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SUBNASIO-SELLA DISTANCE FOR TRANSNASAL APPROACH TO THE SELLA REGION: INDIRECT Vs. DIRECT MEASUREMENT ON SAGITTAL SECTION OF THE SKULL IN NIGERIANS

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[1]Ihuoma.A.Igwilo,[2]Ademola.A.Oremosu., [3]Okezie.O.Kanu, [4]Olufunke Dosunmu. [1,2,4] Department of Anatomy, Faculty of Basic Medical Sciences, College of Medicine, University of Lagos, Idiaraba,Lagos. [3]Neurosurgery Unit, Department of Surgery, Lagos University Teaching Hospital, Idiaraba, Lagos.

CORRESPONDENCE:

Dr. Igwilo.A.I
Department of Anatomy,
Faculty of Basic Medical
Sciences, College of Medicine,
University of Lagos, Idiaraba,
Lagos
Email:ihuomaigwilo@gmail.com
Tel: 234-803-313-7894

"Comparing Indirect and Direct Subnasio-sella dimensions may guide transnasal microsurgical instrumentation calibration to suit subjects of Sub-Saharan descent."

ABSTRACT

Objectives: The incidence of pituitary pathology requiring surgery is on the increase. The transnasal approach to anterior skull base is a technique which demands a thorough knowledge of the surgical anatomy. There is a dearth of knowledge on reference values for transnasal surgery on subjects of African descent.
Thus the aim of this study is to ultimately improve visualisation of the surgical corridor, minimize surgical risks and improved maneuverability of surgical instruments during transnasal microsurgery (ergonomics).

Methods & Materials: A total of 11 cadavers of Nigerian descent were employed in this study.
Using the 3 piece caliper set (Big Horn Corporation®,India), an indirect measurement of the Subnasio-sella distance was obtained. Subsequently, a direct measurement was obtained from sagittal sections of the same skulls.

Result: All randomly selected cadavers employed in the study were adult males of Sub-saharan descent. The mean indirect (distance from the anterior nasal spine i.e. subnasal point to the sella floor in an intact skull), direct A (subnasio-sella distance in a sagitally transected skull) and sella thickness measurements were found to be 8.6cm ± 0.38 cm, 8.7 cm ± 0.37 cm and 0.2 cm±0.05 cm respectively ,at 95% confidence interval. Comparison of the indirect and the direct A measurements showed statistical significance ($p<0.5$). A semi-logarithmic equation was derived:
Direct A= 8.297 ln(Indirect measurement) – 9.079

Conclusion: Since transnasal transsphenoidal approach has been successfully used in the treatment of various anterior skull base pathologies, applying a relationship equation would guide choice of instruments employed and immensely minimize associated operative risks.

Keywords: Anterior nasal spine, transsphenoidal, Pituitary surgery, Transsphenoidal, sella, transnasal, microsurgery.

INTRODUCTION

The transnasal approach to the sella region is a technique, which has established itself in the recent years, demands a thorough knowledge of the surgical anatomy and a huge amount of anatomical variations involving the sphenoid sinus.[1]

Anthropometry, which is the systematic collection and correlation of measurements of the human body originated as a discipline in the 19th century when early studies of human biological and cultural evolution stimulated an interest in the systematic description of population both living and extinct.[2]

Cephalometry on the other hand is the scientific measurement of the dimensions of the head, usually through the use of standardized lateral skull radiographs or cephalograms.[3] Therefore, where anthropometric measurements are carried out on the body, cephalometric measurements are done on radiographs. Studies done to analyse these differences were initially carried out and emphasized by orthodontists.[4] One of such studies which assessed the relationship between anthropometric and cephalometric measurements and proportions of the face of healthy young Caucasian adults (men and women) showed that the cephalometric normal measurements varied significantly with those obtained anthropometrically on the same set of subjects.[5]

Consequently, the need for actual anthropometric measurements and subsequent establishment of reference values on this basis cannot be overemphasized.

