

# Computed Tomography Exclusion of Osseous Paranasal Sinus Injury in Blunt Trauma Patients: The "Clear Sinus" Sign

DAVID M. LAMBERT, DDS,\* STUART E. MIRVIS, MD,†  
K. SHANMUGANATHAN, MD,‡ AND DONALD L. TILGHMAN, DDS§

**Purpose:** This prospective study was designed to assess the association of clear paranasal sinuses (no free fluid) as shown by facial computed tomography (CT) with the absence of fractures involving the paranasal sinus walls.

**Patients and Methods:** All facial CT scans performed during a 12-month period to rule out maxillofacial injury in blunt trauma patients were reviewed. The scans were made using 5-mm slice thickness and 4-mm table incrementation. They were assessed for the presence or absence of free paranasal sinus fluid (hemorrhage) and the presence and location of facial fractures.

**Results:** A total of 366 CT scans of the face were performed during the study. Among them, 180 scans (49%) were identified that showed no evidence of free paranasal fluid. Twenty-two (12%) of these 180 CT studies showed isolated nasal fractures ( $n = 13$ ) or zygomatic arch fractures ( $n = 9$ ). No patient without free paranasal sinus fluid had any midfacial fracture involving a paranasal sinus wall ( $P < .001$  by Fischer exact test).

**Conclusion:** The absence of free paranasal sinus fluid after facial trauma is a highly reliable criterion to exclude fractures involving the paranasal sinus walls. Other fractures involving osseous structures not contiguous with the paranasal sinus walls, such as nasal or zygomatic arch fractures, are not excluded. The CT "clear sinus" sign is a simple, rapid method to exclude paranasal sinus fractures.

The diagnostic imaging assessment of the facial skeleton is an important component in the evaluation and management of maxillofacial fractures in blunt trauma patients. Commonly used diagnostic techniques include plain film radiography, radiographic tomography, and computed axial tomography (CT). Conven-

tional plain film radiographic surveys serve as an appropriate study to exclude or confirm fractures in certain regions of the face, including isolated fractures of the zygomatic arch, nasal bones, or mandible. However, in patients who have sustained significant trauma to the mid and upper thirds of the midface, panfacial trauma, or in patients with suspected facial and coexisting craniocerebral injury, CT currently provides the reference standard for diagnosis.<sup>1,2</sup> CT offers superior diagnostic accuracy in the assessment of osseous and soft tissue because of its ability to provide high spatial resolution images of the facial anatomy in both direct axial or coronal planes, potentially supplemented by other reformed two-dimensional planes, or three-dimensional surface contour images,<sup>1,2</sup> thus eliminating the overlapping of osseous structures inherent in plain radiographic studies. CT also provides greater contrast resolution than plain radiographs, improving detection of soft tissue injury.

In the setting of major multisystem trauma, CT is

---

Received from the University of Maryland Medical System, Baltimore.

\* Resident, Department of Oral and Maxillofacial Surgery.

† Professor, Chief-of-Diagnosis, Department of Diagnostic Radiology.

‡ Assistant Professor of Radiology, Department of Diagnostic Radiology.

§ Professor, Department of Oral and Maxillofacial Surgery.

Address correspondence and reprint requests to Dr Lambert: Department of Oral and Maxillofacial Surgery, University of Maryland Medical System, 22 South Greene St, Room NGE08, Baltimore, MD 21201. e-mail: DLAMBERT@UMABNET.AB.UMD.EDU.

© 1997 American Association of Oral and Maxillofacial Surgeons  
0278-2391/97/5511-0003\$3.00/0

often the initial screening study for the assessment of suspected maxillofacial injury. In many trauma patients, other CT examinations are frequently required, such as of the cranium, facilitating assessment of the face or mandible at the same time. In addition, the quality of plain radiographs of the face is often compromised by the use of portable equipment, as well as poor or limited ability of patients to cooperate in this clinical setting.

