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High-Resolution CT Scanning of Facial Trauma

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Computed tomographic (CT) scanning offers a simple, fast, and accurate study of complex maxillofacial trauma especially in the patient with multiple injuries. At the time of CT brain scanning, the facial bones can be scanned with only minimal extra time. High-resolution scanning provides excellent bony detail equal to or better than complex-motion tomography with the advantage of better contrast resolution as well. Application of craniofacial surgical techniques is facilitated by the accurate display of the nature and extent of fracturing. Surgical findings of extent of fracturing correlate better with high-resolution scanning than with plain films and conventional tomography.

Major facial trauma often accompanies multiple trauma elsewhere. Of about 800 multiple trauma patients seen at Sunnybrook Medical Centre between 1976 and 1981, 25% had severe facial injuries. In the stress of acute management of the other severe injuries, good standard radiologic views of the face are difficult to obtain and tomograms are usually not feasible. Both conventional radiographic plain films and tomograms usually do not show the degree of comminution seen at surgery in patients with complex facial trauma. However, high-resolution computed tomography (CT) has changed this situation. It can provide excellent display of the many comminuted fragments that must be managed in the treatment of complex facial fractures. Further, it can provide this information when the patient is first examined and at little inconvenience or discomfort. Our experience with CT in facial fractures is reviewed.

Materials and Methods

Of the 300 major facial injuries treated in the last 6 years at Sunnybrook Medical Centre, about one-third had CT scans. Since high-resolution scanning has become available we have used it for our definitive study. When possible, CT was performed of the facial bones in addition to the brain on the initial study in multiple trauma cases. All scans were obtained with a General Electric 8800 scanner using 5 mm contiguous sections in the transverse plane without overlapping slices. Reformatting was mainly in the coronal plane. Retrospective high-resolution image analysis (ReView) of the facial bones was performed in most cases; this allowed the patients to be imaged more rapidly. By preselecting slices to be viewed (e.g., the top and bottom slice), the patient was often able to leave earlier than if all the slices were viewed in consecutive order. Extended CT number scale and image reversal were also used. Direct coronal scans were obtained in some cases in either the prone or supine position but were usually not obtained at the time of the initial study.

Representative Case Reports

Case 1

A 25-year-old man sustained severe craniofacial injuries and cerebrospinal fluid (CSF) leak after a motor vehicle accident. Facial injuries included bilateral LeFort II and a LeFort I fracture, bilateral orbital floor, and right medial orbital wall blowout fractures. The nasofrontoethmoid area fracturing extended to the right cribriform region and two dural defects were present allowing CSF leak. In addition, there was a compound comminuted left mandibular fracture.

Axial CT (fig. 1) revealed the medial blowout and suggested that there were orbital floor blow-out fractures. Comminuted fractures of the maxillae, pterygoids, nasal bones, and the nasoethmoid fracture displacement on the right were seen. The medial rectus muscle was not entrapped. Coronal reformatting confirmed orbital floor blowout and the right medial orbital blowout fracture.

Case 2

A 29-year-old man suffered very severe head and facial injury when a truck tire on which he was working exploded and struck his face. Through lacerations of his forehead, his brain could be seen. His frontal bone was shattered from right to left and some bone fragments had been lost through the laceration (fig. 2A). Most of the right orbit and the entire medial superior left orbit were fragmented. There was complete disruption of the remaining orbital walls, the right zygoma, and maxilla, and complete craniofacial separation was present.

Exploration of the facial fractures was performed the same day after a right epidural hematoma was removed. The neurosurgical coronal incision was enlarged and incisions on the cheek were explored to identify the pattern of fragments. The lower face, orbits, and zygoma were fixed with internal fixation wires. The frontal bone was reconstructed using rib grafts which were wired to the skull and orbital rims were fashioned. The fixed nasozygomatic-orbital complex was stabilized to the skull above. A rib graft was used to fashion the nose (figs. 2B and 2C).

Case 3

A 33-year-old woman was attacked and struck repeatedly with a baseball bat causing severe cranial and facial injuries. The nasoethmoid smash caused traumatic telecanthus with midface flattening. Fractures of nasal bones, both maxillae, zygomatic bones and orbits were found. Axial and coronal CT were performed. The coronal views were made with the patient supine (fig. 3).