Modern pituitary surgery began with Harvey Cushing during the early years of the 20th century with the use of sublabial transsphenoidal approach which was initially associated with reduced visualisation of the sella and poor results.[6]

Currently, the basic surgical approaches to the skull base are the transcranial and transnasal approach which may be microscopic or endoscopic. The main advantage of the endoscope, as opposed to the microscope, is that it gives the surgeon the opportunity to advance his visualising instrument and his light source (his 'eyes')-a few centimetres from his target- and then look around, instead of being limited in a narrow corridor allowed by the light and depth of view of the microscope. This does not necessarily indicate a much better dissection of a tumour.[7] Transnasal pituitary surgery has allowed access to lesions located in complex regions in the skull base under direct visual control. It has also been associated with a shorter patient recovery time and reduced surgical risks. In a study carried out by Komoter et al in 2008 to assess the benefit and limitations of various approaches to the resection of craniopharyngiomas, it was observed that the endonasal transsphenoidal approach proved to be safer, potentially surgically aggressive, yet minimal access and a more effective alternative to open transcranial approach.[8] Although, transnasal pituitary surgery may be associated with CSF rhinorrhoea, meningitis, diabetes insipidus, haemorrhage, visual disturbances or damage to structures around the sella turcica, it remains an innovative surgical technique used to remove brain tumors and lesions-some as large as softballs-all through the nose. This approach is emerging as an ingenious, less invasive treatment for pituitary adenomas and has become the optimal surgical approach. It also allows surgeons to treat many hard-to reach tumors and lesions at the skull base, even those, once considered "inoperable", without disturbing the face or skull. It has so far, been associated with less trauma to the brain and critical nerves, few side effects, and shorter recovery times.

Furthermore, a study carried out in Italy pointed out the lack of adequate instrumentation as a major challenge in employing this minimally invasive approach. The researchers also stated that this lack made it almost impossible to manage structures visible within the transnasal surgical corridor.[9]

Although an elaborate research aimed at obtaining and documenting the Apex-sella reference dimensions as well as other relevant reference dimensions, is yet to be sighted in literature, instruments specifically Hardy nasal retractors and nasal speculum, have been generally calibrated are currently employed in transnasal surgery centres around the world. In order to ensure the suitability of transnasal microsurgical instruments on Nigerian patients, it is important to obtain appropriate calibrated values; more importantly as the choice of this minimally invasive approach gains momentum in this part of Sub-Saharan Africa. It is therefore imperative that such reference values designed for Nigerian subjects and accommodating the platyrrhine nasal architecture characteristic of subjects in Sub-Saharan African descent, are obtained, documented and made readily accessible to the surgeons in the fields of Otorhinolaryngology, orthodontics, Oral & Maxillofacial surgery, ophthalmology, neurosurgery, and allied specialties, who may wish to embark on this trending surgical approach that is currently being used in Nigeria.

It is noteworthy that in modern craniofacial anthropometry, features that typify skulls of subjects of Sub-Saharan descent include a broad and round nasal cavity with no dam or nasal sill, quonset hut-shaped nasal bones, notable facial projection in the jaw and mouth area (prognathism), a rectangular-shaped palate, a square or rectangular eye orbit-shape, a large megadontic teeth[10,11], and it has been established according to Ohki *et al* 1991, that there are unique differences between the platyrrhine, leptorrhine (Caucasian) and mesorrhine (Oriental) noses and these differences are statistically significant.[12] Also among the Nigerian people, there exists anthropological differences between ethnic groups, such as, Itsekiri and Urhobo tribes of Nigeria, according to a study carried out by Oladipo *et al 2009*. [13]

The judgment of an anatomic variation is very subjective. The incidence of anatomic variations differs significantly whether assessed by endoscopic inspection, anatomical dissection, or thin-sliced computed tomography (CT) scanning.[14]

In order to obtain a reference measurement of the anterior nasal spine-sella distance on subjects of Sub-Saharan descent for a transnasal pituitary surgical approach to the sella, it is important to determine if there is a statistically significant difference between an indirect and a direct measurement taking into consideration the thickness of the sella bone.

Due to socio-cultural and religious concerns in this environment, there is a need to know if an indirect measurement can be justifiably extrapolated to a direct one; and if indirect measurement values can be established as reference values to guide the choice of instruments employed in this approach, on patients of Sub Saharan descent.