The diagnostic interpretation of maxillofacial CT studies for trauma requires complete familiarity with axial and coronal CT facial anatomy to distinguish sutures, fissures, foramina, normal areas of bone thinning, "pseudo-fractures" created by partial volume averaging, and variations of normal anatomy from true osseous injury.<sup>3</sup> Facial injuries may be seen as overt displacements of the facial skeleton but are often quite subtle. Important, but potentially subtle, minimally displaced fractures may involve the orbital floor, orbital roof, or frontal sinus walls. Even major fracture patterns, including the zygomatico-maxillary complex fractures and Le Fort I patterns, may be relatively subtle on CT. Indirect signs of facial skeletal injury include soft tissue swelling and paranasal sinus fluid. The anecdotal retrospective experience of two trauma radiologists (S.M., K.S.) in our trauma center suggested that the presence or absence of free fluid in the paranasal sinuses on maxillofacial CT serves as a sensitive marker for adjacent facial fractures, particularly in the midface regions abutting the sinuses. To ascertain the value of paranasal sinus free fluid as an easy to detect marker of underlying osseous injury, a prospective evaluation of facial trauma CT scans was performed comparing the presence or absence of free paranasal sinus fluid with the presence and location of any facial fractures ultimately diagnosed by CT.

### Patients and Methods

During a 12-month period, patients with blunt trauma to the face in whom clinical concern for fractures existed were examined by CT scanning. Scans were ordered by the admitting trauma team as a part of their workup for maxillofacial trauma independently from either the radiology or maxillofacial surgery services. Scans were performed from the maxillary alveolar ridge to the top of the frontal sinuses with a Siemens Somatom Plus 4 spiral scanner (Siemens Medical Systems, Iselin, NJ) using 5-mm axial sections and 4-mm table incrementation. If there was special concern regarding the orbits, these were scanned at 2-mm contiguous slices. Reformations of the face were routinely obtained in the coronal plane to better assess horizontally oriented bony structures (struts) such as the orbital floor, orbital roof, and hard palate. CT studies were

interpreted by staff radiologists (S.M. and K.S.) with expertise in facial CT interpretation. Studies were reviewed for overall technical quality, presence or absence of free fluid in any paranasal sinus, and the presence or absence of facial skeletal injury. Thickening of the paranasal sinus mucosa that appeared chronic in nature was not considered to represent free intrasinus fluid; free fluid required the presence of a clear air-fluid level interface.

### Results

All facial CT examinations were judged to be technically adequate. A total of 366 facial/orbit CT scans on blunt trauma patients were performed during the 12-month study. There were 180 patients (49%) identified without free fluid in any paranasal sinus ("clear sinus" sign). Among these 180 patients, none had a fracture directly involving a paranasal sinus wall, but 22 (12%) had non-paranasal sinus facial fractures involving either the nose ( $n = 13$ ) (Fig 1) or zygomatic arch ( $n = 9$ ) (Fig 2). The absence of free paranasal sinus fluid by CT was statistically highly associated with the absence of a fracture involving the paranasal sinus walls ( $P < .001$ ).

There were 137 (37%) of the 366 study patients who had both free paranasal sinus fluid and adjacent fractures of the paranasal facial skeleton. An additional



FIGURE 1. Axial CT image of blunt trauma patient shows a minimally displaced left nasal bone fracture (*arrow*). The maxillary and other paranasal sinuses (not shown) showed no evidence of free fluid.

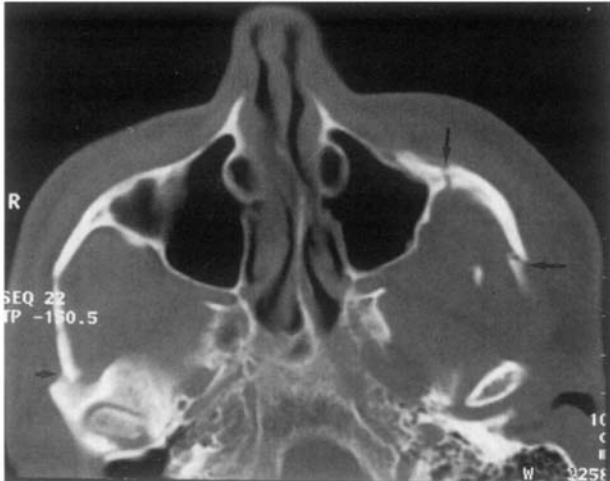


FIGURE 2. Axial CT image of blunt trauma victim shows isolated double left zygomatic arch fracture (arrows). The posterior right zygomatic arch is also fractured (arrowhead). The maxillary and other paranasal sinuses (not shown) were clear.

