Section: Radiology

Original Research Article

MULTI DETECTOR COMPUTED TOMOGRAPHIC EVALUATION OF ANATOMICAL VARIATION OF PARANASAL SINUSES

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Abstract

Background: Paranasal sinuses are subjected to multiple anatomical variations which can lead to repeated sinusitis and can also cause intracranial and intra-orbital complications during procedures like Functional Endoscopic Sinus Surgery (FESS). Hence the knowledge about the normal anatomy and its variants helps in early diagnosis as well as in avoiding surgical complications. Multiplanar imaging, particularly coronal reformations, offers precise information regarding the anatomy of the sinuses and its variations, which is an essential requisite before surgery. The main aim of this study is to provide information regarding various anatomical variations of sinuses, and their distribution according to age, sex and side. **Materials and Methods:** This cross-sectional study is carried out in the Department of Radio-Diagnosis collaborating with the Department of ENT in Burdwan Medical College & Hospital. We studied 100 consecutive patients who are referred from ENT Out-Patient Department (OPD) having symptoms pertaining to chronic rhinosinusitis for CT-scan of PNS region to Department of Radio-diagnosis. The patients were evaluated clinically and radiologically by means of MDCT scan of PNS, performed on HITACHI SCENERIA 128 slice multi detector computed tomography. **Result:** Among 100 patients ,52% is male and 48% female. Mean age of population is 39.3 yr with standard deviation of 15.7 yr. One or more than one anatomical variation is seen in 95 patients, whereas 5 patients show no major or minor anatomical variation. Agger nasi Cellis the most common anatomical variation(66%) followed by Deviated nasal septum(61%) and concha bullosa(51%). Type I variety is the commonest type of uncinate insertion. Kero's Type II is most common type of ethmoid roof. Few of the uncommon variations like, Maxillary sinus hypoplasia, maxillary sinus septaion, peumatization of uncinate process, paradoxical curvature of middle turbinate also seen in our study. **Conclusion:** Computed Tomography of the paranasal sinuses has improved the visualization of paranasal sinus anatomy and has allowed greater accuracy in evaluating paranasal sinus disease. It is fast and inexpensive compared to MRI which provides more soft tissue information than bone. The presence of anatomical variants does not establish genesis of disease but these variations can predispose patients to intro-op complications. The radiologist must pay close attention to variants and provide road map to surgeons and help to avoid possible complications.

INTRODUCTION

Anatomy of paranasal sinuses have lot of variations which predispose to certain pathologic conditions. These variants can cause narrowing or total obstruction and may impair free airflow and predispose to repeated attacks of sinusitis. Anatomical disparities of nose have been reported to predispose to sinusitis. Chronic rhinosinusitis is one of the most common illness, and it has been known to negatively impact health- related quality of life.[1] Common anatomical variations include deviated nasal septum, concha bullosa, air cells – Agger nasi, Haller cell, and Onodi cell. These variants may

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determinate contact points between nasal structures, thereby, stimulating "trigger points" and determining facial pain crisis.[2]

During procedures like Functional Endoscopic Sinus Surgery (FESS) these variations can lead to intra-orbital or intracranial complications. So, for the surgical procedures to be successful and uneventful, thorough knowledge of anatomy and its variations is must, which helps in avoiding and diagnosing potential complications. Thus CT PNS is a roadway map for preoperative assessment and surgical planning.The radiologist must pay close attention to anatomical variations in preoperative evaluation.[3]

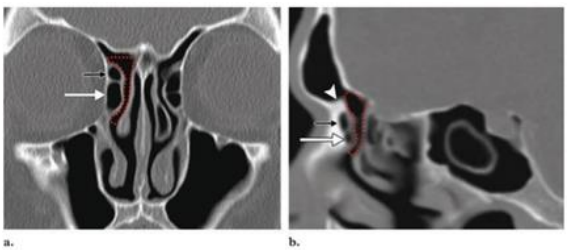
The English literature is rich in the description of anatomical variation of paranasal sinuses, but there is lack of such studies among Indian population, specially Bengali population. Studying and reporting these variations in our society should be helpful for otorhinolaryngologist to consider those variations while dealing with their patients in our region and for planning the surgical interventions on them.

