Protrusion of the Infraorbital Nerve into the Maxillary Sinus on CT: Prevalence, Proposed Grading Method, and Suggested Clinical Implications


AJNR Am J Neuroradiol 2016, 37 (2) 349-353
doi: https://doi.org/10.3174/ajnr.A4588
http://www.ajnr.org/content/37/2/349
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ABSTRACT

BACKGROUND AND PURPOSE: The infraorbital nerve arises from the maxillary branch of the trigeminal nerve and normally traverses the orbital floor in the infraorbital canal. Sometimes, however, the infraorbital canal protrudes into the maxillary sinus separate from the orbital floor. We systematically studied the prevalence of this variant.

MATERIALS AND METHODS: We performed a retrospective review of 500 consecutive sinus CTs performed at our outpatient centers. The infraorbital nerve protruded into the maxillary sinus if the entire wall of the infraorbital canal was separate from the walls of the sinus. We recorded the length of the bony septum that attached the infraorbital canal to the wall of the maxillary sinus and noted whether the protrusion was bilateral. We also measured the distance from the inferior orbital rim where the infraorbital canal begins to protrude into the sinus.

RESULTS: There was a prevalence of 10.8% for infraorbital canal protrusion into the maxillary sinus and 5.6% for bilateral protrusion. The median length of the bony septum attaching the infraorbital canal to a maxillary sinus wall, which was invariably present, was 4 mm. The median distance at which the infraorbital nerve began to protrude into the sinus was 11 mm posterior to the inferior orbital rim.

CONCLUSIONS: Although this condition has been reported in only 3 patients previously, infraorbital canal protrusion into the maxillary sinus was present in >10% of our cohort. Identification of this variant on CT could help a surgeon avoid patient injury.

ABBREVIATIONS: IOC = infraorbital canal; ION = infraorbital nerve

CT of the paranasal sinuses is an important diagnostic technique in the work-up of patients with known or suspected disease of the nasal cavity and paranasal sinuses. CT gives the surgeon a roadmap for surgery and alerts the surgeon to the presence of potentially clinically relevant anatomic variants. Many sinonasal variants are important to identify since their presence may increase the risk of surgical error. With the advent of endoscopic techniques, surgery of the paranasal sinuses has expanded to involve complex procedures that were once reserved for open approaches. Thus, it is extremely important to identify such variations from the normal sinus anatomy, especially in patients who are likely to require extended endoscopic sinus surgery for etiologies such as inverted papilloma, mucocele, trauma, or malignant tumor.

The infraorbital nerve is the distal portion of the maxillary nerve (V2), which originates as the second division of the trigeminal nerve (fifth cranial nerve). After the maxillary nerve traverses the foramen rotundum, it enters the pterygopalatine fossa and gives off nasal and palatine branches before exiting through the inferior orbital fissure and terminating as the infraorbital nerve (ION). The ION then enters the infraorbital canal (IOC) through the infraorbital groove. The IOC is a bony canal typically within the orbital process of the maxilla, synonymous with the floor of the orbit. The ION exits the IOC through the infraorbital foramen of the anterior maxilla. Variably, the IOC can protrude into the maxillary sinus separate from the floor of the orbit. This may leave the ION susceptible to injury during endoscopic or open sinus surgery. To date, just 3 case reports exist in the literature describing this variant, with no large studies describing the frequency with which it occurs. The aim of this study was to establish the presence of infraorbital nerve protrusion into the maxillary sinus and define its common characteristics. This variation is of clinical importance in sinus surgery, and we suggest an accompa-
naging grading scale to relay the degree of protrusion to the surgeon.

MATERIALS AND METHODS
A retrospective image review of sinus CTs performed at our institution was conducted after obtaining institutional review board approval, including a waiver for informed consent. Five hundred consecutive sinus CTs performed on 500 distinct patients at our outpatient centers from February 2, 2014 to July 31, 2014 were included in the study. Most patients had known or suspected sinus inflammatory disease and were referred by an otorhinolaryngologist. All CTs reviewed were acquired in the axial plane at 0.625 mm and reconstructed in a bone algorithm at 1.25 mm in the axial plane. Sagittal and coronal reconstructions in either bone or soft-tissue algorithms at 1.5-mm thickness were also performed on all studies. Coverage on all CT scans was from the vertex of the skull through the level of the hard palate; expanded coverage was performed to fuse data with endoscopic instrumentation in these potential surgical candidates. No CT scans were excluded due to technical inadequacy or an inability to identify the IOC.

