

# Towards the Understanding of Sinonasal Anatomical Variations — A Cadaveric Study

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## Abstract

A thorough understanding of the sinonasal anatomy is required for the performance of a safe and successful surgery. With the aim to identify the variations in sinonasal anatomy in north Indian population twenty fresh cadaveric heads were dissected by messerklinger technique to identify various sinonasal anatomic variations in north Indian population. The variations in the key landmarks of nose and paranasal sinuses during endoscopic sinus surgery were noted and compared with other studies. Identification and differentiation of the normal and the abnormal sinonasal anatomic variations helps in preventing complications and giving optimum surgical results.

**Keywords:** Endoscopic sinus surgery, paranasal sinus anatomy, orbit.

## INTRODUCTION

The realm of endoscopic sinus surgery has expanded from a limited surgical intervention for chronic sinus disease to a favored approach for the treatment of sellar and suprasellar lesions, skull base defects associated with cerebrospinal fluid (CSF) rhinorrhea, orbital and optic nerve lesions. Due to the close proximity of vital structures such as the orbit and skull base, various major complications can occur. The extensive use of radiological imaging and the image guided navigation systems can in no way replace the surgeon's thorough and intimate knowledge of the endoscopic sinonasal anatomy and its possible variations which is a prerequisite to the performance of a safe and successful surgery. In this regard several instructional courses and cadaveric dissection courses are organized all over the world to familiarize the novice endoscopic sinus surgeons with the nuances of endoscopic sinus surgery and the varied anatomical presentations. Various cadaveric and radiological studies have been carried out to identify the critical landmarks and the various variations in sinonasal anatomy. Rontal and Rontal<sup>1</sup> reported in 1991 the usefulness of whole-organ sections to determine the anatomic relationships

and the critical landmarks for Endoscopic Sinus Surgery. Becker<sup>2</sup> analyzed serial sections of frozen cadaver heads in axial, coronal, and sagittal planes with specific attention to the gross anatomy of the paranasal sinuses. However, only a few studies have been carried out in Indian population.

The aim of this cadaveric study was to identify the variations in sinonasal anatomy in north Indian population.

## MATERIALS AND METHODS

Twenty fresh cadaveric heads were used. There were eighteen males and two females. Age of the subjects ranged from 40-70 years. 0 and 30 degree rigid nasal endoscopes (length 18 cm; diameter-4 mm) were used. The other equipments used included the standard nasal endoscopy instruments. The messerklinger technique was adopted for dissection. The various parameters and landmarks relevant to the performance of a safe and successful endoscopic sinus surgery were studied.

## NASAL SEPTUM

The nasal septum was midline in 6 cases; deviation with septal spur was seen in 14.

## INFERIOR TURBINATE

Inferior turbinate hypertrophy was seen in 4 patients – unilateral in 3 and bilateral in 1 patient. Inferior turbinate pneumatization has been reported but is very very rare<sup>3-11</sup>; it was not seen in any of our cases.

## MIDDLE TURBINATE

Paradoxical middle turbinate was seen in 3 cases; concha bullosa was identified in 5 specimens; L shaped middle turbinate was seen in 2 specimens. Separate anatomic studies by Davis<sup>12</sup> and Turner<sup>13</sup> found conchae bullosa in 8% and 20% of cadaveric specimens, respectively radiographic evidence of middle turbinate pneumatization was identified in 9.6%,<sup>14</sup> 10%.<sup>15</sup>

The basal lamella of middle turbinate separates the anterior and the posterior ethmoids and is variably pushed forward or shifted backwards depending on the pneumatization of anterior and posterior ethmoids. Basal lamella is perforated inferomedially to gain entry into posterior ethmoids (Fig. 1).

## SUPERIOR TURBINATE

It was seen in all 20 specimens; sphenoid sinus ostium could be seen medial to superior turbinate in 19 specimens; it was lateral to superior turbinate in just one specimen.

## SUPREME TURBINATE

It was not seen in any of the specimens.

## MAXILLARY LINE

It is a key landmark for endoscopic dacryocystorhinostomies and corresponds to the anterior attachment of uncinat process; it was easily identifiable in all but 1 specimen. The incision for uncinectomy has to be placed just posterior to the maxillary line to ensure complete removal of uncinat process. On removing the frontal process of maxilla, nasolacrimal sac and duct were exposed; the average distance between the duct and the maxillary sinus ostium was 11.2 mm.

