pneumatization and vidian nerve protrusion [6],[10]. In our research we found significant association between gasification of pterygoid process and vidian nerve protrusion keeping up with their findings ($p=0.002$). It seems the most feared encounter for sinus surgeon would be the accidental rupture of the Internal Carotid Artery (ICA) leading to death, overwhelming hemorrhage, pseudo aneurysm formation, arterial spasm, thrombosis, embolism or formation of carotocavernous fistula [16],[17]. Reports of various statistics are found from 1/4961 in endoscopic sinus surgery (ESS) to high figures of 9% of incidence of ICA ruptures in extended endonasal approaches in pituitary surgery [18]. Renn and Rhoton found 71% had ICA bulging into sphenoid sinus [7]. Hewaidi found 41% [6], Sirikci et al found 26.1% [10] while Birsen et al found 30.3% [11] and we found 55% of study population to have ICA protrusion while 24% being bilateral, 19.5% on right and 11.5% on left. Optic nerve damage exists as a true possibility during pathological process as well as during surgery of the sinuses. The risk of blindness is high when the iatrogenic injury happens in the sphenoid sinus according to Maniglia et al [6],[22]. Sirikci et al reported significant association between pneumatized anterior clinoid process and ICA and optic nerve protrusion although in our research after analyzing 200 scans we could not identify any significant association between gasification of ACP and protrusion of neither ICA nor ON ($P=0.96$) [10]. We could not identify significant association between pneumatized opticocarotid recess and ICA or ON protrusion either ($P=0.95$). Sri Lankan population had 54% ON protrusion while Hewaidi found 35.5%, Dessi et al found 8% and Teatinet al found 70% [6]. These wide variations are mainly due to interracial variation as well as difference of definitions of selection criteria. Maxillary Nerve (MN) protrusion into sphenoid sinus was found on 1 (0.5%) on right side, 4 (2%) on left side and 11 (5.5%) of the study population had bilateral MN protrusion while Hewaidi found 24.5% of their population to have MN protrusion [6], Birsen found 30% [11], though Sareen found none of his subjects to have protrusion of MN into sphenoid sinus [19]. Cho JH et al found 41% of cadaveric subjects to have MN protrusion and also association between protrusions with degree of gasification of sphenoid sinus [20]. Different values of MN protrusion among different study populations indicate the degree of interracial variation of sphenoid sinus, and for a pathological process that can mimic trigeminal neuralgia and it's our understanding that further studies in relationship of MN to the sinus is an area that needs more attention [6].

Dehiscence of bony canals.

Dehiscence of the bony canal of vidian nerve (VN), maxillary nerve (MN), optic nerve (ON) and internal carotid artery (ICA) were also studied in our study population. We found 28 (14%) of our population to have VN dehiscence. Hewaidi et al. found 37% of their subjects to have dehiscence in vidian canal in a study which he used 2.5mm CT scan cuts [6]. Lack of clinical evidence of vidian neuralgia and similar picture in sphenoid sinusitis itself may be evidence for the fewer number of exposed VN in the sphenoid sinus among Sri Lankans. In our study we

found 14(7%) to have maxillary nerve dehiscence while Hewaidi et al found 13%, Birsen et al found definite dehiscence in 3.5% and 14.2 % to have very thin wall which according to our criteria would fall in to dehiscence group summing up to 17.8% [11]. In our study we found 46(23%) to have dehiscence in ON and interestingly we did not find any person with bilateral ON wall dehiscence, while Hewaidi found 30.6% [6]. Fujii et al found 4% to have dehiscence and further comments that even the existing bony canal wall, which is 0.5mm thick in 78% of the population, does not offer significant protection [6], [21]. When analyzing the internal carotid artery we found the prevalence of its dehiscence to be 115(57.5%) and 80(40%) of study population had bilateral dehiscence. Hewaidi found 30% [6]. Kennady et al. found 25%, Sirikci et al. found 23% [10]. Birsen et al. found 5.3% [11]. Fujii et al demonstrated that the bony wall overlying the ICA is not sufficient to protect the artery at less than 0.5mm thick and 4-20% of cases the lateral sphenoid wall is dehiscent separating the ICA by dura and sinus mucosa [21]. We did not find any significant association between ICA protrusion or dehiscence with opticocarotid recess pneumatization or any form of septal orientation but Warmold et al. mentions ,carotid dehiscence and sphenoid septal attachment to ICA , which were 57.5% and 187(96.5%) respectively in our research, as major risk factors. [17].

It is our understanding that this is the first time an attempt was made to use the different patterns of sphenoid septal arrangements as an indicator of a protrusion or dehiscence of the vital structures within the sinus. We were unable to find any literature of similar nature and also we could not establish any significant association between septal arrangement and dehiscence and protrusion of internal carotid artery , maxillary nerve, and optic nerve or vidian nerve.

Conclusion.

The anatomical differences of the sphenoid sinus in the Sri Lankan study sample were common indeed. Occurrence of protrusion in optic nerve , maxillary nerve, vidian nerve and the internal carotid artery were 54%, 8.5%, 24.5% and 79% respectively, while dehiscence were 23%, 7%, 14% and 57.5%. Significant association was found between pterygoid process pneumatization and vidian nerve protrusion, anterior clinoid process pneumatization and protrusion of the internal carotid artery.

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