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# Comparative study of the morphological features of paranasal sinuses in human and animal cadavers

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**Abstract**
**Introduction:** Endoscopic sinus surgery is a surgical procedure performed to remove blockage of the paranasal sinuses. It has a wide range of indications from simple nasal polyp removal to Cerebrospinal fluid leak repair. It is relatively safe procedure in the hands of expert otolaryngologist, when performed precise knowledge of the anatomy of the paranasal sinuses and the internal nasal landmarks is essential. Therefore, we felt there is a need to conduct such study between human cadavers and some common animals, which are available easily so that it offers the advantage of similarity in anatomy of the paranasal sinuses which help us to study the morphological features of the sinuses, resemblance and differences between them and promotes easy learning by trainees before embarking on real patients.
**Methods:** The study was carried out into two part: 1) Human part was carried on fifty skulls of Cadavers, formalin treated heads of adult humans. In each skull sagittal sections were done using sharp electric saw. The measurement of height, breadth and depth of each sinus was taken using compass and Vernier Calliper. 2) In animal part we chose sheep, rabbit and dog as 50 fresh dried skulls for each species were studied. Sagittal sections were done in every skull by using electric saw. The measurements and diameters of each sinus were done by the aid of compass and Vernier Calliper. The clinical work was carried out on fifty healthy individuals on complementary basis.
**Result:** The dimension of vertical height, transverse diameter and anterior posterior depth in human by centimeters were near to that of the sheep. The mean vertical height of frontal sinus was 2.98 cm in human and the nearest vertical height of frontal sinus were 2.2 cms in sheep, followed by dog 1.4 cm and rabbit 0.18 cm. In addition, the maxillary sinus was 33.5 cm and the nearest animal was sheep 2.9 cm. Also, the sphenoidal sinus was 2.0 cm in human and 1.35 cms in sheep.
**Conclusion:** The use of endoscopic sinus surgery can be practiced on animals. Sheep is the best laboratory animal for the training this technique of the endoscopic sinus surgery as we can explore the meatus, and maxillary sinus in great details than in dog and rabbit, but they have no ethmoid sinuses. Also the head of sheep is cheaper in price, easily available, than that of any other animal and with the same size of sinuses of that of human being.

**Keywords:** paranasal sinuses morphology animals sinuses, human sinuses, cadavers

## 1. Introduction

Sinus surgery performed by the help of endoscopes is now attracting the attention of clinician's. Killian (1896) [1] developed the art of rhinoscopy in order to explore the middle meatus in great details. The work of many authors; Zuckerkandl (1892) [2], Halle (1915) [3] and Gruenwald (1925) [4] contributed greatly to the development of present day clinical rhinology and endoscopic sinus surgery. In recent years, endoscopes have been used to perform surgery beyond the boundaries of the paranasal sinuses of paranasal sinuses [5]. The modern techniques employed in the work of sinusitis are the nasal endoscopes which greatly enable the clinicians to evaluate and diagnose the pathology in this area [6]. Endoscopic sinus surgery is relatively safe procedure. The magnification and angulation of the endoscopes into the sinus region depend on the anatomic landmarks and configurations of the region. Endoscopes are used for visualization and the attached camera provides magnification of the sinuses, the success of the sheep among the domestic animals may be attributed to the greater number of the paranasal sinuses and the frontal sinus cover the deep seated brain. Despite the lack of the available veterinary literature, concerning the sinus endoscopy, it is necessary to carry out the study in comparison with that of human being for its importance in the field of otorhinolaryngology and sinus surgery. Therefore, the attention of our work was to conduct this study between man and some animals point out the resemblance and differences between them. This will help in solving clinical and surgical issues.

## 2. Materials and Methods

### a) Human Part

The study in the human models was carried on fifty dried skulls of adult, formalin treated heads of adult human (thirty one males and nineteen females), from the dissecting room in a reputed medical school in cooperation with Zagazig and Ainshams university in Egypt. Fifty living clinically healthy cases for the endoscopic examination were also examined.