## UNCINATE PROCESS

Flattened uncinat process was seen in 7 specimen; medially rotated uncinat process was seen in 3 specimens.

## MAXILLARY SINUS OSTIUM

The natural maxillary sinus ostium was situated hidden in the ethmoidal infundibulum (Fig. 2) and was exposed on removal of the posteroinferior end of uncinat process in

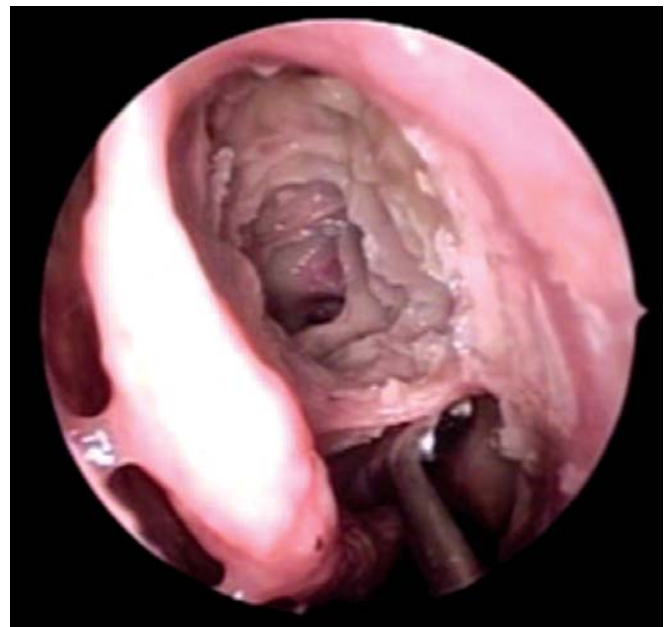


Figure 1: Endoscopic picture showing the middle turbinate, the dissected posterior ethmoids and the basal lamella in cadaver

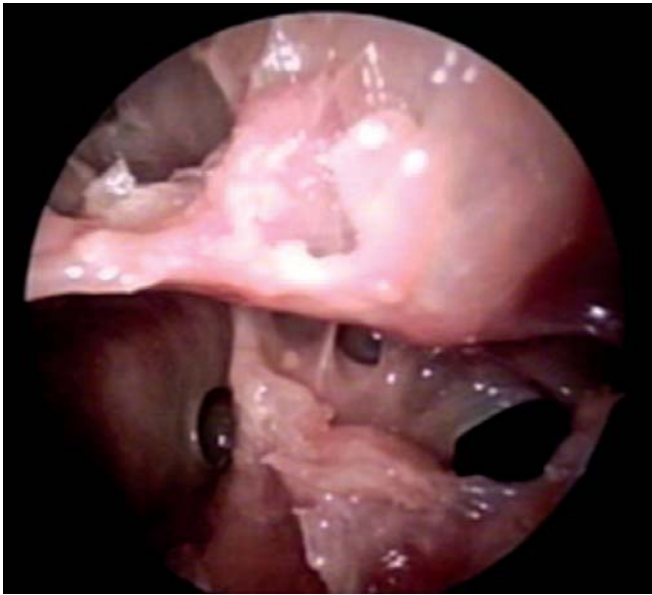


Figure 2: Sagittal cut section of the specimen with the pointer in the ethmoidal infundibulum

all specimens. Accessory maxillary sinus ostium was seen in 7 cases located at the anterior and posterior fontanelles of the lateral nasal wall; unilateral in 2 and bilateral in 5; they were round in 2 and oval in 5 (Fig. 3). Anatomic studies have shown variable configuration of accessory maxillary ostia.<sup>16</sup>

## ETHMOIDAL BULLA

Involvement of the frontal and maxillary sinuses is secondary to the mucosal disease in the anterior ethmoid air cells. Ethmoidal bulla is the largest and most consistent air cell of



**Figure 3:** Endoscopic picture showing the natural and accessory maxillary ostia in cadaver

the anterior ethmoid cells. A well pneumatized bulla ethmoidalis was seen on 39 sides; flat bulla indicating under pneumatization was seen in one patient on left side. Meticulous removal of the bulla is required lest it may result in inadvertent frontal recess obstruction, lamina papyracea perforation, middle turbinate lateralization, or unnecessary posterior ethmoid dissection. Absence or underdevelopment of ethmoidal bulla has been reported in 8 to 40% of cases.

