Nasal Septum Anatomy and Deviations: beyond straight and flat

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Learning objectives

The learning objectives of our work are the following:

- To evaluate the normal anatomy of the nasal septum.

- To review the classification for septal deviations and the findings the radiologist need to consider in patients candidates for septoplasty.

- To evaluate any post-surgical complication.

Background

Nasal septum pathology is highly prevalent and septoplasty is a commonly developed surgery.

Septorhinoplasty or rhinoseptoplasty is the surgical technique with the purpose of correcting the shape and function of the nose at the same time. It associates the reparation of the external nasal pyramid and the remodelation of the interior of the nasal fossa in the same surgical act.

Modern septal surgery was developed by Cottle in the 50's. In the 80's Gübisch described the extracorporeal septoplasty, solving the limitations of previous techniques.

Surgery is indicated in patients with some of the following problems:

- Disfunction of the internal nasal valve
- Disfunction of the external nasal valve
- Complex septal deviations
- Ptosis of the nasal tip

The radiologist's role is important in the third point. Based on imaging techniques, we can not only define the type of deviation, but also provide a presurgical anatomical map and evaluate the potential postoperative complications.
Findings and procedure details

IMAGING OF THE NASAL SEPTUM

There are three imaging techniques available for the study of the nasal septum: radiography, computed tomography (CT) and magnetic resonance imaging (MRI).

• Plain radiography

Although it is a widely available technique, with low cost and a low rate of radiation, the value of plain radiography in septal pathology is small. It can only visualize significant deviations located in the bone portion of the septum.

The main limitations of the technique are the absence of visualization of the quadrangular cartilage, the two-dimensionality of the image (with the consequent structure overlapping) and the inability to detect anatomical details necessary for surgical planning (Fig. 1 on page 9). For these reasons, at present it is not recommended the use of radiography in the diagnosis of nasal septum deviations, and it is been displaced by CT.

• CT:

It is the technique of choice for the study of nasal septum. Unlike plain radiography, CT values both bone and cartilage portion and thereof provides a detailed anatomical information of nasosinus structures. In addition, once the image is obtained reconstructions can be performed. The main types of useful reconstructions in the nasal region are:

- Multiplanar reconstructions (MPR) which allow to display images in the three planes of the space (Fig. 2 on page 9 A). In particular, the reconstruction in the coronal plane aptly reflects the anatomy as seen by the otolaryngologist, as well as the osteomeatal unit and the relationship of the ethmoid roof with the anterior cranial fossa.

- Volumetric three-dimensional reconstructions (3D VR), to see bone (Fig. 2 on page 9 B) cartilage and air (Fig. 3 on page 10 A), facilitating the interpretation of the anatomy and the pathological findings.

- Reconstructions with "maximum intensity projection" (MIP) (Fig. 3 on page 10 B), which are specially useful in the morphological assessment of septal perforations.
CT has three main functions in the study of nasal septum. First, to identify and characterize the pathology. Furthermore, it provides a map of the preoperative anatomy and possible anatomical variations of normality located in the nasal pyramid and nostrils. Finally, it is useful in the study of complications of surgical procedures.

The major inconvenient is radiation, specially considering that the majority of patients are young adults.

There are two main types of CT:

- Multislice CT:

These scanners perform an isotropic volumetric image acquisition, allowing the generation of high quality reconstructions. The images obtained allow a proper assessment of bone and soft tissue of the sinonasal region. The study is performed without contrast administration. The technical parameters vary depending on the device. In a 64-detector CT, the following parameters can be used: beam width 24x1.2 mm; section collimation: 1.2mm; slice thickness: 3mm; window width /level: 350/40 soft tissue, 2000/200 bone; kV: 120; mAs: 70; rotation time: 1.0 sec.

- Cone beam CT (CBCT):

It is an emerging technique in the field of otolaryngology and maxillofacial surgery. The main advantages of CBCT compared with multislice CT are:

1) Dose reduction: the dose is significantly lower than in conventional CT.