**Methods**

In order to study the paranasal sinuses, we must study them in relation to the nasal cavity, dried and fifty formalin treated heads skulls have been used. Each skull was studied, sagittal sections were done by using sharp electric saw, the measurement of height, breadth and depth of each sinus was taken using compass and Vernier. The turbinate bones have been resected by using turbinectomy scissors and toothed forceps. The different and communication of the paranasal sinuses with the nasal cavity were studied on fifty formalin treated models.

**The clinical work**

Endoscopic view of the lateral nasal wall, middle turbinate, nasal septum, maxillary ostia and were carried out in fifty healthy human beings (30 females and 20 males) and the findings were correlated clinically, the healthy individuals were adults with an age range from 30 to 50 years.

**b) Animal Part**

In the animal models we chose sheep, rabbit and dog as fifty fresh dried skulls for each species were studied. A sagittal section had been done in every skull by using electric saw and is completed by the help of toothed forceps. The measurement and diameters of each sinus was done by the aid of compass and Vernier.

**3. Results**

**3.1 Human model**

Fig (1) Lateral nasal wall of the human being to show:

1. Hard palate
2. 2- soft palate
3. Frontal
4. Openings of the middle and anterior ethmoidal air cells
5. Inferior turbinate
6. Eustachian tube orifice
7. Sphenoid sinus
8. Septum
9. Tongue

**Fig 1:** Lateral nasal wall of the human being

**Sphenoidal sinus:** There are two sinuses within the body of the sphenoid bone, superiorly related to the optic chiasma and the fossa for the pituitary gland posteriorly. They are asymmetrical in shape with c- shaped intervening septum, in most examined cases the left sphenoidal sinus was larger than right one and extends across the median plane posterior to invade the basilar part of the occipital bone.The average mean value of the sphenoidal sinuses are 2cm the vertical height, 1.7cm the transverse breadth and 2.1cm the anteroposterior depth.

**Frontal sinus:** Frontal sinuses are bilateral asymmetrical cavities behind the supraciliary arches of the frontal bone. The inter sinus septum is deviated in the studied specimens and was not exact meddling, the floor of each frontal sinus is funnel shaped toward its ostium forming frontal infundibulum. The average mean value of each one is 2.98cm in height, 2.39cm in breadth and 1.95 in depth. In the majority of the studied specimens where the frontonasal duct was recorded the mean value of the length of the duct is 5.25mm.

**Maxillary sinus:** Is the largest pyramidal air nasal sinuses, localized in the body of the maxillary bones. Its average height is 3.55cm, breadth 2.45cm and depth 3.25cm.

**3.2 The animal models**

**3.2.1 Paranasal sinuses of the sheep**

**Frontal sinus:** Is the largest paranasal sinus and extends within the frontal bone. Its length 5.3cm, width 3.3cm cranially and 3.95cm caudally. Its separated by a thin plate of bone which is 3.2cm in length and 0.6cm in height.The frontal sinus is divided into two parts, medial and lateral. The medial one is deeper and narrower than the lateral one, it's about 1.2cm in length at the middling and 1.4cm in width and 0.7cm in depth. The lateral sinus is extensive and larger than the medial one, and is about 4.1cm in length, 1.9cm cranially and 2.3cm caudally.

Fig (2) Right side of dried skull of sheep show:

1. Lateral part of frontal sinus
2. Medial part of frontal sinus
3. Cornual sinus
4. Lacrimal Sinus
5. Maxillary sinus


**Fig 2:** Right side of dried skull of sheep

**Maxillary sinus:** It is the largest paranasal sinus present in the maxilla and extend upto zygomatic bones. The vertical height Is about 2.9cm, the transverse breadth is about 1.9cm, and the anteroposterior depth is about 3.5cm.

It is divided into two parts by a bony septum containing the infraorbital canal, medial and lateral compartment. The lateral one is the largest and communicates with the palatine and lacrimal sinus. The medial compartment communicates downward with the palatine sinuses, over the infraorbital canal.