Unpublished data obtained from a study carried out in a tertiary health institute in South- western Nigeria on bodies during autopsy indicated a range of between 8.3 cm and 10.2 cm Apex sella dimension (indirect) in the intact skull of the 50 subjects (male and female)using the three piece caliper. These skulls were only coronally cut to expose the brain and pituitary gland which were removed during autopsy. Sagittal sections of the skulls were not carried out on these bodies for ethical reasons. Thus, there was a need to sagitally dissect skulls of bodies that were probably either abandoned or given up for research purposes (such bodies are usually very few in this part of the world) to compare an indirect similar measurement with a direct measurement on a sagittal section using the same instrument and on the same subjects. It is expected that a relationship might be established between the indirect and direct measurements.

MATERIALS AND METHODS

A total of 11 cadavers randomly selected from the available ones that were previously abandoned or given up for research, obtained from the Gross anatomy lab of the Department of Anatomy, College of Medicine, University of Lagos, were employed in this study.

The study was approved by the ethical committee of the department. Procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional or regional) and with the Helsinki Declaration of 1975, as revised in 1983.

A coronal sawing of the skull was done and the brain parenchyma and pituitary removed to expose the hypophyseal fossa. Using the 3 piece caliper set (Big Horn Corporation®,India), an indirect measurement of the subnasio-sella distance was taken on each body and values recorded (Fig 2). A tip of the craniometer/caliper was placed at the centre of the sella floor and the other tip, at the anterior nasal spine. Subsequently, the skulls were mid sagitally transected in an 'open- book' pattern and a direct measurement from the anterior nasal spine to the sella floor in the sagittal section of the nasal lumen using the same instrument, was measured as well on the same set of subjects and values recorded(Fig 3).

Data was collected and analysed using the Epi info 3.5.1 statistical software.

Aim & Objectives of study:

1. To compare an indirect (distance from the anterior nasal spine i.e. subnasal point to the sella floor in an intact skull) with a direct A measurement (subnasio-sella distance in a sagitally transected skull) using the same instrument and on the same subjects, to find out if there is a statistical significant difference between both parameters and possibly establish a relationship equation between the parameters in view.
2. To evaluate the difference between Direct A (subnasio-sella distance in a sagitally transected skull) and Direct B (distance between the anterior nasal spine/subnasal point and the sphenoid sinus facing wall of the sella floor), which will be equivalent to the sella bone thickness (x) in centimetres.

RESULT

All eleven available cadavers employed in the study were adult males of Sub-Saharan descent. Measured Measured parameters were repeated thrice and the mean noted. The mean indirect, direct A and sella thickness measurements were found to be 8.6 cm ± 0.38 cm, 8.7 cm ± 0.37 cm and 0.2 cm±0.05 cm respectively, at 95% confidence interval. The indirect subnasio-sella length ranged from 7.5 cm to 9.8 cm while for direct A, it was found to be 7.7 cm to 9.9 cm and sella thickness yielded a range of 0.1 cm to 0.4 cm.

The median of the grouped data yielded 8.5 cm, 8.6 cm and 0.2 cm for indirect, Direct A and sella thickness respectively.

Applying T-test in comparing the indirect and the direct A measurements, they were both found to be statistically significant beyond that attributable to chance i.e. Null hypothesis was rejected ($p<0.5$).

Both the difference in indirect and direct subnasio-sella mean dimensions were statistically significant, a semi-logarithmic plot was therefore carried out on the data to determine the correlation equation between the direct A and indirect data. The following equation was derived from this plot:

Direct A= 8.297 ln (Indirect measurement) – 9.079

Where ln – natural logarithm

Correlation graph can be seen in the figure 6.