Aims and Objectives

1. To document the anatomical variations of paranasal sinuses using Multi Detector Computed Tomography scan (MDCT scan).
2. To assess the frequency of occurrence and distribution by side of these documented variations

Variation of Sino-nasal anatomy: Numerous variations in the sinonasal anatomy have been described. Many of them have important clinical and surgical relevance, and it is very important to identify them on the presurgical scans obtained in such patients. MDCT with its multiplanar reformations provides the best details of the complex bony anatomy and anatomical variants of the sinonasal cavities. It is extremely important to review the CT images in all three planes for better understanding of the anatomy and identification of these anatomic variations.

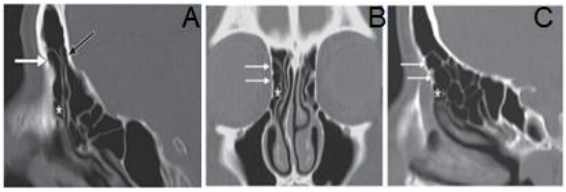
Frontal recess: is bounded anteriorly and laterally by an agger nasi cell and a type 1 frontal cell , medially by the middle turbinate, and posteriorly by the ethmoid bulla and bulla lamella. The nasofrontal process forms the floor of the frontal sinus and demarcates the level of the frontal sinus ostium. The clinical relevance of frontal recess cells lies in their potential for causing frontal sinusitis by obstructing frontal sinus outflow at the level of frontal recess.[4]



a. b.

Agger Nasi cell: represents the intranasal portion of the frontal process of the maxilla [Figure 4].The agger nasi serves as the anterior limit of the frontal recess. Pneumatization of the agger nasi (resulting in the so-called agger nasi cell) occurs in 78%–98.5% of individuals.[2,5] When present, agger nasi cells are considered the most anterior of all ethmoid cells,[6] and can pneumatize posteriorly to narrow the frontal recess.[1]

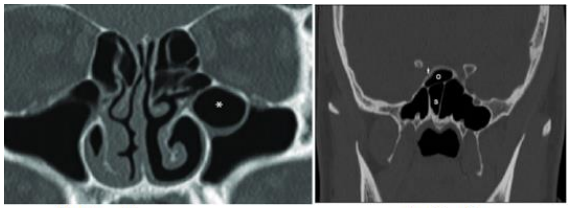
Other Frontal cells: In addition to agger nasi cells, there are several other named frontal recess cells, which include frontal cells type1, type2, type3 and supraorbital ethmoid cells, frontal bullar cells, supra-bullar cells, and inter–frontal sinus septal cells.[7,8]



a-Type 1frontal cell, b-Type 2 frontal cell, c Type 3 frontal cell

*Agger nasi cell

Onodi (Sphenoethmoid) cell: They are ethmoid cells that have migrated to the anterior region of the sphenoid sinus and intimately related to the optic nerve.[9-11]



Haller cell Onodi cell

Haller (Orbitomaxillary) cell: They are pneumatized ethmoid air cells that project along the medial roof of the maxillary sinus. When enlarged, it can cause obstruction of the posterior aspect of the ethmoidal infundibulum and ostium leading to maxillary sinusitis.[12,13]

Uncinate process variation: Three types of uncinate processes have been described, depending on the superior attachment that impacts the drainage of the frontal sinus. Type I uncinate process is the commonest type and attaches to the lamina papyracea, Type II uncinate attaches to the skull base, and Type III turns medially and attaches to the middle turbinate. The uncinate process may also be medialized or lateralized. An uncinate bulla maybe seen.

Nasal septal variation: Deviation represents a divergence of the septum from the midline. They are usually accompanied by compensatory hypertrophy