Fig (3) Lateral wall of the sheep show:

1. Infraorbital canal
2. Inferior part of the maxillary sinus
3. Palatine sinus
4. Frontal sinus
5. Superior part of the maxillary sinus
6. Sphenoid sinus

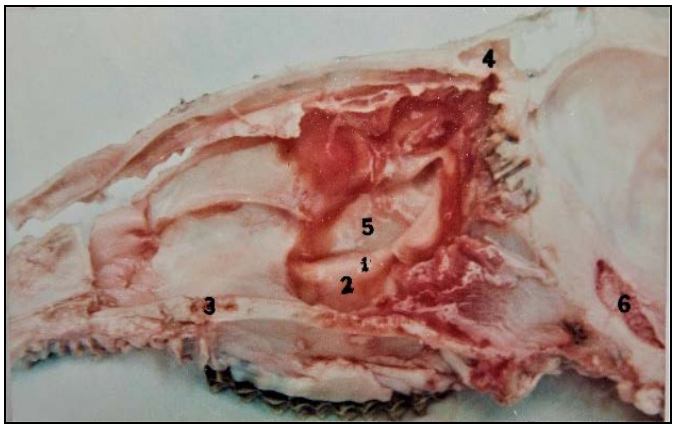


**Fig 3:** Lateral wall of the sheep

**Sphenoidal sinus:** It is nearly quadrilateral in shape about 1.3cm in length and width. The sphenoid sinus occupied in presphenoid bone and rostrally it communicates with the caudo-ventral part of the ethmoid bone. The cadual part of the ethmoid bone projects into the rostral end of the sphenoid sinus. The two sinuses are separated by inter sinus bony septum.

### 3.2.2 Paranasal sinuses of the dog

The frontal sinus and the maxillary sinus are the only paranasal sinuses in dog.

**Frontal sinus:** Is the largest paranasal sinus and divided into three compartments the lateral one is the largest and it divided into small recesses by bony lamellae which are occluded by the turbinate bone.

The medial compartment of the frontal sinus is small and related to the median septum, the ectoturbinate bone invade to this compartment. The rostral part of the frontal sinus, the smallest one lies at the junction of the maxilla with the frontal and nasal bones.

**Maxillary sinus:** Is very small and bounded by the maxilla, lacrimal and Palatine bones.

### 3.2.3 Paranasal sinuses of the rabbit

The frontal sinus and the maxillary sinus are the only paranasal sinuses recorded in rabbit.

Fig (4) lateral nasal wall of the rabbit show:

1. Frontal sinus
2. Maxillary sinus ostia
3. Superior turbinate
4. Inferior turbinate's
5. Middle turbinate's

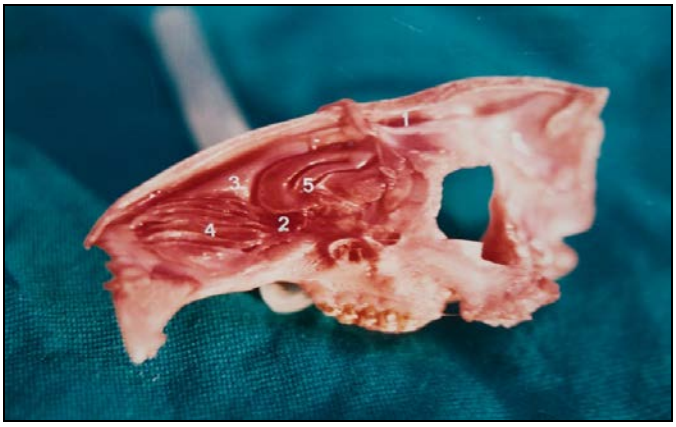


**Fig 4:** lateral nasal wall of the rabbit

**Frontal sinus:** It is small in size about 4mm in anteroposterior, 2mm in transverse breadth, 1.5mm in vertical height.It is excavated in the frontal bone. The opening of the frontal sinus extends into the posterior part of the ethmoturbinate into the middle meatus.

