“SNOT RACE”: Dhulikhel Hospital Protocol for Analysis of Computed Tomography of Nose, Paranasal Sinuses

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Citation

K.C. AK, Shrestha BL, Dhakal A. “SNOT RACE”: Dhulikhel Hospital Protocol for Analysis of Computed Tomography of Nose, Paranasal Sinuses. *Kathmandu Univ Med J.* 2025; 89(1): 119-22.

ABSTRACT

The anatomy of nose and paranasal sinuses is highly complicated and is most often characterised by considerable anatomical variations. These variations have often been linked to the aetiopathogenesis of inflammatory sinonasal pathology. Also apart from diagnostic value, these variations also predispose the surrounding critical structures to iatrogenic trauma during functional endoscopic sinus surgery (FESS). Some of these variations also have a role in recurrence of disease. Computed tomography (CT) is the mainstay of diagnosis and surgical planning for sinonasal diseases, and a structured checklist to assess possible anatomic variants helps to reduce the risk of surgical complications. Hence, we developed a checklist at our centre with the mnemonic “SNOT RACE”.

KEY WORDS

Anatomical variations, Computed tomography, Functional endoscopic sinus surgery, Paranasal sinuses

INTRODUCTION

Functional endoscopic sinus surgery (FESS) is the surgical procedure of choice for recurrent or refractory sinusitis. It is a minimally invasive surgery that aims to restore the patency of sinus drainage pathways. However, these procedures may result in some serious, life threatening, or even fatal complications.[1] Computed Tomography (CT) imaging is the mainstay of surgical planning, and provides an opportunity to assess the anatomical variations that may predispose the patients to surgical complications. Consistent assessment of these anatomical variations is possible with a checklist based on the mnemonic “SNOT RACE” as proposed by our protocol (Table 1).

Table 1. **Anatomical Landmarks in CT Nose, Paranasal Sinuses**

Checklist		Things to Consider
S	Sinuses	Disease distribution Pneumatization, Septation
N	Nasal Cavities	Disease distribution
	Nasal Septum	Deviation, Spur, Pneumatization
O	Ostiomeatal Complex	Blockage, Widening
	Olfactory fossa	Depth
	Orbital wall (Lamina papyracea)	Erosion
	Optic Nerve	Compression
T	Turbinates	Hypertrophy, Pneumatization, Paradoxical turbinate
R	Recesses (Frontal, Sphenoethmoidal, Opticocarotid)	Disease distribution
A	Arteries (Anterior Ethmoidal, Carotid)	Location, Dehiscence
C	Cells (Haller, Onodi, Agger nasi)	Presence
E	Bony Erosion or Expansion	Presence

Anatomical Landmarks to consider

The paranasal sinuses are air-filled spaces surrounding the nasal cavity, and are named from the facial bones in which they are located (Fig. 1 and 2). Presence of soft tissue density and distribution patterns in various groups of sinuses is noted. Emphasis is given to characteristic findings like “double-density” sign and bony remodeling characteristic of fungal rhinosinusitis.

Figure 1. **Showing Frontal (star) and Maxillary sinuses (white arrow) (Coronal section)**

Figure 2. **Showing extensive disease in bilateral anterior and posterior ethmoids and sphenoid sinuses (Axial section)**

Figure 3. **Showing Right deviated nasal septum (Axial section)**

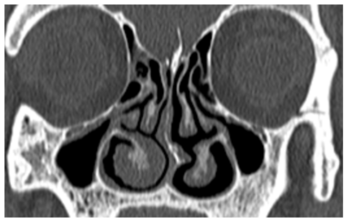

Figure 4. **Showing Left septal spur with Right Inferior turbinate hypertrophy and OMC (Coronal section)**

Maxillary sinuses: Pyramidal in shape, with apex in zygomatic process of maxilla and base at the lateral nasal wall, roof is formed by the orbital floor, and floor is formed by the alveolar part of maxilla. There is considerable variation in size and shape of maxillary sinus. Pneumatization may extend to involve the palatine recess and alveolar recess.[2] Maxillary sinus hypoplasia is uncommon and may be misdiagnosed as chronic sinusitis.[3] Maxillary sinus hypoplasia is often associated with orbital enlargement.[4] This may predispose to iatrogenic orbital penetration. Maxillary sinus septation is the commonest variation reported in literature.[5] Antral septa is frequently vertical at anterior and horizontal at posterior part.