CTs were performed on one of our several scanners including a LightSpeed Pro-16 or HD-750 scanner (GE Healthcare, Milwaukee, Wisconsin) and were reviewed on a PACS on bone window settings (width/level, 4095/600) by a neuroradiology fellow (J.E.L.). All CTs reviewed were obtained and reconstructed in a bone algorithm at 1.25 mm in the axial plane. Sagittal and coronal reconstructions in either bone or soft-tissue algorithms at 1.5-mm thickness were also performed on all studies. Coverage on all CT scans was from the vertex of the skull through the level of the hard palate; expanded coverage was performed to fuse data with endoscopic instrumentation in these potential surgical candidates. No CT scans were excluded due to technical inadequacy or an inability to identify the IOC.

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RESULTS
The study population consisted of 272 females (54.4%) and 228 males (46.6%) with a median age of 47 years (range, 6–95 years). Protrusion of the IOC into the maxillary sinus was identified in 54 patients (10.8%); it was bilateral in 28 (5.6%) and unilateral in 26 (5.2%). All protruding IOCs were anchored to a wall of the maxillary sinus by at least 1 bony septum. The median length of the septum attaching the IOC to the wall of the maxillary sinus was 4 mm (range, 1–11 mm). The median distance posterior to the inferior orbital rim at which the ION began to protrude into the sinus, measuring posteriorly from the fixed anatomic landmark of the inferior orbital rim (Fig 2C). Note was made of whether the protruding IOC was unilateral or bilateral. Patients with IOC protrusion were divided into 3 classes based on maximal septum length: 1–3; 3–6; and ≥7 mm.

FIG 1. Axial (A), right parasagittal (B), and left parasagittal (C) sinus CT images in a 55-year-old woman show unilateral right-sided protrusion of the IOC into the maxillary sinus (arrowhead in A and B). While part of the wall of the left IOC protrudes into the sinus, the entire circumference of the IOC is not distinct from the anterior maxillary sinus wall; this feature is confirmed on the sagittal image through the left maxillary sinus (arrows in A and C). Additionally, no measurable bony septum connects the IOC to the wall of the maxillary sinus. This distinction was chosen to define protrusion of the IOC into the maxillary sinus.

FIG 2. Axial (A), coronal (B), left parasagittal (C), and right parasagittal (D) CT images in a 72-year-old woman show bilateral protrusion of the ION (arrowheads) into the maxillary sinus. The septum attaching the IOC to the anterior wall of the sinus was measured ( bracket in A) on the axial image. The distance at which protrusion begins posterior to the inferior orbital rim ( bracket in C) was measured on the sagittal image.

<table>
<thead>
<tr>
<th>Class</th>
<th>Septum Length</th>
<th>No. of Patients</th>
<th>Median Age (yr)</th>
<th>Female/Male</th>
<th>Bilateral (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1–3 mm</td>
<td>26</td>
<td>62.5</td>
<td>15:11</td>
<td>12 (46%)</td>
</tr>
<tr>
<td>2</td>
<td>4–6 mm</td>
<td>18</td>
<td>48.5</td>
<td>9:9</td>
<td>8 (44%)</td>
</tr>
<tr>
<td>3</td>
<td>7–11 mm</td>
<td>10</td>
<td>43.5</td>
<td>5:5</td>
<td>8 (80%)</td>
</tr>
</tbody>
</table>

*The most medial septum was chosen in patients with multiple septa.
of the septum attached to the protruding IOC (Table). Possibly We chose to group our patients into 3 classes based on the length established at what length the septum becomes clinically relevant.

mm and 10 (2%) had septa measuring

publication.

not have had IOC protrusion based on the images provided in that

this definition, 1 of the 2 patients reported by Mailleux et al may

with a wall of the maxillary sinus on at least 1 axial CT image. With

define a clinically relevant variant that may place a patient at

surgical risk for iatrogenic injury.4

is considered clinically relevant, placing the patient at the highest

range in the length of this septum. The length of this sep-
tum is important because the further into the sinus the IOC pro-
trudes, the more susceptible it may be to injury during sinus sur-
gery. When multiple septa were present, we measured the most

maxillary sinus was invariably present in our study, and we found a

width of septum attached to the anterior wall. No patient had a bony

sinus had a prevalence of 10.8%. At present, only 3 case reports

anterior ethmoidectomy; the reported incidence of this variant

posterior ethmoid cell that pneumatizes superiorly above the

The variant impairs normal drainage pathways, hinders endo-

The prevalence of internal carotid artery dehiscence and protru-

Reported prevalence for optic nerve protrusion ranges from 8%

14%.7 Optic nerve or internal carotid artery canal dehiscence and protrusion into the sphenoid sinus increase the risk of injury to those structures as well. Most of the literature supports a prevalence of optic nerve dehiscence of 0.7%–8%.6

Reported prevalence for optic nerve protrusion ranges from 8%

time at what point this measurement becomes clinically relevant.