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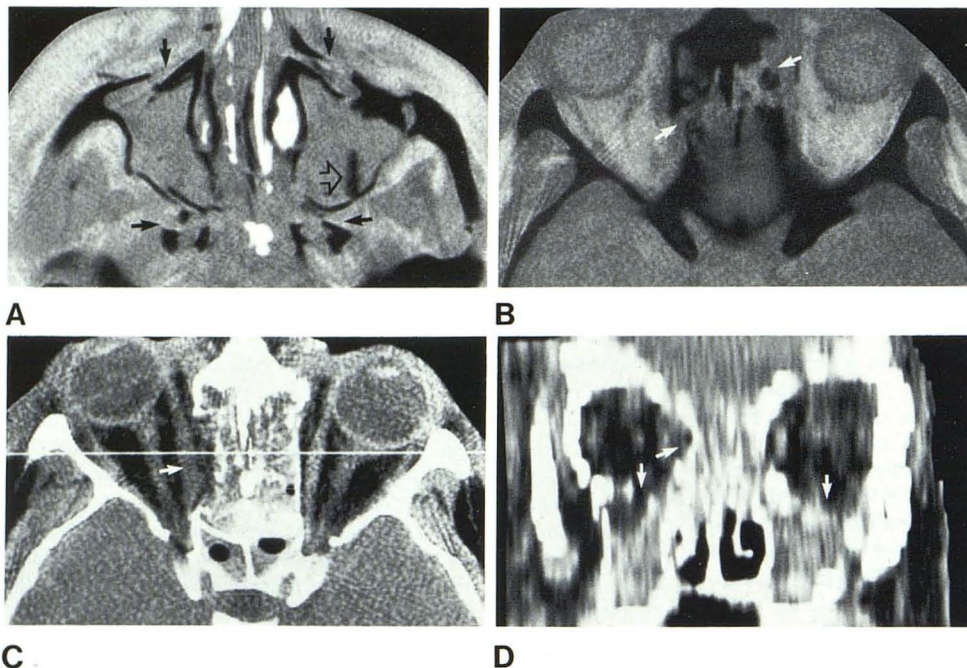


Fig. 1.—Case 1. **A**, Depressed comminuted fragments anterior maxilla (vertical arrows), pterygoid fractures (horizontal arrows). Bone fragment in left maxillary sinus (open arrow) is part of depressed left orbital floor. Not marked are lateral wall maxillary sinus and nasal septum fractures. **B**, Comminuted fracture across ethmoids with displacement to right (arrows). **C**, Lower slice. Window is set for soft tissue. Medial wall blowout on right with medial rectus well seen (arrow). **D**, Coronal reformatting through axis in **C** (white line). Bilateral orbital floor and right medial wall blowout fracture (arrows).

