Original Contribution

Computed tomography of the head as a screening examination for facial fractures

Jon Marinaro MD<sup>a,b</sup>, Cameron S. Crandall MD<sup>b</sup>*, David Doezema MD<sup>b</sup>

<sup>a</sup>Department of Surgery, University of New Mexico, University of New Mexico, Albuquerque, NM 87131-0001, USA
<sup>b</sup>Department of Emergency Medicine, University of New Mexico, Albuquerque, NM 87131-0001, USA

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Abstract We hypothesized that head computed tomography (CT) is an accurate screening tool for detecting nonnasal midfacial fractures in trauma patients. We retrospectively reviewed charts and official readings for all patients who underwent both head and facial CT scans for trauma at our trauma center between August 2002 and April 2003. The ability of head CT to diagnose nonnasal bone midfacial fractures was compared with that of facial CT using sensitivity, specificity, accuracy, as well as positive and negative predictive values. Agreement was measured with $\kappa$ statistics. Ninety-five percent confidence intervals (CIs) were used to assess precision. Ninety-one patient records with head and facial CT scan reports were reviewed. Of the patients, 50 (55%) had nonnasal bone midfacial fractures. The sensitivity and specificity of head CT were 90% (95% CI = 79%-96%) and 95% (95% CI = 84%-99%), respectively; the positive and negative predictive values were 96% (95% CI = 86%-99%) and 89% (95% CI = 76%-95%), respectively. The rate of accuracy was 92%. The agreement was excellent ($\kappa = 0.85$, 95% CI = 0.74-0.96). Head CT was sensitive and specific for identifying nonnasal bone midfacial fractures. An initial head CT alone may limit the need for a Waters view radiography or screening facial CT in detecting injuries.

$^*$ Corresponding author. Tel.: +1 505 272 5062; fax: +1 505 272 6503. E-mail address: ccrandall@salud.unm.edu (C.S. Crandall).

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1. Introduction

1.1. Background

Blunt facial trauma is often accompanied by mechanisms that indicate a need for brain imaging to evaluate for injury [1]. We have noticed that many patients who had undergone head CT had evidence of facial fractures as seen on most caudal images.

1.2. Importance

Physical examination, 3-view facial series, single-view facial radiography, and computed tomography (CT) of the face are all methods for determining the presence of facial fractures in blunt trauma patients. Each of these methods has limitations. Physical examination often is hindered by pain, soft tissue swelling, lacerations, and altered mental status [2]. Facial radiography is limited by interpretation difficulties by nonradiologists [3] and has a lower diagnostic utility as compared with facial CT [4]; however, facial CT is an expensive screening test often requiring cervical spine clearance to obtain direct coronal images. Few will contest that the gold standard in evaluation is facial CT [5].
1.3. Goals

We compared head CT scan findings with facial CT findings among patients with blunt trauma to determine the usefulness of head CT in screening for facial fractures. We hypothesized that the sensitivity of head CT as compared with that of facial CT in diagnosing nonnasal midfacial fractures was adequate for it to serve as a screening test.

2. Methods

We retrospectively reviewed radiological dictations of consecutive patients who had undergone both head and facial CT scans for blunt trauma in the same visit between August 2002 and April 2003. Data were collected at an urban level I trauma center with 421 beds and an annual emergency department (ED) census of more than 75,000 visits. The study design was approved by our institutional review board.

Scans were ordered at the discretion of the ED attending physician or an upper-level resident. Computed tomographic scans of the head were performed using 5-mm collimation through the posterior fossa and then with 10-mm collimation through the rest of the brain.

Cases were identified from a radiology reading book maintained by the institution's CT technicians. All head and face CT scans are documented in this book by a CT technologist before interpretation by a board-certified neuroradiologist. Consecutive cases with both head and facial CT scan data during the cited period were identified from the reading book.

Data collection was performed by a single nonblinded emergency physician (J.M.) who reviewed the formal dictations identified from the reading book. All midfacial and upper facial fractures, except for nasal bone fractures, were considered. Although many nasal fractures are clinically significant, it is not the practice at our institution to obtain radiographs to diagnose them; thus, we excluded nasal fractures to reduce diagnostic biases. Facial fractures on head CT were identified by the presence of the terms fracture (not skull), intracranal air, and extracranal air in the dictations. Patients with a penetrating injury or whose scans were not performed during a single hospitalization or ED visit were excluded.