2) Reduction of metal artifacts derived from dental or surgical supplies.

3) Lower cost.

4) Comfort: scanning is performed with the patient sitting.

The main disadvantage of CBCT compared with multislice CT is that due to the use of low dose, it does not allow a proper assessment of soft tissue.

- MRI:

MRI is not routinely used in the study of the nasal septum. However, some authors advocate for its use in nasal pre and postoperative assessment. The main advantages
of MRI are the absence of radiation and the capacity to evaluate soft tissue. Current 3T MRI scanners provide better anatomical definition (Fig. 4 on page 10). Also, it is the technique of choice if postoperative infectious complications are suspected.

The essential limitation of MRI is that provides little information of bone structures. Other limitations of the technique include less availability than CT, longer scanning time, the presence of artifacts with metallic material and general complications for MRI.

RADIOLOGIC ANATOMY OF THE NASAL SEPTUM

The nasal septum is an osteocartilaginous wall that divides the nasal cavity into halves.

The bony components of the nasal septum are the following: (Fig. 5 on page 11 and Fig. 6 on page 11).

1. The perpendicular plate of the ethmoidal bone superiorly, that articulates with the cribiform plate. The traumatic handling of this area can lead to cerebrospinal fluid leaks.

2. Vomer bone inferior and posteriorly, a bone in a shape of a keel that extends posteriorly to the sphenoid and inferiorly to the nasal crest of the maxilla and the palate.


5. The anterior nasal spine of the maxilla forms the most anteroinferior portion of the septum.

6. The anterior nasal spine of the frontal bone forms the most anterosuperior part of the septum.

The cartilaginous part is composed of (Fig. 5 on page 11 and Fig. 6 on page 11):

1. Septal cartilage or quadrangular cartilage. It articulates with the posterior aspect of the columella, between the two medial cruras of the lower lateral cartilages. This particular disposition provides some protection to the septum, because the high mobility of the movement of the membranous septum provides some degree of absorption of impact forces on the nose.

2. Vomeronasal cartilage: this is a thin strip between the quadrangular cartilage and the vomer.
RADIOLOGIC EVALUATION OF SEPTAL DEFORMITY

The deformity of the nasal septum can be classified into:

1) Spurs or ridges

2) Deviations

3) Dislocations or deformity of the chondro vomeral junction.

- Spurs:

Septal ridges or spurs are acute angulations of the septum located at the junction of the septal ethmoid cartilage superiorly with the vomer bone inferiorly (Fig. 7 on page 12). They can appear in association with septal deviation or in isolation. The largest spurs acquire "bridge" form, bridging the nasal meatus and imprinting the lateral wall of the nasal septum.

- Deviations:

It represents a divergence of the septum from the midline (Fig. 8 on page 12). It may be focal or affecting the entire septum, C-shaped or S-shaped, in either the vertical or the horizontal plane and can affect both the cartilage and the bone portion.

They are usually accompanied by compensatory hypertrophy of the contralateral turbinate and ethmoid bulla. Anterior septal deviations are frequently associated with deviations in the external nasal pyramid.

- Dislocations:

The anterosuperior margin of the vomer is in the form of a variable groove that hosts the adjacent edge of the quadrangular cartilage. When a significant disruption of this relationship occurs, the inferior edge of the quadrangular cartilage is displaced from the midline and projects into one of the nasal fossas (Fig. 9 on page 13). They can be associated with spurs.

CLASSIFICATION OF NASAL SEPTUM DEVIATIONS
**Cottle** has classified septal deviations in three types:

- **Simple deviation:** mild septal deviation, with no nasal obstruction. It is the most frequent type and it does not require treatment.

- **Obstruction:** more severe septal deviation, that touches the lateral wall of the nasal fossa. On decongestion with vasoconstrictors the turbinate shrinks and separates from the septum. Surgery is not indicated in this cases.