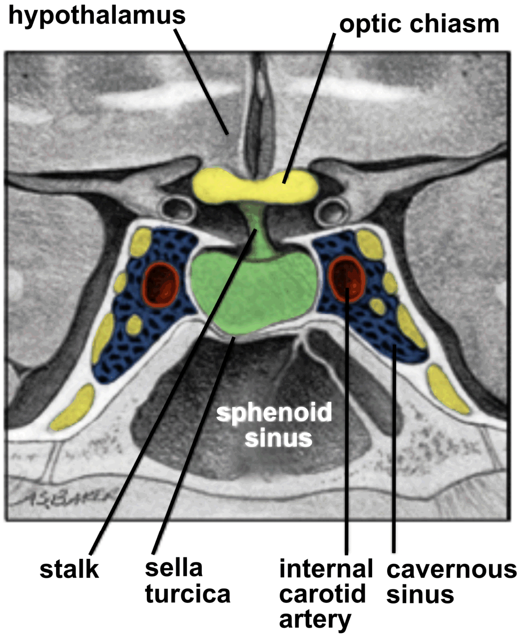


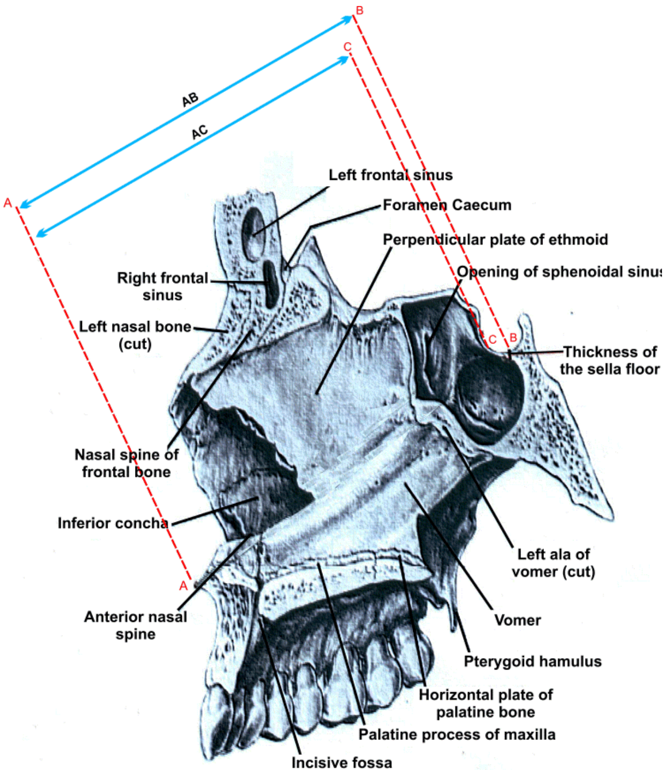
Figure1. A schematic diagram of the sella turcica housing the pituitary gland and located superior to the sphenoid sinus and its proximity to vital neurovascular structures (culled with permission from www.mayfieldclinics.com)

DISCUSSION

The traditional transseptal/translabial approach is the standard transsphenoidal approach, considered as the ‘gold standard’, associated with minimal morbidity and mortality. In the last 20 years, however, the introduction and the development of specialist instrumentation have redefined pituitary surgery. The transnasal approach is increasingly popularized and progressively replacing the gold standard approach in pituitary surgery.

The thickness of the hypophyseal fossa floor (mean = 0.2 cm) (Fig 6) probably accounts for the statistical significant difference in the length between the anterior nasal spine (subnasal point) and the sella floor obtained indirectly (Fig 2) and directly (Direct A) (Fig 3) beyond that attributable to chance ($p < 0.05$). Same values were obtained as the means for the mode and median of the sella floor thickness. In comparing the direct measurements from the subnasal point to the inner wall of the sella floor (Direct B) and from the subnasal point to the outer wall of the sella floor (Direct B), statistically significant difference in both measurements were

Figure2. (Indirect Measurement) A picture showing the subnasio-sella dimension taken indirectly from inside out, on a body during autopsy using a craniometer; Obtained with permission from the ethical board of the Lagos University Teaching Hospital



AB--- Direct A ; AC--- Direct B

Figure 3. Showing the medial wall of the left half of the nasal cavity, showing the vomer in situ as well as the points of reference for Direct A & B distances with respect to the thickness of the sella floor obtained with permission from www.prohealthsys.com

obtained, confirming further that sella floor thickness should be taken into cognisance when fashioning the hardy retractor and nasal speculum used in transnasal pituitary surgical approach to the sella region. (Table 1, Fig 7A &7B)

A semi-logarithmic relationship between the indirect and direct A measurements was determined. (Fig 7) This equation which was applied to the indirect values measured obtained the corresponding direct A value with a ±0.1 error; This provides a useful guide in the choice of instruments used in such approach, based on these calibrations. Calibrated instruments are often recommended to gauge sphenoid location based on the average distance of sinus from the anterior nasal spine. In a study carried out in India, on the sphenoid sinus anatomy by Deepika.S. *et al*, this distance was found to be 7.9 cm on an average.[1]