### SINUS LATERALIS

Sinus lateralis is synonymous with retrobullar and suprabullar recess. It is a space bordered by the Basal lamella posteriorly, the Ethmoidal Bulla anteriorly and inferiorly, the lamina papyracea laterally, and the fovea ethmoidalis superiorly. A well developed sinus lateralis was identifiable on 36/40 sides (Fig. 4). In the study by Picerno et al.<sup>17</sup> sinus lateralis has been suggested as a consistent landmark because of its presence in 98% of anterior ethmoid specimens. They have also proposed a classification system describing four configurations of sinus lateralis. Lamina papyracea dehiscence was also noted in just one specimen on right side. Agger nasi cells were noted in 12 (80%) specimens. Davis,<sup>12</sup> Mosher,<sup>18</sup> van Alyea,<sup>19</sup> and Bolger et al.<sup>20</sup> reported agger nasi cells in 40%, 60%, 89%, and 100% of the cases, respectively.

### SPHENOID SINUS

Sphenoid sinus was approached by medial to middle turbinate approach in all the specimens. Sphenoid sinus ostium was

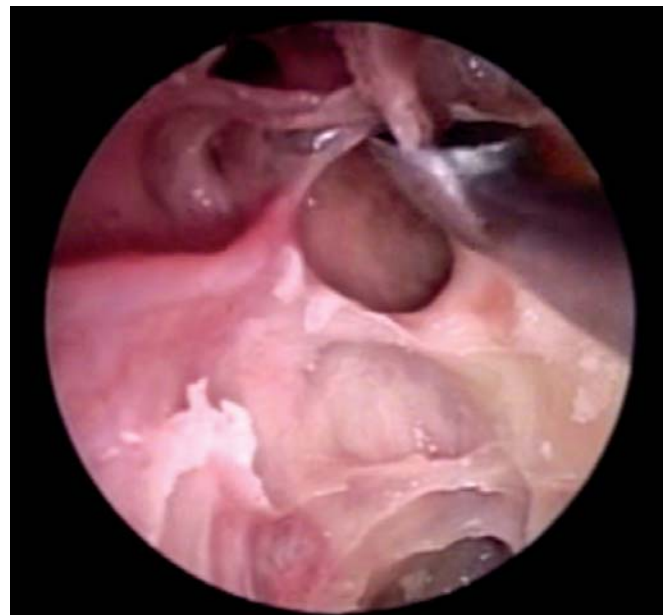
identified in the sphenoid recess medial to superior turbinate. It was round in 20%; slit like in 30% and oval in 50% of specimens. A wide sphenoidotomy was done after excising the lower one-third of superior turbinate and the bulge of the optic canal, carotid canal and sella, medial and lateral carotico optic recess were identified. Any septations of the sphenoid sinus and the attachment of septae were noted.

Sellar bulge was seen in 14 cases.

The bulge of the optic canal (Fig. 5) and the carotid canal and carotico optic recess could be seen in all cases. After dissection sagittal sections of the specimen were cut to study the course of optic nerve beyond the sphenoid sinuses (Fig. 6).

In 5 cases single intrasphenoidal septum and in 15 cases multiple septae were seen. The sphenoid sinus was lateral to midline in 16/20 cases intrasphenoidal septum was seen to be attached to the carotid canal in 3 cases – one in single septum group and two in multiple septae group. In a study by Birsan et al.<sup>21</sup> intrasphenoidal bony septa were seen in 19 cadaveric sinuses (79.1%); the septa were inserted into the bony covering of the carotid arteries in two sinuses (8.3%) and none into the optic canal.