- **Impaction:** massive angulation of the septum, with a spur that contacts the lateral nasal wall. The space does not enlarge even with vasoconstrictors, so surgery is indicated in this patients.

**Mladina** classified septal deviations in seven types:

- **Type I:** Mild anterior deviation in the vertical plane that does not compromise nasal function. It presents like an anterior crest along the area of the nasal valve and does not contact with the lateral nasal valve, so the airway is not compromised. (Fig. 10 on page 14)

- **Type II:** Moderate anterior vertical deviation, associated with an unilateral vertical crest in the area of the nasal valve that compromises the airway. (Fig. 11 on page 14)

- **Type III:** Posterior vertical deviation. There is a vertical unilateral crest near the head of the middle nasal concha. It can associate with concha bullosa in the contralateral middle nasal concha. (Fig. 12 on page 15)

- **Type IV:** "S" shaped septal deviation, defining two crests: one at the level of the head of the middle nasal concha and the other on the opposite side of the valve area, disturbing the valve functions. (Fig. 13 on page 15)

- **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. (Fig. 14 on page 16)

- **Type VI:** Similar deviation as in type V, with a deep horizontal sulcus on the opposite side. (Fig. 15 on page 17)

- **Type VII:** A mix of types I to VI.
Septal deviation can associate with anomalies in the orientation of the hard palate. In some patients the hard palate is inclined with respect to the nasal midline; in other cases the midline of the hard palate is displaced to the right or the left respect to the nasal midline, or a combination of this two situations may exist.

To study this anomalies of the hard palate with imaging studies, we use the coronal plane of a CT study. We draw a reference vertical line along the central nasal region passing trough the crista galli superiorly and the hard palate inferiorly, with the line being perpendicular to a line that crosses the superior orbital margins (Fig. 16 on page 17).

There are anatomy variants of normality of the morphology and pneumatization of the sphenoid sinus that are potencially dangerous for surgery, such as a low insertion of the sphenoid sinus (Fig. 17 on page 18) and the anteriorized position of the sphenoidal rostrum (Fig. 18 on page 19).

**POSTOPERATIVE COMPLICATIONS**

Imaging tests are useful for detecting complications secundary to septoplasty. In general, when a postoperative complication is suspected, the initial imaging technique of choice is CT.

The prime complications are the following:

- **Septal hematoma and infection:**

  It is produced due to hemorrhage after the procedure, with blood accumulation under the mucosal lining of the septum, forming a collection that can potentially get infected. In this context, the administration of intravenous contrast material in both CT and MRI will allow to delimitate the possible abscesses. MRI can be very useful in this patients due to the high capacity to evaluate soft tissue and thereby the extention of the infectious process. (Fig. 19 on page 20).

- **Septal perforation:**

  It occurs when breaks appear in both sides on the mucosal lining of the nasal septum (Fig. 20 on page 21 and Fig. 21 on page 22). These breaks are relatively frequent because septal deviations are usually associated with thickening of the lining in the deviation area. The perforations cause problems such as crusts or sibilant sounds during breathing, but most of them do not require treatment.
- Changes in the nasal appearance:

There are parts of the nasal septum that contribute to the shape of the nose. Usually, the procedure of septoplasty does not change this areas, but sometimes the approach of them is essential. In these cases, in spite of every precaution, there is risk for the shape of the nose being modified after surgery.

Images for this section:

Fig. 1: Comparison of information provided by plain radiography (Waters projection) (A) and CT (B). The dimensionality in the radiograph causes overlapping of structures limiting the interpretation of the findings. Furthermore, only the bony elements of the nasal septum are displayed. In CT image (B) fine anatomical details are obtained, assesing both bone and cartilaginous portion of the septum, their relation to sorrounding structures and the possible deformities.
Fig. 2: CT reconstructions for the study of nasal septum: multiplanar reconstructions (MPR)(A) and volumetric three-dimensional reconstruction (3D VR) for bone (B).