The development of pituitary surgery over the past century is largely credited to the pioneer work of Harvey Cushing in the early 1900s, whose accumulated extensive experience in various operative techniques included transcranial and transseptal-transsphenoidal approaches to the pituitary gland, but ultimately came to favour the transcranial approach.[15] This may have been due to the paucity of equipment for the transnasal approach at the time. In 1907, Schloffe performed the first transsphenoidal pituitary tumor resection and later in the 1960s, Jules Hardy introduced fluoroscopy and microscopy to transseptal-transsphenoidal pituitary surgery while the transcranial approach was reserved for larger pituitary tumours with extensive parasellar and suprasellar invasion. With the advent of modern equipment, momentum in the field of pituitary surgery has stemmed from clinical findings comparing the endoscopic and microscopic approach. It was found that the latter allowed for a more thorough tumor resection

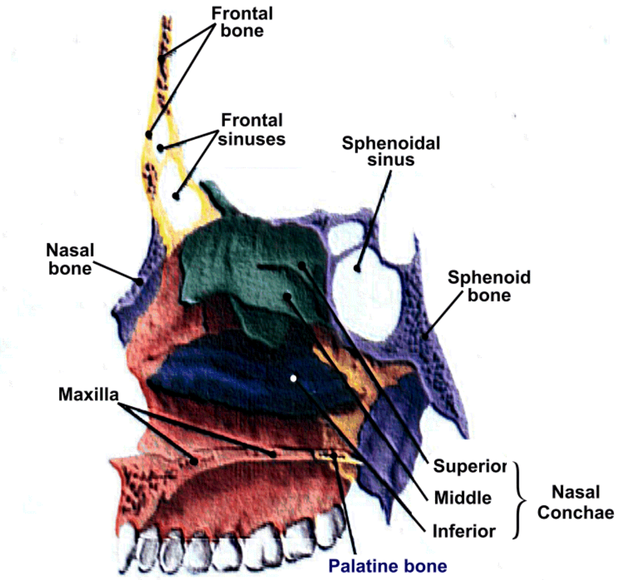
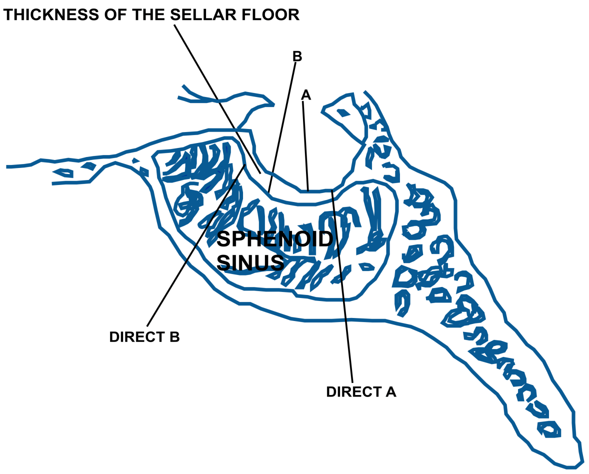


Figure 4. A more lucid schematic diagram of the sagittal view of the nasal cavity (similar to figure 3) obtained with permission from www.flashcardmachines.com

& fewer associated surgical complications.[15] Although the claims of the protagonists of Endoscopic endonasal transsphenoidal approach of better results, less



AB = Thickness of the sellar floor

Figure 5. A schematic diagram focusing on the thick sella bone and the proximal points of reference for Direct A & B measurements (obtained with permission from neurosurgery 2008;63;ONS44-ONS53)

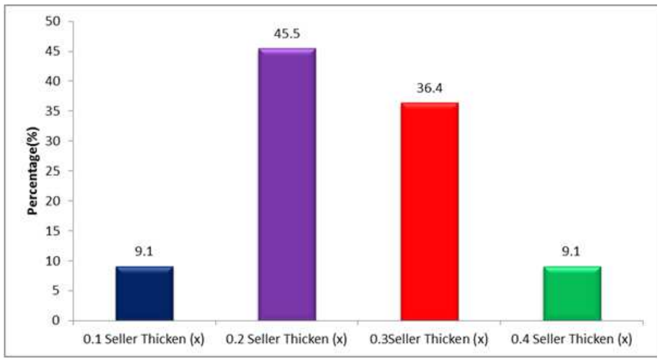


Figure 6. A bar chart showing the distribution of sella thickness(x)