49 (14%) of the 366 study patients exhibited free paranasal sinus fluid without adjacent paranasal sinus wall fractures; 20 of these patients had nonparanasal sinus facial fractures involving the nose ( $n = 15$ ) or zygomatic arch ( $n = 5$ ). The presence of free paranasal sinus fluid after blunt facial trauma was highly associated with the presence of a paranasal wall fracture ( $P < .001$ ) (Table 1).

### Discussion

The frontal, ethmoid, maxillary, and sphenoid sinuses reside prominently in the maxillofacial region and are therefore at risk for injury from blunt facial impact. The centrally located maxillary sinuses are particularly prone to injury associated with midface fractures, including Le Fort patterns, the zygomaticomaxillary complex injury, posterior dentoalveolar fractures, and orbital floor fractures. Injury to the ethmoid labyrinthine air cells, frontal sinus, and maxillary sinus may result from naso-orbital-ethmoid fracture patterns. Medial orbital wall fractures typically produce hemorrhage in the adjacent ethmoid air cells, and fluid in the frontal sinus reflects injury to the anterior, posterior, or both tables of the frontal sinus.<sup>4</sup>

The paranasal sinuses are lined by mucoperiosteum containing a rich vascular supply.<sup>5</sup> Transmission of energy from blunt impact that disrupts the osseous integrity of the sinus will simultaneously produce tearing or laceration of the mucoperiosteum, causing free hemorrhage into the sinus. Based on this assumption, the premise that the absence of free paranasal sinus fluid (hemorrhage) ("clear sinus" sign) excludes frac-

tures involving the paranasal sinus walls was evaluated in this study. Our results support the use of paranasal sinus free fluid as a valuable indirect sign of osseous injury to the maxillofacial region. Isolated injury to bones that do not directly border a paranasal sinus, such as the zygomatic arch or nasal bones, cannot be excluded by the lack of paranasal sinus fluid, as occurred in 22 (12%) of our patients without free paranasal sinus fluid. It is also conceivable that other structures could be violated, such as the nasal septum or anterior maxillary dentoalveolar region without producing paranasal sinus free fluid. Although no such cases occurred in this series, a larger population study might reveal such examples.

The potential limitations of applying these results in the clinical setting include presentation of patients with blunt facial trauma with preexisting paranasal sinus free fluid from sinusitis unrelated to the traumatic event suggesting the presence of a sinus wall fracture, or traumatic paranasal sinus hemorrhage limited to the submucosal region without production of an air-fluid level within the sinus. These limitations can usually be assessed by determining the CT density of the paranasal sinus fluid. Hemorrhage usually exhibits a CT attenuation of 30 to 40 Hounsfield Units (HU), and clotted blood measures 60 to 80 HU.<sup>6</sup> Serous effusion associated with inflammatory conditions would be expected to have a lower attenuation near the density of water (0 HU). Submucosal blood clot also may be differentiated from simple mucosal inflammation by measurement of CT attenuation. In this study, no patients were identified with only submucosal hematomas associated with paranasal sinus wall fractures. Finally, a nondisplaced, bending, or greenstick type of sinus wall fracture could occur without disrupting the mucoperiosteal lining and thus not show free intrasinus hemorrhage. We did not detect such examples in this series, and the requirement for intervention in such minimal injuries is limited or unnecessary.

The implication of these results is that a good quality, plain facial radiograph obtained in the Waters pro-

**Table 1. Association of Paranasal Sinus Wall Fractures With Paranasal Sinus Fluid by CT**

	Paranasal Sinus Fluid (+)	Paranasal Sinus Fluid (-)
Paranasal sinus wall fracture (+)	137	0*
Paranasal sinus wall fracture (-)	49	180†

\*  $P < .001$  by Fischer exact test.

† Twenty-two patients had nonparanasal wall fractures including nasal ( $n = 13$ ) and zygomatic arch fractures ( $n = 9$ ).

jection should serve as an excellent screening test for midface fractures, although the radiograph most likely lacks the sensitivity of CT for detection of small quantities of free fluid. The lack of free paranasal sinus fluid on a high-quality Waters view radiograph might well serve to exclude significant midface fractures at a much lower cost than CT scanning, whereas demonstration of a paranasal sinus fluid might appropriately prompt a CT scan to ideally show the nature and extent of bone and soft tissue injury. Selected use of nasal and submental vertex radiographs should serve to adequately show isolated injuries to these regions without requiring CT assessment. When facial CT is performed for trauma, the absence of paranasal sinus free fluid virtually excludes a fracture of the sinus walls. Direct prospective blinded comparison of Waters view radio-

graphs and facial CT scans of trauma patients is needed to further assess the implications of our results.