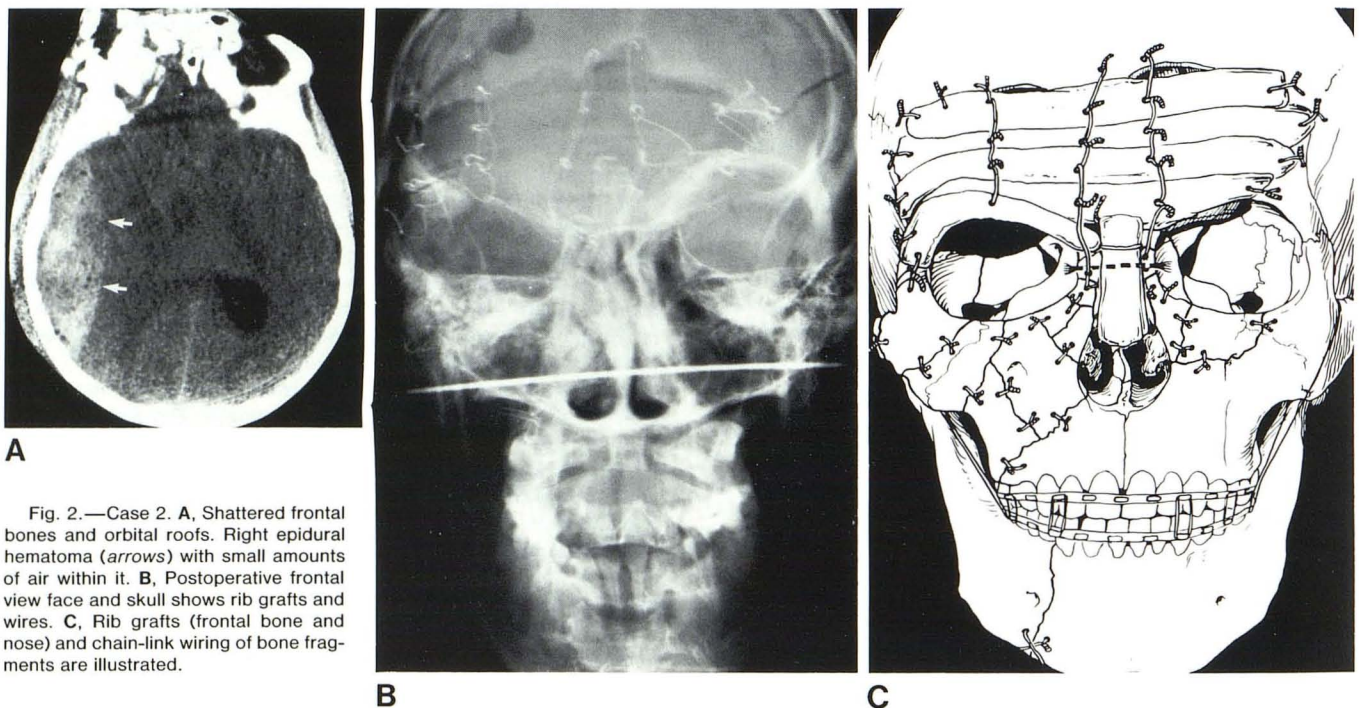


Fig. 2.—Case 2. **A**, Shattered frontal bones and orbital roofs. Right epidural hematoma (arrows) with small amounts of air within it. **B**, Postoperative frontal view face and skull shows rib grafts and wires. **C**, Rib grafts (frontal bone and nose) and chain-link wiring of bone fragments are illustrated.

Observations

The degree of comminution of facial fractures is better assessed by high-resolution CT than by tomography. This is especially true in the orbital roof, the maxilla, and the ethmoid area. LeFort-type fractures are well demonstrated by CT (fig. 1) although when fracture lines run parallel to the axis of the CT slice, reformatted

views at right angles or direct coronal scans are required. LeFort fractures are often not of the pure type I, II, or III but are mixed and there is usually much comminution [1, 2]. Medial blowout fractures of the orbit also are best assessed by CT, which, by virtue of demonstrating the medial rectus muscle, can suggest whether entrapment of this muscle is present or not [3]. When true coronal CT is performed, blowout fractures of the floor are readily shown

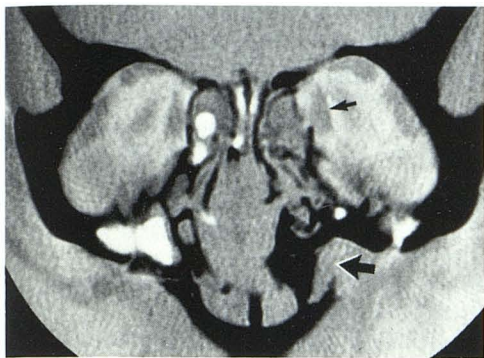


Fig. 3.—Case 3. Supine coronal view has been reversed so that the patient's right is on viewer's right. Fractures of both maxillae are evident with displacement of right fragments (*large arrow*). Fracturing of right medial orbital wall is evident. Medial rectus is well visualized (*small arrow*).

and entrapment of the inferior rectus or oblique muscles may be assessed. Unfortunately, reformatted coronal views are generally rather coarse when 5 mm contiguous slices without overlap are taken in the axial plane; however, useful information can still be gained from them.

CT is able to demonstrate small amounts of air, whether intracranial, within the orbit, or within the soft tissues of the cheek, not demonstrated by other studies. Injury to the orbit with globe displacement and foreign bodies is also better assessed by CT than conventional tomography. In addition, CT is able to demonstrate intracranial hemorrhage, and, if cervical spine fracture is suspected, it may be studied by CT at the same time.

Aside from obvious intracranial traumatic hemorrhage, which is readily detected by CT, subtle findings such as slight pneumocephalus may be detected (fig. 2A). Frontal sinus fractures are readily seen along with depression of fragments and posterior wall fractures. Fine comminuted fragments of the ethmoid complex can be detected with CT, and, as well the bone tissue detail, it allows visualization of medial wall blowout fractures (figs. 1B, 1C, and 2A). alization of medial wall blow-out fractures (figs. 1B, 1C, and 2A).