less complications and decreased morbidity have not yet been substantiated, there are indications that transnasal approaches have less approach-related morbidity and a lower approach-related complication rate than transseptal and sublabial transsphenoidal approaches. It is not yet clear whether a microsurgical approach or an endoscopic approach differ in their results.[14] In order to minimize the deleterious effects of facial incisions, approaches to these tumours have become progressively less invasive such as the transnasal approach to the sella which has been associated with reduction in operating time, recovery time and complications. An extensive discourse on the benefits of microscopic over endoscopic or vice versa, is beyond the scope of this work. The idea here is to communicate that in the course of determining appropriate reference values of instruments used in this procedure, it is important to take into cognisance the thickness of the sella floor (Fig 7A & 7B) which has been found to statistically & significantly alter the subnasio – sella (direct) dimension as compared to the indirect. Thus, a relationship equation may be applied to the indirect measurement to obtain an almost accurate direct measurement, which will guide the choice of appropriate instruments for this less invasive approach to be meticulously, appropriately and atraumatically performed, keeping in mind that the wall of the sphenoid sinus borders the carotid arteries, cavernous sinuses and optic chiasm.(Fig 6) Obtaining pre-operative computed tomography images of the transnasal surgical corridor cannot be overemphasized. In a study carried out by Abe *et al* (2003) in Japan on the usefulness of

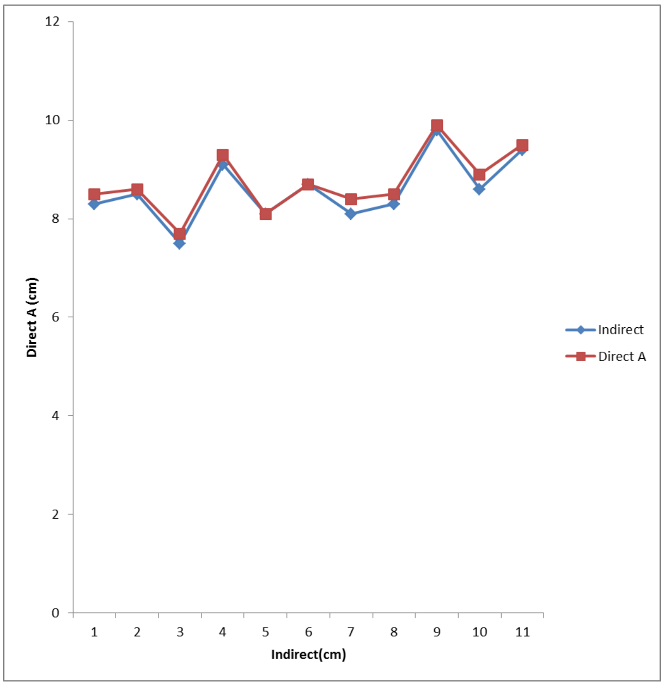


Figure 7A. A line plot graph showing the distribution and relationship between Indirect and Direct A

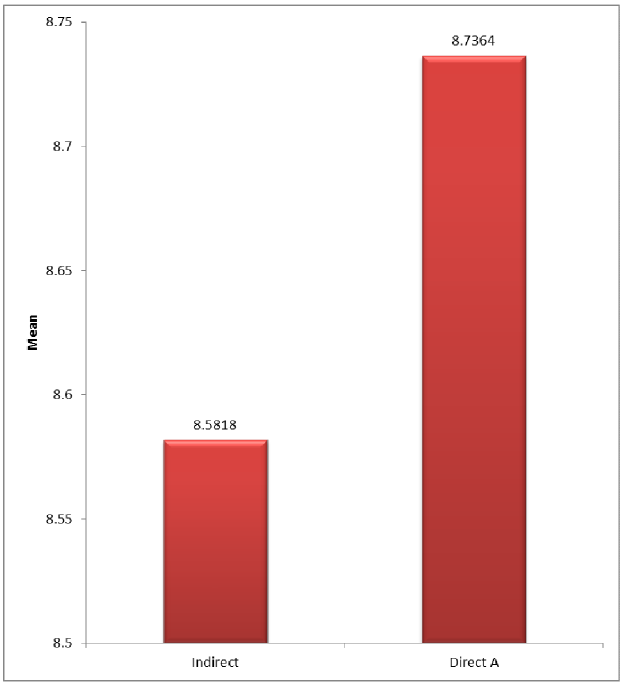


Figure 7B. A bar chart showing the mean distribution of Indirect and Direct A values

bone window computed tomography images parallel to the transnasal surgical route for pituitary disorders, it was found that image slices parallel to the transnasal route provided direct visualisation of the nasal anatomy for a transnasal approach as well as being helpful in determining how far to remove the sella floor laterally, especially in cases requiring repeat surgery.[16]