Fig. 3: CT reconstructions for the study of nasal septum: Volumetric three-dimensional reconstruction (3D VR) for air (A) and reconstruction with maximum intensity projection (MIP)(B).
**Fig. 4:** MRI of the nasal fossa: T1 weighted sequence in axial (A) and coronal (B) planes.

**Fig. 5:** Anatomy in CT with MPR coronal reconstruction (right) and VR for airway (left). FS (frontal sinus), PPF (perpendicular plate of the ethmoid), QC (quadrangular cartilage), MS (maxillary sinus), VB (vomer bone), IF (incisive foramen), PB (palatine bone)
Fig. 6: Anatomy in MPR with sagital reconstruction (right) and VR for bone (left). FS (frontal sinus), NSFB (nasal spine of the frontal bone), CNB (crest of the nasal bone), PPE (perpendicular plate of the ethmoid), QC (quadrangular cartilage), ANSM (anterior nasal spine of the maxilla), IF (incisive foramen), CMB (crest of the maxillary bone), HP (hard palate), CPB (crest of the palatine bone), V (vomer), RS (rostrum of the sphenoidal sinus), SS (sphenoidal sinus).

Fig. 7: CT with MPR reconstruction in coronal (A) and axial (B) planes. Spur (orange arrow) that produces secundary hypoplasia of the right middle nasal turbinate.
Fig. 8: CT with MPR reconstruction in coronal (A,B) and axial (C,D) planes. Septal deviation associated with concha bullosa (orange star) in the left middle nasal turbinate.
**Fig. 9:** CT with MPR reconstruction in coronal (A) and axial (B) planes. Dislocation in the chondro vomeral junction (orange arrow) associated with septal deviation.

**Fig. 10:** Scheme (A) and CT with coronal (B) and axial (C) reconstructions. Type I septal deviation.
**Fig. 11:** Scheme (A) and CT with coronal reconstruction (B). Type II septal deviation.

**Fig. 12:** Scheme (A) and CT with coronal reconstruction (B). Type III septal deviation.
Fig. 13: Scheme (A) and CT with axial (B) and coronal (C,D) reconstructions. Type IV septal deviation.
**Fig. 14:** Scheme (A) and CT with coronal reconstruction (B). Type V septal deviation.

**Fig. 15:** Scheme (A) and CT with coronal reconstruction (B). Type VI septal deviation.
**Fig. 16:** CT with MPR reconstruction in coronal plane. The vertical black line is marking the septal deviation. Asymmetrical inclination of the hard palate, contralateral to the septal deviation (arrow).
Fig. 17: CT with MPR reconstruction in coronal (A,B,C) and axial (D) planes. Septal deviation associated with ipsilateral turbinate hypoplasia and anatomy variant of normality with low insertion of the sphenoid sinus.
Fig. 18: CT with MPR reconstruction in axial (A) and coronal (B,C,D) planes. Septal deviation and anteriorized position of the sphenoidal rostrum as anatomy variant of normality.
Fig. 19: Contrast enhanced CT with MPR reconstructions of the sinonasal area in axial (A) and coronal (B) planes. Diffuse thickening of the cartilaginous portion of the nasal septum, with postoperative abscess located anterior to the perpendicular plane of the ethmoidal bone. The collection protrudes to the right nasal fossa contacting with its lateral wall. Enlarged images of the septum (C).
Fig. 20: CT with MPR reconstruction in coronal (A,B) and axial (C,D) planes. Septal perforation secondary to septoplasty few years ago.
Fig. 21: CT with sagital MIP reconstruction (A) and 3D VR airway reconstruction (B). Septal perforation (orange arrow) secondary to septoplasty few years ago.
Conclusion

Radiologists have an important role in the management of patients with nasal septum deviations. We should be aware of the anatomy of the nasal septum, the key points to evaluate the surgical correction of its deviation and the possible postsurgical complications.

With this guide, we will be able to make understanding and useful report for the otolaryngologist.

Personal information

References