Ethmoid sinuses: Complex and delicate structure which consists of cribriform plate, perpendicular plate, and two ethmoidal labyrinths. Anterior and posterior ethmoidal cells are separated by the Basal lamella of middle turbinate.

Sphenoid sinuses: Variation in the pneumatization pattern of sphenoid sinus includes sellar, post-sellar and conchal types. Pneumatization may also extend towards the lateral recess, anterior clinoid process, vomer, palatine bone, lesser wings, greater wings, pterygoid process and clivus.[2] Septations may be present which may be unsafe type when attached to the carotid canal or optic canal.[6] The carotid artery, optic nerve, maxillary nerve and vidian nerve may be dehiscent inside the sphenoid sinus increasing the susceptibility to iatrogenic injuries.[7]

Frontal sinuses: The two sinuses are often unequal in size. Hypoplasia or aplasia of the sinus is noted. Pneumatization is variable and may include the crista galli.

Nasal cavities: Bilateral structures bounded inferiorly by the hard palate, laterally by the maxillary sinuses, and superiorly by the nasal, ethmoid and sphenoid bones.[8] These cavities are assessed for the adequacy of airway, and distribution of disease process.

Nasal septum: Mixed osseous and cartilaginous structure that separates the two nasal cavities. The commonest finding includes septal deviation which is the deviation of septal contour towards one side of the nasal cavity (Fig. 3).[9] Septal deviation may be towards the right or left, or may be S-shaped curvature. It may be cartilaginous, osseous or combined deviation. Septal deviation is often associated with compensatory hypertrophy of the contralateral inferior turbinate and concha bullosa of the middle turbinate.[10] Septal spur may or may not be associated with septal deviation. Pneumatization of nasal septum is rare.

Ostiomeatal complex (OMC): Primary drainage pathway for the anterior paranasal sinuses. This key area is bounded by the uncinate process, lateral margin of middle turbinate, and medial and inferior walls of the orbit.[1] It includes the maxillary antrum, infundibulum, hiatus semilunaris and middle meatus (Fig. 4). This area is evaluated in coronal views for obstruction or widening by disease processes. Attention is also given to anatomic variants like concha bullosa, paradoxical middle turbinate, septal deviation, Haller cell thay may predispose the patient to rhinosinusitis. Uncinate process is attached inferiorly to the inferior turbinate, anteriorly to the lacrimal bone, with a free posterior margin and a variable superior attachment. Uncinate process may be pneumatized known as “uncinate bulla”.

Olfactory fossa depth: A line is drawn passing through thr two infra-orbital foramina (IOP). Two reference points are chosen at the skull base: Point of articulation of medial ethmoidal roof with lateral lamella of cribriform plate (MERP) and lowest point on cribriform plate (CP). The olfactory fossa depth is calculted as the difference of vertical height of MERP and vertical height of CP from the IOP line.[11] The depth is classified according to the Keros classification: Keros Type I (< or = 3 mm depth), Keros Type II (4-7 mm depth), and Keros Type III (> 7 mm depth) (Fig. 5). Lateral lamella is the thinnest and most vulnerable bony portion of the skull base. With an increase in the depth of the olfactory fossa, there is an increased risk of intraoperative injury to the lateral lamella that may result in a cerebrospinal fluid (CSF) leak.[1] Asymmetrical depths of olfactory fossa is also important to identify.

Medial orbital wall or lamina papyracea: Thin layer of ethmoid bone and should be evaluated for dehiscence or erosion. Injury to the lamina intraoperatively can lead to orbital fat prolapse, or extraocular muscle injury, or at worst intraorbital hematoma.

Optic nerve: is assessed to rule out its involvement by any disease process at the orbital apex. The structure is also assessed for dehiscence within the sphenoid sinus or Onodi cell, when present.

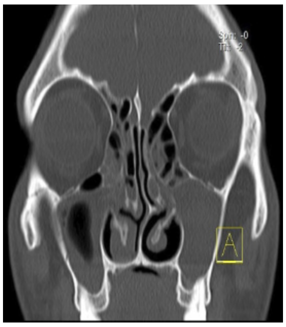

Figure 5. **Showing Keros Type III Olfactory fossa (Coronal section)**

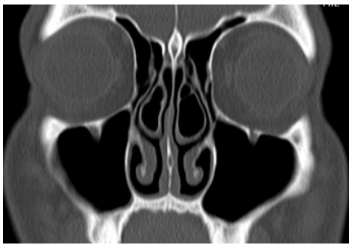

Figure 6. **Showing Bilateral concha bullosa (Coronal section)**

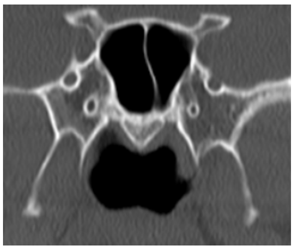

Figure 7. **Showing Optic nerve and Carotid artery in relation to sphenoid sinus (Coronal section)**