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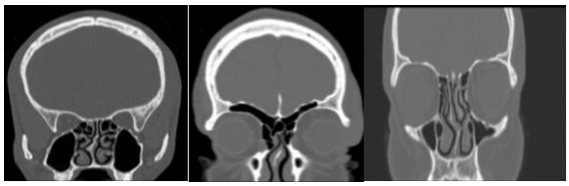
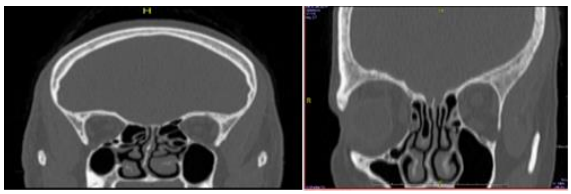
of the contralateral turbinate and ethmoid bulla. Mladina classified septal deviations in seven types:[14] Type I: Mild anterior deviation in the vertical plane that does not compromise nasal function. Type II: Moderate anterior vertical deviation, associated with an unilateral vertical crest in the area of the nasal valve that compromises the airway. Type III: Posterior vertical deviation. It can associate with concha bullosa in the contralateral middle nasal concha. Type IV: "S" shaped septal deviation, defining two crests. Type V: Unilateral ridge on the base of the septum that contacts the lateral nasal wall, while on the other side the septum in straight. Type VI: Similar deviation as in type V, with a deep horizontal sulcus on the opposite side.Type VII: A mixed type



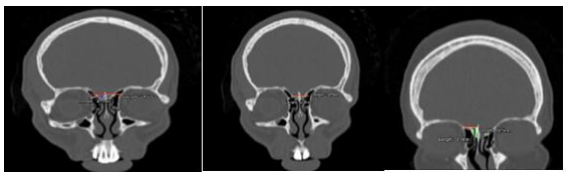
Middle turbinate variation: The middle turbinate usually convex medially. This is considered to be normal curvature of middle turbinate. When the convexity is reversed and faces laterally it is called Paradoxical middle turbinate.[6,15,16]



Paradoxical curvature of both middle turbinate andPneumatised right middle turbinate with transverse septation at right maxillary sinus

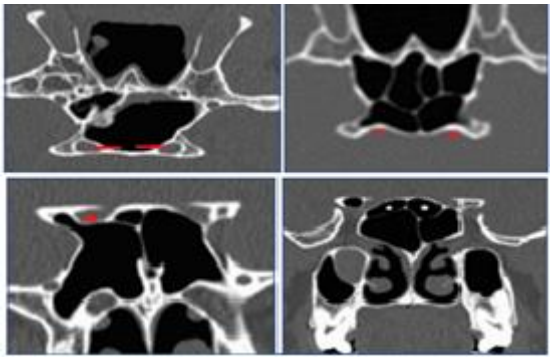
Concha bullosa represents the presence of air cell in the turbinates. Concha bullosa can be unilateral or bilateral and can be classified into three types according to the site of pneumatization i.e. lamellar, Bulbar, Extensive or large type.

Variation of Ethmoid roof: The Olfactory fossa (OF) is a depression in the anterior cranial cavity whose floor is formed by the cribriform plate of ethmoid. OF is bounded laterally by the lateral lamella of cribriform plate and medially by crista galli.[10] The relationship between the OF and the ethmoid roof was studied by Keros.[12,13] The depth of OF is measured by the vertical height of the lateral lamella of the cribriform plate Type I ethmoid roof has a depth of 1 to 3 mm, Type II a depth of 4 to 7 mm, and Type III a depth of 8 to 16 mm. Type III relationship is the most dangerous type for endoscopic sinus surgeries.[14-16]

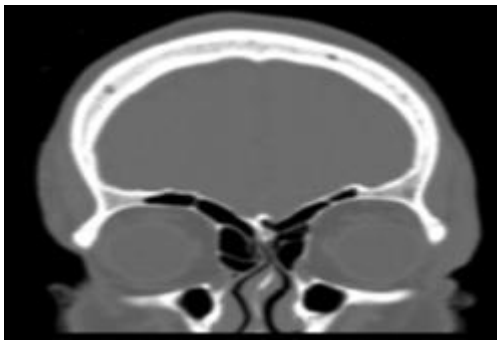


Type 2 OF,Type 1 OF,Type 3 OF

Variation of Optic canal: The most common position of the ONC with the sphenoid sinus is superolateral position.[9] Four types of optic nerve canals (OCs) have been described, Type I OC is the commonest type and runs immediately adjacent to the sphenoid sinus, without indentation of the wall Type II OC courses like the type I but indents the sphenoid sinus wall. Type III OC runs through the sphenoid sinus, with at least 50% of the nerve being surrounded by air and Type IV OC lies immediately adjacent to the sphenoid sinus and the posterior ethmoid air cells.



