International Journal of Health Sciences and Research
www.ijhsr.org ISSN: 2249-9571

Review Article

Anatomical Variations of the Paranasal Sinuses in Patients with Chronic Rhino Sinusitis Using Computerised Tomography Scan (CT) - A Review

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Received: 07/10/2015 *Revised: 12/01/2016* *Accepted: 25/01/2016*

ABSTRACT

Computerised tomography (CT) scan imaging techniques acts as a guide for functional endoscopic sinus surgery (FESS). It plays a vital role in the successful outcome of the treatment and management of the paranasal sinus variations. The frequent predisposing factors of chronic sinusitis are the anatomical variations of the paranasal sinus and nasal region. Computed tomography (CT) scan plays a fundamental role in the diagnosis of anatomical variations as well as of sinonasal diseases for a better guidance in the decision making about clinical, therapeutic and surgical approaches.

Keywords: Anatomical variations, Paranasal sinuses, Computed tomography (CT) scan, Functional Endoscopic Sinus Surgery (FESS).

INTRODUCTION

The paranasal sinuses are the frontal, ethmoid, sphenoid and maxillary sinuses, housed within the bones of the skull. All sinuses open into the lateral wall of the nasal cavity through their corresponding ostia. [1,2]

Computerised tomography (CT) scan imaging techniques acts as a guide for functional endoscopic sinus surgery (FESS). It plays a vital role in the successful outcome of the treatment and management of the paranasal variations. The identification of the anatomical variations helps the endoscopic surgeons to avoid major risks in approaching the vital anatomical structures. Significance of the paranasal variations is predicted also for the prevalence and contribution to chronic rhino sinusitis. Advances in understanding the regional anatomy, utilization of the diagnostic imaging tools and implementing the recent surgical techniques tends to reduce complications in the paranasal sinus region. [1-3]

The detailed anatomy of paranasal sinuses (maxillary, sphenoid, ethmoid, frontal) and the osteomeatal complex displayed by CT scan acts as a road map to the surgeons for an effective treatment. This review assesses the frequency and prevalence of anatomical variations of the paranasal sinuses in chronic sinusitis which blocks the normal sinus drainage pathway.

Chronic Rhino Sinusitis

Chronic sinusitis is repeated bouts of acute infection or persistent inflammation of the paranasal sinuses that can be caused by anatomic variations of the nasal cavity and paranasal sinuses. The factors that cause immune suppression or any blockage of normal sinus drainage are responsible for perpetuating the disease progress. The frequent predisposing factors of chronic sinusitis are the

anatomical variations of the paranasal sinus and nasal region. Untreated chronic sinusitis can result in orbital cellulitis, osteomyelitis, subdural empyema, frontal lobe abscess, cavernous sinus thrombosis and worsen the morbidity rate. [2-5]

Imaging technique

Computed tomography (CT) scan plays a fundamental role in the diagnosis of anatomical variations as well as of sinonasal diseases for a better guidance in the decision making about clinical, therapeutic and surgical approaches. Spiral CT provides axial, coronal and sagittal images that facilitate good appreciation of the size and relationship of the paranasal sinuses. It is currently the gold standard to study the imaging modality of choice for evaluating paranasal sinuses and adjacent structures. [6,7]

CT of the paranasal sinuses reveals a spectrum of findings associated with the normal pneumatization process, both inside the sinus cavities and in the adjacent marrow spaces. Clear understanding of sinonasal anatomy and anatomic variants provides a better surgical approach in such narrow and vital areas. [7-9]

Advances in technology with the development of small fiber optic endoscopes and CT scanning of the paranasal sinuses over the conventional radiography have allowed a direct and accurate detailed study of sinus disease that was not possible earlier. Conventional radiography is of minimal value for functional endoscopic sinus surgery as the sinus walls are obscured by overlying structures. It is possible to detect the bony variations and mucosal abnormalities of paranasal sinuses with CT scan, which clearly visualize the anatomical variations that contributes to recurrent and chronic sinusitis. [9,10]