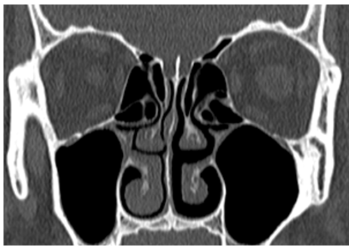

Figure 8. **Showing area of Anterior Ethmoidal Artery (white circle) (Coronal section)**

Turbinates: Usually three in number, sometimes a 4th Supreme turbinate (Santorini's concha) may also be present. They are bony structures extending from the lateral and superior walls of the nasal cavity that project infero-medially and contain meatuses inferolateral to them.[12]

Inferior turbinate hypertrophy is a common finding. Rare variations include paradoxical inferior turbinate and pneumatized inferior turbinate.

Middle turbinate is attached vertically to cribriform plate superiorly, and to lamina papyracea laterally via basal lamella, and posteriorly runs in an axial plane to form roof for the posterior portion of middle meatus.[2] The basal lamella separates the anterior and posterior ethmoidal cells. Pneumatisation of middle turbinate (concha bullosa) is a common finding. It may be lamellar (pneumatization in vertical lamella), bulbous (pneumatization in bulbous segment) or extensive (pneumatization in both lamella and bulbous portion) in types (Fig. 6).[13] This variant may hinder the OMC. Paradoxical middle turbinate refers to scroll convexity in lateral aspect rather than medial aspect, that may narrow the OMC. This usually occurs bilaterally.[14]

Superior turbinate pneumatization is a rare occurrence.

Frontal recess: space into which the frontal sinus drains. This area is bounded medially by lateral lamella of cribriform plate and vertical lamella of middle turbinate, and laterally by lamina papyracea and lacrimal bone. It is located posterior to the frontal beak formed by the nasal process of frontal bone.[15] This space is assessed to identify the cells that eventually affect the direction and position of the frontal sinus drainage pathway. These cells include anterior cells (Agger nasi, Supra-agger, Supra agger frontal), posterior cells (Supra-bulla, Supra-bulla frontal, Supraorbital) and medial cell (Frontal septal cell).

Sphenoethmoidal recess: final drainage pathway for the posterior ethmoid and sphenoid sinuses. It lies above and posterior to the superior turbinate. This area is assessed for the distribution of disease.

Opticocarotid recess: space between the optic nerve and carotid artery in relation to the superior and lateral walls of the sphenoid sinus (Fig. 7). This area is assesed for any dehiscence that may predispose these neurovascular structures to iatrogenic injuries.

Anterior ethmoidal artery: branch of Ophthalmic artery identified on coronal CT images at anterior ethmoidal notch (Kennedy's nip) (Fig. 8). It is important to identify whether it runs in the skull base (notch abutting fovea ethmoidalis or lateral lamella) or lies in a mesentery (supraorbital pneumatization of ethmoid air cells above the notch).[16] Intraoperative injury to the artery with its subsequent retraction into the orbit may cause intraorbital hematoma with consequent loss of vision.

Carotid artery: assessed to see for any dehiscence into the sphenoid sinus which may put it at risk during sphenoidotomy.

Haller cell (Infraorbital cell): anterior ethmoid air cell located along the medial orbital floor which narrows the maxillary sinus ostium and infundibulum. It may result in recurrent maxillary sinusitis.[3] It may also increase the risk of iatrogenic orbital injuries during ethmoidectomy.[17]

Onodi cell (Sphenoethmoid cell): posterior ethmoid air cell located superior, posterior and lateral to the sphenoid sinus. The optic nerve may course through the Onodi cell. The presence of Onodi cell may result an increased risk of injury to optic nerve and internal carotid artery.[3]

Agger nasi cell: most anterior of all ethmoid cells, located in anterior superior portion of middle turbinate. They are generally bilateral and can narrow the frontal recess.[18] These cells are best assessed in coronal and sagittal images.

Presence of bony erosion or expansion or remodelling signify neoplasms of nose and paranasal sinuses.