The degree of impaction of maxillozygomatic and nasomaxillary fractures can be assessed in the axial plane (fig. 1A), while rotation of zygomatic fractures is best seen on coronal scans. Reformatted imaging in the coronal or other planes may confirm suspicious orbital floor blow-out fractures (fig. 1D) or direct coronal CT scanning may be attempted at a later time. Unfortunately, good reformatted images require overlapping of 5 mm slices or thinner slices, which entails longer scanning time and greater radiation dose. However, perhaps this technique with overlapping and reformatting may be the best way to study these fractures [4].

Discussion

The great value of CT in demonstrating cerebral hemorrhage and other intracranial pathology has overshadowed its value in other areas such as facial trauma. Some reports of the use of CT in facial trauma have appeared in the literature, however, the better bone detail of complex-motion tomography compared with CT did not encourage the routine use of CT. In patients with multiple trauma and facial fractures, there is often accompanying craniocerebral trauma, and, even if the head injury is not severe, CT brain scanning is often requested before anesthesia for repair of other injuries.

Although CT study of the facial bones can be accomplished at the time of brain scanning with only minor delay, these studies are often not performed, perhaps because a low priority is put on the facial injuries or because of the precedence for using conventional tomography. Also, these multiple injury cases often arrive in the evening, during the night, or on weekends when the desire of everyone is to get the patient out of the CT room as quickly as possible and to get on with the treatment of his other injuries. Although the treatment of facial fractures is often delayed, in patients with multiple injuries, early surgical intervention may be of benefit, and, in the study of Mekubjian [5], mortality was not increased.

Even before high-resolution CT, the axial view was very valuable in demonstrating fractures such as orbital roof, which were not easily appreciated with conventional techniques (fig. 2A). Manfredi et al. [6] described five patients with clinical evidence of indirect injury to the optic nerve in whom the optic canal fracture together with associated orbital roof fractures were demonstrated by CT. The fragments of blowout fractures were better appreciated by CT than by polytomography [7, 8], and complex midfacial fractures were better appreciated by CT as well [7].

Before high-resolution scanning, several authors noted the ability of CT to demonstrate complex fractures of the facial skeleton [9–14]. However, many believed that CT did not replace complex-motion tomography at that time, since fine bony detail was better seen with conventional tomography [12–15]. Other problems with CT were artifacts caused by dental restorations and patient movement causing distortion of the picture. Faster scanning times and high-resolution CT now offer superb bony detail of such thin structures as ethmoidal air cell walls [4, 16], and tomography now might be superfluous when high-resolution scanning is available [17]. The amount of radiation is also decreased when CT is compared with conventional polytomography.

We still prefer to have plain films in addition to axial CT in order to get a total picture of the facial injuries, since CT in the axial plane alone may miss fracture lines parallel to this axis where there is minimal displacement of the bone. Related fracture of the upper cervical spine and mandible and skull may be seen on these plain films as well. When the plain film and axial CT study are indeterminate (e.g., in the case of orbital floor trauma), reformatted images are obtained and, if these are unsuccessful, direct coronal scanning can be tried, or, if this is not possible, conventional tomography may be used [18]. The axial and the coronal scan are complementary, the one possibly indicating some information not obtained on the other.

Different surgical techniques are available in the treatment of complex facial fractures, one of which is the use of craniofacial technique. In this technique, all the fractures are directly exposed and wired together. Where bone is missing, primary bone grafting with rib grafts is performed (figs. 2B and 2C). Thus, reconstitution of the facial skeleton is performed as one procedure, which allows for quicker healing. Usually secondary facial corrective surgery is not needed. Patients return to normal life and normal eating habits faster than with other methods. These techniques are especially useful in "unstable" facial fractures where there is marked mobility, depression, and comminution of fragments, which may involve orbits, nose, zygoma, and maxilla. Absent dentition also favors instability. In the use of these techniques, the accurate radiologic display of the many comminuted fractures and the degree and direction of displacement gives the surgeon a better idea in the planning of his approach and management. The correlation between the CT findings of fracture comminution and those at surgery are much closer than was seen previously with plain films and tomograms.

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