Functional Endoscopic Sinus Surgery (FESS)

The purpose of FESS is to restore physiologic mucociliary flow. The area most commonly affected by chronic rhino sinusitis is the osteomeatal complex, located in the middle meatus of lateral nasal wall. Here the maxillary, frontal, and anterior ethmoid sinuses drain. It is this area which is subjected to numerous significant anatomical variations. FESS technique is based on the concept that Osteomeatal complex (OMC) of the sinonasal cavity is the key area in the pathogenesis of recurrent acute or chronic infective rhino sinusitis. [10,11]

Endoscopic sinus surgery restores the drainage pathways and preserves the mucosa of the sinuses. The critical anatomical information provided by pre-FESS-CT scan has an impact on the surgical approach adopted by the surgeon and subsequently on the postoperative benefit to the patient. [12,13]

Anatomical Variations

Nasal cavity

Bony anatomical variations and mucosal abnormalities ranging from minimal mucosal thickening to total sinus opacification contribute to severity of the paranasal sinusitis. The cribriform plate is located lower than the ethmoid roof and the lateral lamellae form the floor, walls, and upper limit of the olfactory fossa. The configuration of the cribriform plate in relation to the roof of the ethmoid sinus is of clinical significance in relation to the risk of skull base injuries and cerebrospinal fluid leak. The classification put forward by Keros describes the depth of the olfactory fossa. [14-16]

A variation in the nasal septum plays an important role in causing rhino sinusitis. They are the nasal septal deviation, absence of the posterior part of the nasal septum, pneumatization or aplasia of the nasal septum etc. Septal deviations can be cartilaginous, cartilaginous-bony type, or a combination of both. Asymmetric nasal septum can force nasal turbinates laterally, resulting in narrowing of the middle meatus and ultimately blocking drainage of the ipsilateral maxillary, anterior ethmoid and frontal sinuses. [16-18]

Osteomeatal Complex (OMC)

Osteomeatal complex (OMC) is the area in the middle meatus where frontal, maxillary and anterior ethmoid sinus drains into the nasal cavity. This small area is the key to proper physiological function of the sinuses. Nasal septal deviation can laterally compress the middle concha and uncinate process into the infundibulum leading to obstruction of the osteomeatal unit. The blockade in the osteomeatal complex leads to impaired drainage of maxillary, frontal and anterior ethmoid sinuses thus perpetuating into chronic sinusitis. [16-18]

The coronal plane of the CT scan is the preferred imaging plane that best displays the osteomeatal unit. Middle meatus obstruction and successive rhino sinusitis could be due to concha bullosa, deviated nasal septum, haller cells, paradoxical middle turbinates, aggernasi cells and lots of other anatomical variations. The obstruction of mucociliary clearance in this area leads to tissue hypoxia, stasis of secretions, bacterial overgrowth, cycles of worsening inflammation and obstruction leading to irreversible changes in the sinus mucosa. [18,19]

Paranasal Sinus variations

The anatomical variations that aggravate the severity of chronic sinusitis are concha bullosa, paradoxical middle turbinate, over pneumatised or huge ethmoidal bulla (giant bulla), aggernasi cells, haller (infraorbital ethmoid) cells, onodi (sphenoethmoid) cells, displaced lamina papyracea, maxillary sinus septa pneumatization of uncinate process etc. The variations can obstruct the paranasal sinus drainage pathways and leads to superadded infection of the stagnated secretions. [19,20]