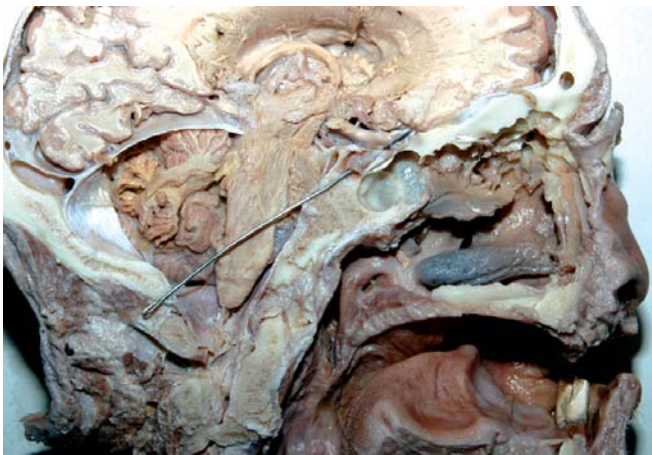
Dehiscence of bone over the optic canal was seen in 2(5%) specimens – both on the right side. Sareen et al.<sup>22</sup> in her study did not notice any protrusion or dehiscence of optic nerve. Sirikci et al.<sup>23</sup> reported concomitant dehiscence of bony coverings of both ICA and optic nerve in 3.2% cases. In the study by Sprinzl et al.<sup>24</sup> the intersphenoid septum was noted to lie lateral to the midline in 86.7% of specimens. In 4 of 30 specimens (13.3%) dehiscence in the lateral wall



**Figure 4:** Endoscopic picture showing the suprabullar recess



**Figure 5:** Endoscopic picture showing the optic canal bulge



**Figure 6:** Sagittal cut section of the specimen showing the course of the optic nerve in relation to the sphenoid sinus

of the sphenoid sinus was found with the internal carotid artery being covered only by mucous membrane. In our study dehiscence of the bone over internal carotid artery was seen in 1(5%) specimen on both the sides. It was similar to few other studies (sareen et al<sup>22</sup>, birsen et al<sup>21</sup> –5.3%, elwany et al<sup>25</sup> –4.8%). However, few other studies have reported a higher incidence. Sirikci et al<sup>23</sup> reported dehiscence of internal carotid in 22.8% of cases; Hewaidi et al<sup>26</sup> reported 30% dehiscence in Libyan cadavers. Occasionally, the bone would be completely deficient and internal carotid artery with only mucoperiosteal covering would be seen in such cases even infection of sinus may make the protruding artery vulnerable to damage.

## ONODI CELLS

Onodi cells are posterior ethmoid cells superolateral to the sphenoid sinus and are intimately associated with the optic nerve. The knowledge of existence of onodi cell in a particular case is extremely important to prevent inadvertent injury to the optic nerve during endoscopic sinus surgery. Onodi cells were seen in two cases on the right side and 2 cases on the left side (10%) in our study (Fig. 6). The optic nerve was seen to lie intimately along its lateral wall which was dehiscent in two cases. Weinberger et al<sup>27</sup> reported onodi cells in 14% (6/44 cadavers) they were located lateral, superior or superolateral to the sphenoid sinus.

Sareen et al<sup>22</sup> did not come across any onodi cell in their specimens.

Sanguansak et al<sup>28</sup> found an onodi cell in 39 of the 65 specimens (60%) Ong and tan<sup>29</sup> reported onodi cell in 52 of the 102 half heads (51%; b/l in 43.1%; u/l in 7.8%).

## FRONTAL SINUS

Unilateral hypoplastic frontal sinus was seen in 2 cases (5%) while in the rest frontal sinus was well pneumatized (95%) (Figs 7 and 8). Bent and Kuhn frontal cells configuration in our specimen cohort was as follows (Table 1).

## DISCUSSION

Knowledge and familiarity with the different anatomical variations helps in the prevention of various potential major and minor complications during endoscopic sinus surgery. The various anatomical variations may not be pathological per se but their identification preoperatively helps maintain the orientation of the surgeon in the performance of a safe and accurate surgery.