Nevertheless, stating this measurement may give a surgeon an

idea of the severity of the protrusion and in what location to

expect the nerve when entering the sinus.

The wall to which a septum attaches is important to note as well; while we did not find a patient with an attachment to the

medial wall, such a septum could theoretically be at greater risk
during maxillary antrostomy. Only 1 patient had a single septum
attaching a protruding IOC to the posterior wall (Fig 3), with the

remaining patients all having at least 1 such septum attached to

the anterior wall.

The significance of a protruding IOC into the maxillary sinus has not been fully addressed in the literature. For a sinonasal vari-
ant to be considered relevant, 1 of the following 4 must be true:
The variant impairs normal drainage pathways, hinders endo-

scopic access to distal areas, serves as a focus for occult disease, or

increases the risk of surgical error.1 Examples of anatomic vari-

ants detectable on CT that may increase the risk of iatrogenic

injury include sphenothmoid (Onodi) cells, optic nerve or inter-

nal carotid artery protrusion into the sphenoid sinus, insertion of

the intersphenoid sinus septum onto the carotid canal, and aer-

ation of the anterior clinoid process. A sphenothmoid cell is a

posterior ethmoid cell that pneumatizes superiorly above the

sphenoid sinus and posteriorly beyond the anterior sphenoid

face, with the optic nerve being intimately related to its lateral

wall. It places the optic nerve at increased risk of injury during

due to posterior ethmoidectomy; the reported incidence of this variant

ranges from 8% to 14%.7 Optic nerve or internal carotid artery
canal dehiscence and protrusion into the sphenoid sinus increase

the risk of injury to those structures as well. Most of the literature

supports a prevalence of optic nerve dehiscence of 0.7%–8%.6

We also measured the distance at which the IOC begins to

protrude into the maxillary sinus posterior to the inferior orbital

rim because the inferior orbital rim is a fixed anatomic landmark

and it may be a useful way for a surgeon to conceptualize the

degree of protrusion before an intervention. The IOC began to

protrude into the sinus more proximally with a longer measure-

ment. As with the length of the bony septum, it is not clear at this

FIG 3. Axial CT image in a 56-year-old man shows left-sided protru-
sion of the ION into the maxillary sinus (arrowhead) attached to a

single posterior septum (arrow). This was the only patient with a

septum attaching a protruding IOC to the posterior wall of the max-

illary sinus without an additional septum attaching to the anterior

wall.

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open, anterior approaches to the maxillary sinus place a protruding ION at increased risk of iatrogenic injury because most are connected to a bony septum attached to the anterior maxillary sinus wall. Thus, we believe that in the presurgical setting, identification of the location of the ION should be part of the routine search pattern for interpreting physicians to reduce the risk of ION injury.

The prevalence of 10.8% of IOC protrusion in this cohort suggests that it is a common anatomic variation, though its prevalence in the general population not referred for imaging is unknown. Although we have no reason to suspect it, IOC protrusion into the maxillary sinus may be more common in individuals with known or suspected sinus inflammatory disease. In this instance, our prevalence would not be applicable to the general population, and future studies may help confirm that our number is generalizable to the greater population. Furthermore, we suggest a classification that can be used to easily convey the degree of protrusion to the surgeon. At this time, because the rate of iatrogenic injury to the protruding ION is unknown, the clinical utility of this classification scale is not clear. Still, because there are an estimated 250,000 endoscopic sinus surgical procedures per year performed in the United States and the maxillary sinus is the most commonly instrumented sinus, a rate of 10.8% ION protrusion is of particular clinical relevance.¹⁹

CONCLUSIONS
To date, only 3 case reports in the literature have described protrusion of the IOC into the maxillary sinus rather than within the orbital process of the maxilla (orbital floor). Using the definition that the entire wall of the IOC had to be separate from all walls of the maxillary sinus on a single image, we found a prevalence of 10.8% for this variant during review of 500 CT scans. The distance of protrusion into the sinus should be noted because this information may help avoid iatrogenic injury during surgical intervention.

REFERENCES