The uncinate process is a thin, bony hook like leaflet with a sagittal orientation, passing from anterosuperior to poster inferior direction. Its concave posterosuperior free margin is parallel to the anterior surface of the ethmoid bulla. The superior aspect of the uncinate tip can pneumatise or deviate laterally, medially or anteriorly out of the middle meatus. This variation seems to narrow the in fundibulum and cause impaired sinus ventilation. The uncinate process with the ethmoidal bulla is significant in relation to paranasal sinus drainage. Uncinate process is the principle surgicall and mark while performing FESS. Preoperative diagnosis of anatomic variations of the uncinate process helps to prevent intra-operative damage to the nasolacrimal duct, medial orbital wall and sphenopalatine artery. [21,22]

The presence of Haller cells (infraorbitalethmoid cells), is pneumatization of the anterior ethmoid cells found between the maxillary sinus and the orbit and increases the risk of orbital injury during ethmoidectomy. [23,24]

The word ‘concha bullosa’ was coined by Zuckerlandl in 1862 to describe pneumatization of the middle turbinate. This variation leads to secondary deformity of the middle turbinate and increase the chance of obstruction of the middle meatus leading to recurrent ethmoid sinusitis. Concha bullosa is best diagnosed by CT scan. The enlarged concha can compress or deviate the uncinate process against the lateral wall of the nasal cavity or compress the middle meatus and narrow the ethmoid infundibulum and forms a source for ipsilateral maxillary sinus disease. [24-26]

The paradoxical curvature of the middle turbinates, lateral instead of medial convexity will also produce an impact on the drainage of the middle meatus and alters the nasal air flow dynamics. [23,24]

Septal deviation, haller cell and concha bullosa are the major risk factors for maxillary rhino sinusitis. These variations causes narrowing or obstruction of the osteomeatal channels, thereby hamper the normal airflow and mucociliary clearance of the sinuses. Agger nasi cells are located in the anterior floor of the frontal sinus, on the drainage

pathway of the frontal sinus, and are frequently involved in recurrent or chronic frontal sinusitis. [24,25]

The frontal sinus can divide into a number of communicating recesses by incomplete septa, agenesis of the frontal sinus, one sinus overlapping in front of the other, or extending posterior as far as the lesser wing of the sphenoid bone.

Anatomical variations of the maxillary sinus are maxillary sinus septation, duplication, rudimentation, complete agenesis etc will also plays a inevitable role during FESS. [23,27]

The pneumatization pattern of the sphenoid sinus varies and can extend to the bones covering the carotid arteries and optic nerves that become thin or even absent, making these structures susceptible to iatrogenic injury. The optic nerve is least nourished and susceptible to injury due to surgical trauma or complications of the sinus disease. Onodi cells are the posterior-most ethmoid air cells that stretch out superior to the sphenoid sinus. Identification of these cells is essential prior to endoscopic sinus and skull base surgery due to their complicated relationship with the optic nerves and carotid arteries, which may lead to destructive complications. [28,29]

The variations like sphenoid septum, anterior ethmoidal artery, optic nerve, internal carotid artery, roof of ethmoid, lamina papyracea are more to be negotiated to avoid complications during FESS. The pneumatization of the anterior clinoid process usually occurs from the most posterior ethmoid cells and surrounds the optic nerve, which increases the risk of injury to the nerve during surgical procedures. [29-31]

CONCLUSION

Understanding the localization and extent of the pathology of sinus and skull base disease is based on the detailed knowledge of the anatomical structures. Appropriate attention should be given during the diagnosis and treatment of chronic sinusitis for all the anatomical variations and pathological abnormalities in order to avoid recurrence.

It is vital for surgeons and otolaryngologists to be aware of paranasal variations which predispose patients to chronic inflammatory diseases of the sinuses and also leads to increased risk of intraoperative complications. Identifying the predisposing anatomical factors using CT scan and eliminating by FESS helps in re-establishing the normal ventilation and mucociliary clearance of the sinuses.

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How to cite this article: Vinodhini P, Bhat S, Sree Ram MN. Anatomical variations of the paranasal sinuses in patients with chronic rhino sinusitis using computerised tomography scan (CT) - a review. Int J Health Sci Res. 2016; 6(2):367-372.

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