It is important to prepare the surgery well with adequate decongestion of the nasal mucosa. This can be achieved with patties drenched in a mixture of cocaine hydrochloride 5% and epinephrine 1mg/ml placed medially to the middle and inferior turbinates. Some surgeons prefer a monostril approach, whereas others advocate a binostril approach. Protagonists of the former claim less traumatization; however, introduction of instruments might harm the nasal mucosa or necessitate removal of the middle turbinate which undercuts this procedure's "minimally invasive" feature.[14]

In a study of variations of endonasal anatomy and its relevance to transnasal approach by Erik *et al 2010*, carried out to register the frequency of transnasal anatomical variations and to evaluate whether these variations hinder the progress of the transnasal approach, it was found that anatomical variations are frequent (e.g. septum deviations, spina septi, concha bullosa, narrow nasal lumen, presence of onodi cells) as seen in almost half of the patients in the study, this number is speculated to be lower in radiological studies. However, these variations do not pose a relevant obstacle to this surgical approach.[14]

Even though transnasal pituitary surgical approach is normally associated with minimal blood loss, there is a potential for significant haemorrhage given the proximity of the pituitary to the internal carotid arteries, and though infrequent, this may be fatal. In such cases, deliberate hypotension may improve visualisation and help to facilitate repair.[17] In the study by Erik *et al 2010*, it was also found that postoperative complications related to the this approach are rare and occurred in only 3.8% of patients ranging from loss of orientation resulting in cerebrospinal fluid leakage, severe epistaxis and postoperative sinusitis.[14] This further buttress the

Table 1. Indirect and Direct Subnasio-sella measurements of eleven (11) cadaveric heads of Nigerian descent.

Cadaver No	Indirect	Direct A	Direct B	Sella thickness
1	8.3	8.5	8.2	0.3
2	8.5	8.6	8.5	0.1
3	7.5	7.7	7.3	0.4
4	9.1	9.3	9	0.3
5	8.1	8.1	7.9	0.2
6	8.7	8.7	8.5	0.2
7	8.1	8.4	8.2	0.2
8	8.3	8.5	8.3	0.2
9	9.8	9.9	9.6	0.3
10	8.6	8.9	8.7	0.2
11	9.4	9.5	9.2	0.3

need for applying this semi-logarithmic relationship equation possibly accrued to the sella bone thickness in obtaining reference values for the hardy retractor and nasal speculum used in such surgical approach.

The sphenoid sinus is subject to considerable variation in size, shape and degree of pneumatisation.[18] The first description of sphenoid sinus mucocoele in 1989 (Stankiewicz) has led to the development of a variety of surgical approaches to the sphenoid sinus e.g. Intracranial, transeptal, transantral, external, etc. But all these approaches had their inherent problems. The transnasal approach, however, affords outstanding visualisation and a safe, straightforward approach to the sphenoid sinus.[1] Based on the extent of its pneumatisation, the sphenoid sinus has been classified into the conchal, presellar and sella/post sella types. In the conchal type, the area below the sella is a solid block of bone without an air cavity. In the presellar type, the air cavity does not penetrate beyond a plane perpendicular to the sella wall. The sella type is the most common; occurring in 70% of individuals, and the air cavity extends into the body of the sphenoid below the sella and may extend as far posterior as the clivus. The postsellar type of sphenoid sinus is well pneumatised with bulging of the sellar floor into the sinus.[1] The conchal type is common in children under the age of 12 years and infrequent in adults. The ostia of the sphenoid sinus are usually located in the spheno ethmoidal recess, medial to the superior turbinate. The medial and superior walls are usually smooth and the superior wall may balloon outwards from pressure of the sella turcica.