Maxillary Sinus Hypoplasia: Maxillary sinus hypoplasia is an uncommon condition that may be misdiagnosed as chronic sinusitis.[11] Maxillary sinus hypoplasia predisposes to orbital penetration during endoscopic sinus surgery.[12]



Maxillary sinus septation: The maxillary sinus may show septations, resulting in inadequate drainage of sinus secretions.

MATERIALS AND METHODS

Study Area: An observational study is conducted in the Department of Radio-diagnosis and Imaging, Burdwan Medical College and Hospital, Burdwan

Study Population: 100 consecutive patients who are referred from ENT Out-Patient Department

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(OPD) having symptoms pertaining to chronic rhinosinusitis for CT-scan of PNS region to Department of Radio-diagnosis and Imaging from 01/09/2022 to 31/08/2023.

Method of Data Collection: Details of the study protocol will be explained to the subjects and appropriate informed consent to be obtained from them. Following which the patients will be subjected to CT scans of PNS using Multi slice Computed Tomography Machine (Scenaria 128, Hitachi). Scanning protocol is to take 5mm slices with 3mm retro reconstruction.

Inclusion Criteria

Patients who will be referred from ENT OPD from 1/09/2022 to 31/08/2023 with symptoms pertaining to rhinosinusitis.

Exclusion Criteria

Previous history of facial trauma, Previous sinonasal surgery, Sinonasal anatomy alteration or obscuration due to advanced inflammatory diseases (When bony detail was obscured by polypoid mucosal disease), Paranasal sinus neoplasm.

Study Design: Cross sectional study.

Sample Size: The estimated sample size of 96 will be expanded to 100 to allow for 5% possible non respondent / missing data. Consecutive sampling was done.

Study Tools & Imaging Protocols: 1. Clinical data 2. MDCT Scan Machine (SCENARIA 128, HITACHI)

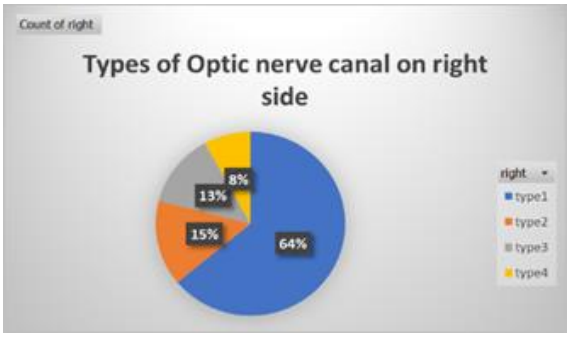
Study Procedure: The targeted patients are the ones who are requested to undergo MDCT scan of paranasal sinuses from ENT OPD. The principal investigator had to explain to the patients the study in order to obtain consent from them. Personal details of the patients are then taken along with brief clinical history. For CT examination patient will be positioned in supine position with neck extended and angulation will be perpendicular to hard palate. Imaging will be done from posterior margin of sphenoid sinus to anterior margin of frontal sinus with FOV of 14 to 16 cm. Thickness will be 5mm slices with 3mm retro reconstruction. The images will be reviewed using bone and soft tissue windows and the following details will be analyzed:Nasal Septal Deviation, Agger nasi cell, Onodi cell, Haller Cell, Frontal Cell, Uncinate Process Superior attachment, Uncinate process pneumatization, Middle turbinate Paradoxical Curvature, Concha Bullosa, Ethmoid roof, Maxillary sinus septation, Maxillary Sinus Hypoplasia, Other findings: Inflammatory sinus disease acute, chronic or allergic.

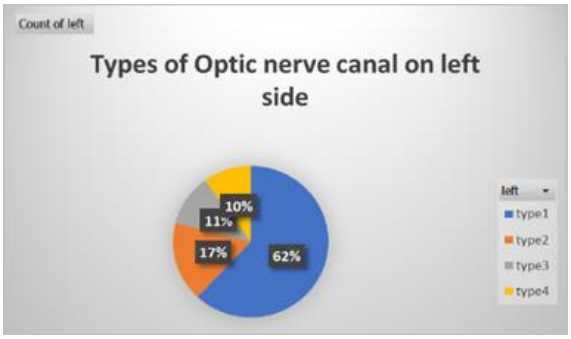
Statistical Analysis: On the basis, of these clinical and radiological data, the frequency of different type of anatomical variations paranasal sinuses are measured. Results are then presented as table and graphs and charts together with brief descriptions. Confidence level is taken as 95% where applicable.