**Maxillary sinus:** It is larger than the frontal sinus, cone shaped, lies in the maxilla. Its apex lies anteriorly about 1mm from the canine tooth. It measures 9mm in anteroposterior, 6mm in vertical height, at the base of the cone which lies posterior and its transverse breadth is 4mm, its lateral wall is formed by the maxilla, superiorly the junction of the maxilla with the nasal bone, posteriorly the lacrimal bone, ventraly the palatine process of the maxilla. It is opens into the middle meatus.

## 4. Discussion

The frontal sinuses have similar morphological features, in man and dog but there is difference in their drainage, where in man in majority of cases which are studied in our work it evacuates either through the frontonasal duct which drain into the superior part of the hiatus semilunar or in the frontal recess which communicates with the ethmoidal infundibulum.

In dog the frontal sinus opens into the dorsal ethmoidal meatus. The rule played by the anterior prolongation of the nasal cavity in dog revealed in the present study the enlargement of the frontal sinus in dog and its division into three compartment medial, lateral, rostral.

In sheep the frontal sinus is divided into (lateral and medial sinuses) on each side, the lateral sinus communicates with the nasal cavity in the rostro-lateral region of the sinus and opens into the olfactory part of the middle nasal meatus between the middle nasal concha and the lacrimal bone. The medial frontal sinus opens independently into the same region of the nasal cavity, rostral to the opening of the lateral sinus. The comparative data on the mean value of the frontal sinus in the studied adult human being, sheep, dog & rabbit are present in (table 1).

**Table 1:** Comparative data on the mean value of the frontal sinus in the studied adult human being, sheep, dog and rabbit

| (1) | Adult human being | Sheep | Dog | Rabbit |
|---|---|---|---|---|
| Vertical height in (cm) | 2.98 | 2.2 | 1.4 | 0.18 |
| Transverse diameter in (cm) | 2.39 | 3.72 | 2.4 | 0.22 |
| Anterior posterior depth in (cm) | 1.95 | 5.3 | 2.15 | 0.43 |

The sphenoid sinus is present in man & animals, but in animals it shows some morphological features and differences [7, 8, 9]. Our findings are nearly similar to that reported by Mehta (1993) [1], Becker (1994) [10] and Sethi *et al*. (1995) [5], the sphenoid sinus is nearly quadrilateral in shape occupied in the presphenoid bone. The sphenoid sinus in man are two sinuses within the body of the sphenoid bone superiorly, related to the optic chiasma anteriorly and the fossa of the pituitary gland posteriorly. While the sphenoid sinus in sheep forming the main floor of the middle cranial fossa. The sphenoid sinus in sheep is bisected by a bony septum dissecting it into two cavities. These cavities open by separate opening in the nasal cavity.

We found that in most examined cases in man the left sphenoid sinus was longer than the right one. The sphenoid ostium is elliptical in shape and situated antero-superior to the sphenoid sinus below the cribriform plate of the ethmoidal bone and it is about 1.2 cm superior the choanal opening. The comparative data on the mean value of the sphenoid sinus in the studied adult human being, sheep are present in (table 3). The maxillary sinus of sheep (table) is divided into two parts by the infraorbital canal, medial and lateral compartments which communicate with each other, the lateral is the largest one. The cone of the lateral maxillary sinus of sheep looks like that in rabbit. In sheep the maxillary sinus opens into the middle meatus in common with the palatine sinus, slightly lateral to the opening of the frontal sinus at the level of the last cheek tooth. While in rabbit the sinus opens into the middle meatus between the superior and inferior turbinate bones. The comparative data on the mean value of the maxillary sinus in the studied adult human being, sheep and rabbit are present in (table 2). The maxillary sinus in man is similar to that of the rabbit but the differences is attributed to the size of the head, it is cone shaped, in the rabbit the base of the cone present posteriorly but in man the base of cone is towards the lateral wall of the nasal cavity.