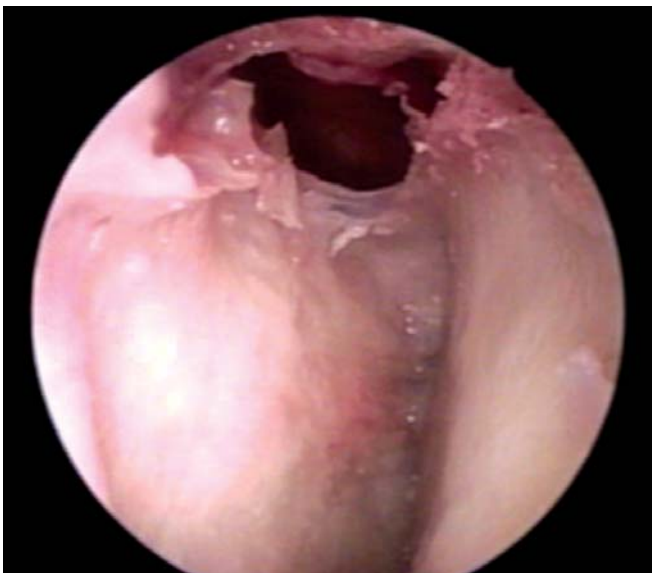
Sprinzl et al<sup>24</sup> in their study using plastinated whole-organ serial sections showed the different bone densities in the various sinus walls. The bone density in the lower part of the sphenoid sinus was found to be higher than the upper part and that the bone density of the lateral wall of the sphenoid sinus is not completely homogenous. The anterior part of the ethmoidal roof was less dense as compared to the posterior part thus being more prone to intraoperative breach.

Septal deviations and septal spurs are very common but they should be surgically corrected only when they cause symptoms.

Middle turbinate is a very important landmark and has a great surgical importance. The various variations in shape, bend and pneumatization are not necessarily pathological. Lateral lamnectomy for concha bullosa should be performed only when it hinders adequate exposure and access during surgery or it blocks the drainage of ethmoidal infundibulum



**Figure 7:** Sagittal cut section showing the pointer in the fronto-ethmoidal recess



**Figure 8:** Endoscopic picture showing the frontal sinus through the widened ostium

**Table 1:** Showing the distribution of various types of frontal cells

Type of frontal cell configuration	Number	Percentage
Type 1	28	70%
Type 2	7	17.5%
Type 3	4	10%
Type 4	1	2.5%

medial part of middle turbinate is not excised for it is attached to skull base and rough manipulation at this region might lead to flabby middle turbinate and injury to the skull base. During endoscopic sinus surgery, one should always stay lateral to middle turbinate to avoid iatrogenic skull base injury.

Superior turbinate serves as an important landmark for sphenoid sinus ostium and sphenoidal recess. The resection of posterior one-third of superior turbinate is usually done in medial to middle turbinate approach to sphenoid sinus.

Supreme turbinate is present in very few cases. The attachment of the middle and superior turbinate to the skull base may be separate or they may join before getting attached via a single bony plate to the skull base.

Resection of the uncinete process is the primary step of any endoscopic sinus surgery. Partial uncinectomy (i.e. removal of postero-inferior part of uncinete process) suffices for maxillary antrostomy in cases of isolated maxillary sinus disease. Complete removal of uncinete process is essential in cases of pan sinus involvement especially for addressing frontal recess and frontal sinus pathology. The superior attachment of uncinete process is variable – to skull base, or lamina papyracea, or to middle turbinate and it must be ascertained preoperatively by computed tomography. Inadvertent injury to lamina papyracea and orbital fat exposure may occur during uncinectomy. Various techniques of uncinectomy have been described viz. conventional, swing door, etc; it mainly depends on the preference of the surgeon.

Variation in pneumatization of Ethmoidal bulla is very common. Overly pneumatized bulla may obstruct the drainage of ethmoidal infundibulum and frontal recess. In cases with under pneumatized bulla or torus tubaris chances of injury to lamina papyracea are very high if preoperative evaluation is not done. Intact bulla technique can be used when the bulla is not overly pneumatized so as to obstruct the sinuses. This technique reduces the chances of orbital injury as there is an intervening mucosa covered cell between the lamina and the surgeon.

## CONCLUSION

An indepth knowledge of the surgical anatomy coupled with acquaintance with the various anatomic variations is essential for the endoscopic sinus surgeon in his sojourn through the nose and paranasal sinuses to the orbit and the skullbase.

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