## References

1. Lawrason JN, Novelline RA: Diagnostic imaging of facial trauma, in Mirvis SF, Young JWR (eds): *Imaging in Trauma and Critical Care*. Baltimore, MD, Williams & Wilkins, 1992, pp 243-290
2. Pathria MN, Blaser SI: Diagnostic imaging of craniofacial fractures. *Radiol Clin North Am* 27:839, 1989
3. Rogers LF (ed): *Radiology of Skeletal Trauma* (ed 2). New York, NY, Churchill Livingstone, 1992, p 379
4. Maran AGD, Lund VJ: *Clinical Rhinology*. New York, NY, Georg Thieme Verlag Stuttgart, 1990, pp 131, 136
5. McGowan DA, Baxter PW, Jacqueline J: *The Maxillary Sinus and its Dental Implications*. Oxford, England, Wright, 1993, p 18
6. Federle MP, Jeffrey RB Jr: Hemoperitoneum studied by computed tomography. *Radiology* 148:187, 1983

J Oral Maxillofac Surg  
55:1210-1211, 1997

# Discussion

## Computed Tomography Exclusion of Osseous Paranasal Sinus Injury in Blunt Trauma Patients: The "Clear Sinus" Sign

Curtis W. Hayes, MD

Virginia Commonwealth University, Medical College of Virginia, Richmond, Virginia

Dr Lambert et al examine the association between paranasal sinus fluid detected by computed tomography (CT) and the presence of adjacent fractures in traumatized patients. The hypothesis—that the absence of free fluid in the sinuses reliably excludes adjacent fractures—was convincingly confirmed. The authors conclude that the presence or absence of free fluid is a useful, indirect CT finding in trauma and suggest that, with confirmation, the same finding could be applied to plain radiographic studies in the form of screening tests for facial trauma.

The study is an excellent example of a thorough, yet simple, experimental design inspired by a common clinical problem—rapid but accurate evaluation of the traumatized patient. In perusing the article, I believed that some practical conclusions and interesting implications can be drawn from this study.

First, the authors have shown that in interpreting maxillofacial CT in the acute trauma setting, the absence of free fluid in the sinuses reliably excludes fractures in adjacent bones. Although this conclusion probably comes as no surprise to most experienced traumatologists, the scientific validation is more than just a comfort. The application of this sign will allow a more definitive interpretation in cases in which there may be deformity from previous trauma or in which normal anatomy resembles a fracture.

The "clear sinus" sign also has potential to be applied as a CT screening examination in trauma. In particular, patients already undergoing cranial CT for trauma could have the examination extended inferiorly so as to cover the dependentmost portion of the maxillary sinuses. The scan could be continuous, or possibly an additional one or two "cuts" could be shown to suffice as a screen. Air-fluid levels in the sinuses would signal the need for a complete evaluation, either radiographic or by CT. A "clear sinus" sign would obviate the need for further studies unless, as the authors clearly state, there is call for evaluation of nonadjacent structures, such as the nasal bones or zygomatic arches.

The "clear sinus" sign could also be useful in the interpretation of potential fractures in difficult-to-image locations. Evaluation of the orbital floor is best done through direct coronal scanning, a position that may be contraindicated in an acutely injured patient. In these cases, the absence of fluid in the paranasal sinuses on the conventional CT scan would be a useful signal that acute fracture is not present. Conversely, a positive air fluid level would signal the need for additional evaluation.

The authors state that their results imply that a good quality plain radiograph in the Waters projection would make an excellent screening test for midface fractures. However, they correctly point out that a study comparing the accuracy of CT versus the Waters projection for the assessment of free fluid is needed before making this recommendation.

A screening Waters view is, indeed, appealing in that it might save time, cost, and allow a reduction in radiation dose in some patients. However, in practice, I am afraid that it may have less impact than it may first appear. First, the projection must be performed with the patient upright to detect air-fluid levels. Any patient incapable of being placed