**Table2:** Comparative data on the mean value of the maxillary sinus in the studied adult human being, sheep and rabbit

| (2) | Adult human being | Sheep | Rabbit |
|---|---|---|---|
| Vertical height in (cm) | 33.5 | 2.9 | 0.5 |
| Transverse diameter in (cm) | 2.45 | 1.9 | 0.42 |
| Anterior posterior depth in (cm) | 3.25 | 3.5 | 1.0 |

**Table 3:** Comparative data on the mean value of the sphenoidal sinus in the studied adult human being and sheep

| (3) | Adult human being | Sheep |
|---|---|---|
| Vertical height in (cm) | 2.0 | 1.35 |
| Transverse diameter in (cm) | 1.7 | 0.8 |
| Anterior posterior depth in (cm) | 2.1 | 1.55 |

From this study, we noticed that:

1. The use of endoscopy in E.N.T gives a good picture of the lateral wall of the nose, the turbinate's, and the maxillary ostia.
2. Sheep is available and cheaper in price as well as the nose of the sheep is wide and long enough due to the anterior prolongation of the nasal cavity, makes it easy for training by the use of sinus copy to perform exploration of the maxillary sinus, frontal duct, turbinate's, meatuses, Eustachian tube opening, fossa of rosenmuller and thick Eustachian couch.
3. We found that the use of sinuscopy in sheep is a guide to the veterinary surgeons to do functional endoscopic sinus surgery like polypectomy, antrostomy, turbinoplasty for the viable animals as racehorses and others, like the E.N.T surgeon perform.
4. Our finding and the technique which are used with sinuscopy in the studied animals is considered a new technique in the field of veterinary sinus surgery.

Fig (5) Endoscopy to the left side of the nose of sheep show the left inferior turbinate, septum, middle meatus and middle turbinate

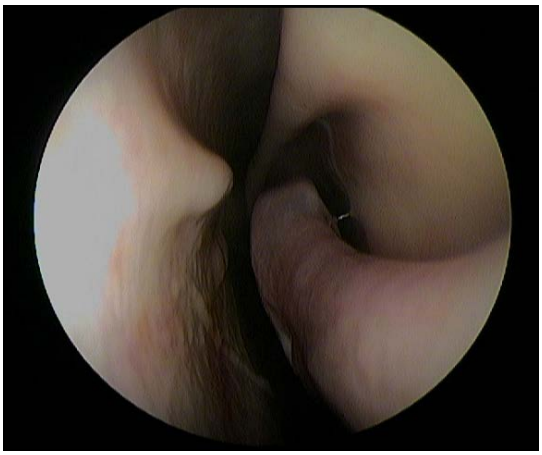

**Fig 5:** Endoscopy to the left side of the nose of sheep show the left inferior turbinate, septum, middle meatus, and middle turbinate

## 5. Conclusions

It is seen that frontal and maxillary sinus are present in man and all the selected animal modules. The frontal sinus is supplemented by the corneal sinus, in some animals i.e. those which have a horn. The maxillary sinus opening placed upward (in the middle meatus) in man and all the selected animal's module. The maxillary sinus in man is similar to that of rabbit, it is cone shaped but in the rabbit the base of the cone posteriorly, in man the base of the cone is toward the lateral wall of the nasal cavity. The ethmoidal and sphenoid sinuses are absent in some animal species other than in man (e.g. dog in this study).Some animal species have different sinuses (not present in man) as the lacrimal and palatine sinuses. Sheep is the best laboratory animal for the training technique of the endoscopic sinus surgery as to be able to explore the meatuses and maxillary sinus in great details than in dog and rabbit, but they have no ethmoid sinuses. Also the head of sheep is cheaper in price than that of any other animal with the same size of human being. The use of endoscopic sinus surgery is a better technique for functional endoscopic nasal and neurological surgeries in sheep and other animals rather than the traditional surgeries.

## 6. Acknowledgments

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