RESULTS

This study was carried out in the Department of Radio-Diagnosis collaborating with the Department of ENT in Burdwan Medical College & Hospital. We studied 100 consecutive patients who are referred from ENT Out Patient Department (OPD) having symptoms pertaining to chronic rhinosinusitis for CT-scan of PNS region to Department of Radio-diagnosis and Imaging from 01/09/2022 to 31/08/2023. The patients were evaluated clinically and radiologically by means of MDCT scan of PNS. This is an analytical type of observational study.

Type1 optic nerve canal is most common variety in both the sides while type2 is second most common followed by type3. 64% of optic nerve canal on right side is type1, 15% is type2, 13% is type3 and 8% is type4. 62% of optic nerve canal on left side is type1, 17% is type2, 11% is type 3, and 10% is type4.





71% of the study population have Kero's Type2 ethmoid roof, which is the most common type, 20% have type 1 and 9% have type3.

65% of uncinate process have type 1 superior attachment,16% have type 2 and 4% have type 3 attachment.

Nasal septal deviations are seen in 65% of study population. Most common type of Nasal septum is type 1, seen in 38% of population. Nasal septal spur noted in 21% population.

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Table 1: Sidewise distribution of optic nerve canal.

Type of optic nerve canal				
Side	**Type1**	**Type2**	**Type3**	**Type4**
Right	64%	15%	13%	8%
Left	62%	17%	11%	10%

Table 2: Distribution of ethmoid roof according to Kero's classification

Kero's classification	Number of patient	Percentage
Type1	20	20%
Type2	71	71%
Type3	9	9%

Table 3: Classification of Uncinate process according to superior attachment.

Superior Attachment	Number of patient	Percentage
Blunt	15	15%
Type1	65	65%
Type2	16	16%
Type3	4	4%

Table 4

Anatomic Variant	Prevalence	Bilateral
Nasal septal deviation	65	NA
Nasal septal spur	21	NA
Agger nasi cell	66	35
Frontal cell	13	NA
Sphenoethmoidal(Onodi) cell	9	2
Infraorbital ethmoidal (Haller) cell	24	12
Uncinate process pneumatization	5	2
Concha bullosa	51	20
Paradoxically bent middle turbinate	7	2
Maxillary sinus hypoplasia	6	2
Maxillary sinus septation	5	1

Agger Nasi Cell is present in 66% of population. Among them 35% bilateral, 17% in isolated left side and 14% in isolated right side. Frontal cell is present in 13% of population. Among them most common is type1 seen in 8% of population. Onodi cell is present in 9% of population, among them 2% bilateral, 4% on isolated left side and 3% on isolated right side. Haller cell is present in 24% of population. 12% among them are bilateral, 7% on right side and 5% on left side.

Maxillary sinus hypoplasia is present in 6% of population, among them 3% left sided, 1% right sided, 2% bilaterally present.

Maxillary sinus septation is present in 5% of population, among them 3% left sided, 1% right sided and 1% bilaterally present.

DISCUSSION

The nasal fossa and para nasal sinuses together constitute single anatomical and functional unit covered by the same mucosa, the paranasal sinuses communicate with the nasal cavities via small openings and narrow ducts that allow both aeration and sinus drainage. In this report, we studied different important anatomic variations in the nose and paranasal sinuses in adult Bengali patients.

The overall prevalence of anatomic variations in our study is higher than that reported in the literature. This result could be due to the difference in population size, the difference in selecting the studied CT scans, the number and nature of included anatomical variations, the quality and standards of the CT scan used, and the subjectivity in reading the CT images.

Among 100 patients selected for the study of variations in the paranasal sinus 52 (52%) were males and 48 (48%) females. Mean age of population is 39.3ye with standard deviation of 15.7 yr. Among them, one or more than one anatomical variation is seen in 95 patient (95%), whereas 5 patients show no major or minor anatomical variation.