CONCLUSION

A structured analysis of anatomical landmarks in CT nose, paranasal sinuses using our checklist helps us to gain insights into the normal anatomy, and anatomical variations that may lead to any untoward complications during the surgery. It also helps us to plan the disease process removal to maximize the postoperative outcomes.

REFERENCES

1. O'Brien WT, Hamelin S, Weitzel EK. The preoperative sinus CT: avoiding a "CLOSE" call with surgical complications. *Radiology*. 2016;281(1):10-21
2. Onwuchekwa RC, Alazigha N. Computed tomography anatomy of the paranasal sinuses and anatomical variants of clinical relevants in Nigerian adults. *Egyptian J Ear Nose Throat Allied Sci.* 2017;18(1): 31-8.
3. Turna O, Aybar M, Karagoz Y, Tuzcu G. Anatomic variations of the paranasal sinus region: evaluation with multidetector CT. *Istanbul Med J*. 2014;15:104-9.
4. Selcuk A, Ozcan KM, Akdogan O, Bilal N, Dere H. Variations of maxillary sinus and accompanying anatomical and pathological structures. *J Craniofac Surg*. 2008;19:159-64.
5. Amine K, Slaoui S, Kanice FZ, Kissa J. Evaluation of maxillary sinus anatomical variations and lesions: a retrospective analysis using cone beam computed tomography. *J Stomatol Oral Maxillofac Surg*. 2020;121:484-9.
6. Devaraja K, Doreswamy SM, Pujary K, Ramaswamy B, Pillai S. Anatomical variations of the nose and paranasal sinuses: a computed tomographic study. *Indian J Otolaryngol Head Neck Surg* 2019;71(Suppl 3):S2231-40.
7. Liu S, Wang Z, Zhou B. Related structures of the lateral sphenoid wall anatomy studies in CT and MRI. Lin Chuang Er Bi Yan Hou Ke Za Zhi. 2002;16:407-9.
8. Parks ET. Cone beam computed tomography for the nasal cavity and paranasal sinuses. *Dent Clin North Am*. 2014;58:627-51.
9. Koo SK, Kim JD, Moon JS, Jung SH, Lee SH. The incidence of concha bullosa, unusual anatomic variation and its relationship to nasal septal deviation: a retrospective radiologic study. *Auris Nasus Larynx.* 2017;44:561-70.
10. Cellina M, Gibelli D, Cappella A, Martinenghi c, Belloni E, Olivia G. Nasal cavities and the nasal septum: anatomical variants and assessment of features with computed tomography. *Neuroradiol J.* 2020 Aug;33(4):340-7.
11. Shrestha BL, Karmacharya S, Shrestha KS. Radiological analysis of olfactory fossa depth : a tertiary care hospital based study. *BJHS.* 2018;3(3)7: 575-9.
12. Dalgorf DM, Harvey RJ. Chapter 1: sinonasal anatomy and function. *Am J Rhinol Allergy.* 2013;27:S3-6.
13. Bolger WE, Butzin CA, Parsons DS. Paranasal sinus bony anatomic variations and mucosal abnormalities:CT analysis for endoscopic sinus surgery. *Laryngoscope*. 1991;101:56-64.
14. Neskey D, Eloy JA, Casiano RR. Nasal, septal, and turbinate anatomy and embryology. *Otolaryngol Clin North Am*. 2009;42:193-205, vii.
15. Wormald PJ, Hoseman W, Callejas C, Weber RK, Kennedy DW, Citardi MJ, et al. The International Frontal Sinus Anatomy Classification (IFAC) and Classification of the Extent of Endoscopic Frontal Sinus Surgery (EFSS). *Int Forum Allergy Rhinol*. 2016 Jul;6(7):677-96. doi: 10.1002/alr.21738. Epub 2016 Mar 14. PMID: 26991922.
16. Gotwald TF, Menzler A, Beauchamp NJ, zur Nedden D, Zinreich SJ. Paranasal and orbital anatomy revisited: identification of the ethmoid arteries on coronal CT scans. *Crit Rev Computed Tomogr.* 2003;44(5):263-78
17. Shpilberg KA, Daniel SC, Doshi AH, Lawson W, Som PM: CT of anatomic variants of the paranasal sinuses and nasal cavity: poor correlation with radiologically significant rhinosinusitis but importance in surgical planning. *AJR Am J Roentgenol.* 2015;204:1255-60
18. Dasar U, Gokce E. Evaluation of variations in sinonasal region with computed tomography. *World J Radiol*. 2016;8:98-108.