Two bulges on the lateral wall of the sinus are of considerable clinical significance. They are produced by the optic nerve and the internal carotid artery. Depending on the degree of pneumatisation, these two bulges may be barely noticeable or very obvious. Also in a study carried out in India, of sphenoid sinus anatomy by Deepika *et al*,the distance from the anterior nasal spine to rostrum of sphenoid ranged from 7.2 to 9.3 cm (mean=7.9 cm).[1] The thickness of the bone separating the sella from the sphenoid sinus, in the conchal type has been estimated to be least 10mm in cadaver studies,[18] while the width of the planum sphenoidale anteriorly, between the lamina papyracea has been estimated at 26±4 mm, and narrows to 16±3 mm posteriorly at the posterior aspect of the tuberculum sella.[18] A sphenoid sinus that has presellar pneumatisation on one side and sella type on the other side is not uncommon. This emphasizes the importance and usefulness of cadaveric dissection is learning transnasal anatomy. The Freer elevator or the use of a mallet to perceive the thickness of the sella floor may be bypassed if the exact length of the surgical corridor can be predetermined. This will also be useful in fashioning out the appropriately sized transnasal microsurgical instruments such as the hardy retractor and the nasal speculum.

In 1975, Rhoton, together with Renn dissected and analysed the microsurgical anatomy of 50 adult sella regions removed *en bloc*.

The particular emphasis of their study was to investigate the implication the variations in the anatomy held for different surgical approaches and the incidence of each variation. Their findings considered factors disadvantageous to the transnasal approach were large anterior intercavernous sinuses extending anterior to the gland just posterior to the anterior sella wall (10%), a thin diaphragm (62%), a diaphragm with a large opening (56%); carotid arteries exposed in the sphenoid sinus with no bone covering (4%), the carotid arteries that approach within 4mm of the midline within the sella (10%), a thick sella floor (18%); sphenoid sinuses with no major septum (28%) or a sinus with the major septum well off midline (47%) and a presellar type of sphenoid sinus with no obvious bulge of the sella floor into the sphenoid sinus (20%).[19,20]

A study of 24 adult Caucasian cadavers carried out at the University of Thessaloniki, Greece, undertaken to assess and document the anatomical measurements within the nasal cavity and sphenoid sinus as routes of instrumentation utilized in sublabial transsphenoidal and transnasal approaches, revealed that the mean thickness of the bony floor of the sella type of sinus was 0.9 ±0.4 mm,[21] which is about a millimeter less than those carried out in this study on cadavers of Nigerian descent, suggesting a close similarity in the data obtained.

The results obtained from this study have attempted to expand the current anatomical knowledge of this segment of the transnasal surgical corridor, and the semi logarithmic relationship equation developed (figure 7), may be applicable in further studies carried out on sagitally non-transected skulls of Nigerian descent and other non-Caucasian races in a bid to possibly obtain reference values, and inter racial variations. This may also be useful in the calibration of newly designed surgical instruments.

Future Research:

Significant points for future study include interracial variations in patterns of septation, bulge or dehiscences related to the maxillary nerve and the sella floor, as well as inter and intraracial variations in terms of relationship of the internal carotid artery and optic nerve to the sphenoid sinus, in the Black population, may also be studied.

CONCLUSION

This study has demonstrated the feasibility of obtaining such reference values for transnasal pituitary surgical approach to the sella region, in subjects of Sub Saharan (Nigerian) descent. Since this approach has been successfully used in the treatment of cerebrospinal fluid rhinorrhoea, removal of encephalomeningocoele, and resection of tuberculum sellae, planum sphenoidale, and olfactory groove meningiomas, applying this relationship equation to obtain a near-accurate approximate which could guide the choice of hardy retractors and nasal speculum employed, would immensely benefit the surgeon's maneuverability, minimize associated morbidity & mortality, and lay a ground work to motivate and inspire future research relevant in this area.

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Keys:

Indirect: Distance between the subnasal point and the skull base wall of the sella bone in an intact skull

Direct A: Distance between the subnasal point and the skull base wall of the sella bone in a sagitally transected skull

Direct B: Distance between the subnasal point and the sphenoid sinus portion or wall of the sella bone in a sagitally transected skull

*The difference between Direct A and Direct B is the sella thickness

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Authors Contributions:

IAI: Concept and Design of the study and data collection, statistical analysis and manuscript preparation.
AAO: Parcitipated in the data collation and supervision.
OOK: Concept and Design of the study, Wrote the protocol of the study. Analysis and interpretation, manuscript preparation, critical revision of the manuscript, statistical analysis, and literature search.
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