In our study Deviated Nasal septum is seen in 65% of patients. Type1 ismost common among them followed by Type 2. Nasal septal spur noted in 21% population.

Type-1 ONC was the most common with 64% prevalence in right side and 62% in left side.

In this study, Kero's type II OF was the most frequent (71%). Type I was seen in 20% and type III in 9%. In the previous Indian studies too, type II OF was the most prevalent followed by types I and III. Similar studies were carried out in various parts of the world as well as India analyzing the ethmoid roof and OF according to Keros classification. Among them, in the study by Kero's, 70% have typeII, 18% have typeIII and 12% have typeI ethmoid roof.

In the studied group, the anatomical variants of superior insertion of the uncinate process, had a higher frequency into the papyracea lamina (65%), followed by those into the middle turbinate (16%) or the skull base (4%), multiple insertionsregistered

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very small percentage. Pneumatization of uncinate process is found in 5% of population, among them 2% are bilateral.

Agger nasi cell is the most anterior ethmoid air cell. It is clinically significant due to its location relevant to the frontal recess and the lacrimal sac. In our study Agger Nasi Cell is present in 66% ofpopulation. Among them 35% bilateral, 17% in isolated left side and 14% in isolated right side. Frontal cell is present in 13% of population. Among them most common is type1 seen in 8% of population, followed by type 2 (4%), and type3 (1%). In our study Onodi cell is present in 9% of population, among them 2% bilateral, 4% on left side and 3% on right side. Haller cell is present in 24% of population. 12% among them are bilateral, 7% on right side and 5% on left side.

Concha bullosa or pneumatized middle turbinate is one of the most frequently studied variant seen in patients with sinusitis. In this report, it was as frequent as 51%. of population among them 20% bilateral, 16% on left side and 15% on right side. Paradoxical curvature of middle turbinate is seen in 7% of population, among them 3% is right sided, 2% left sided and 2% bilaterally present.

Maxillary sinus hypoplasia is a rare anatomical variation of the sinonasal region. The prevalence of maxillary sinus hypoplasia in our study group was 6%, which falls within the previously reported range, among them 3% left sided, 1% right sided, 2% bilaterally present. In our series, we adopted the definition of presentation of maxillary sinus septum regardless of its location, position, or number. The incidence of maxillary sinus septa in our study is 5% among them 3% left sided, 1% right sided and 1% bilaterally present.

Identification of some anatomic variants is crucial in the planning of functional endoscopic sinus or other skull base surgery, because the presence of these variants may influence the surgical approach. Most notably, the presence of Sphenoethmoidal (Onodi) cells is associated with increased risk of injury to the optic nerves or carotid arteries during functional endoscopic sinus surgery and with other transsphenoidal and skull base procedures.

CONCLUSION

There are multitude of anatomic variants of the sinonasal cavities, some of which are so common that they are most likely found in the majority of the population

MDCT of PNS is the imaging modality of choice to evaluate different anatomical variants in paranasal sinus region since conventional radiographs do not provide adequate information because of structural superimposition. Thin sections and multiplanar reconstruction of the MDCT images increases the effectiveness in diagnosing these variations. Thus MDCT of the paranasal sinuses has improved the visualization of paranasal sinus anatomy and allowed greater accuracy in evaluating paranasal sinus disease.

Identification of these variants plays an important role while guiding the surgeons preoperatively and preventing iatrogenic complications. Considering the wide range of variations in the anatomy, each paranasal sinus case should be planned individually and carefully to avoid dreadful complications and maximize patients' benefit.

Therefore, analysis of every routine CT scan of the paranasal sinuses obtained for sinusitis or rhinitis for the presence of different anatomic variants is of questionable value unless surgery is planned.it is important to be aware of certain anatomic variants, such as Sphenoethmoidal (Onodi) cells, pneumatization of anterior clinoid processes, supraorbital cells, infraorbital ethmoidal (Haller) cells and dehiscence of the lamina papyracea. Failure to recognize these variants is associated with a higher rate of surgical complications.

Our findings could be used in future studies with larger sample size. Because of the differences in various populations, identification of anatomic variations within the paranasal sinuses in every individual patient with sinonasal disease is substantially important to ensure safe and complete surgery.

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