Data were analyzed for sensitivity, specificity, as well as positive and negative predictive values. Agreement between the scans for head CT and facial CT was measured with \( \kappa \) statistics. Confidence intervals at the 95% level were used to assess precision.

Fig. 1  Location of facial fractures as identified on CT of the head. Fractures missed on CT of the head but detected on CT of the face are in parentheses.
3. Results

Ninety-one patients who underwent both a head CT and a facial CT were identified. Most of the patients were male (n = 68, 75%). The youngest patient was 12 years old. Mechanisms of injury included nonspecified trauma (34%), assault (27%), transportation-related trauma (25%), falls (11%), and other forms of trauma (2%).

Fifty (55%) patients with fractures and 41 (45%) without fractures were identified. One hundred one fractures were identified among the 50 patients (Fig. 1). Among the patients, for whom 182 scans were evaluated, there were 39 (43%) who had negative findings for a fracture on both head and facial CT scans, 45 (49%) who had positive findings for a fracture on both scans, 5 (5%) who had negative findings on the head CT scan but positive findings on the facial CT scan, and 2 (2%) had positive findings on the head CT scan but negative findings on the facial CT scan (Table 1).

Compared with facial CT, head CT was 90% sensitive, was 95% specific, had a positive predictive value of 96%, and had a negative predictive value of 89%. The agreement between head CT and facial CT was excellent at 0.85 (Table 2).

We identified 2 false-positive cases for which the head CT showed a fracture but the facial CT did not. In 1 case, the fracture seen on the head CT was determined to be old on the facial CT. In the other case, the diagnosis of fracture was made based on the presence of fluid in the maxillary sinus. The subsequent facial CT showed no fracture.

Five false-negative cases were identified. The head CT scans showed no fracture, but the subsequent facial CT scans identified fractures. The missed fractures were (1) an orbital floor fracture characterized as mild on the facial CT, (2) a right posterolateral maxillary sinus wall fracture, (3) a medial orbital wall fracture, (4) a left medial orbital wall fracture, and (5) left anterior and posterior maxillary sinus wall fractures with herniation of fat through the posterior wall fracture and air in the inferior aspect of the left orbit. Of these 5 scans, 3 (cases 1, 2, and 3) were re-presented to the neuroradiologist, who was also asked to specifically evaluate for the presence or absence of facial fractures. Two of the 3 CT scans had fractures identified on reexamination. None of these cases required intervention or surgery.

In addition to midfacial and upper facial fractures, 10 nasal fractures and 5 mandibular fractures were identified on head CT. Several fractures were seen on the head CT scan’s lateral scout film, and the rest were identified by fractures in the condylar region or air in the condylar fossa.

4. Discussion

In our series of patients who had undergone both a head CT and a facial CT for blunt traumatic injury, head CT was both sensitive and specific for the detection of nonnasal bone midfacial fractures.

Several studies over the past 25 years have sought for a sensitive and cost-effective method of screening for facial fractures. Plain radiography, when used, is now often limited to a single Waters view, with a sensitivity between 75% and 100%, depending on which standard the x-ray is compared with [6-10]. A Waters view can however be difficult for nonradiologists to interpret [7]. No previous study had used a definitive facial CT scan to evaluate all patients; thus, potentially important fractures may have been missed.

Thai et al [2] studied physical examination as a way of diagnosing facial fractures and cited accuracy rates of 100%, 80%, 91%, and 84% for detecting frontal, zygomatic, maxillary, and orbital fractures, respectively. They concluded that fractures of the medial wall and floor of the orbit can be difficult to detect by physical examination owing to edema and recommended the use of CT scan to evaluate orbital trauma.

Computed tomographic scanning of the face has been shown by Tanrikulu and Erol [4] as well as by Finkle et al [5] to be the most accurate method of detecting midfacial and orbital fractures as compared with plain radiography and physical examination of the face. However, scanning the face can be a costly method to diagnose facial fractures that frequently require no operative intervention. In addition, many trauma patients will need a head CT, so scanning the face and the head will compound the radiation dose to them. Based on standard Medicare reimbursement charges at our facility, using head CT to screen for facial fractures could save up to $8,370 (estimated by multiplying the total Medicare facial CT charge [$921.46] by the number of true-negative cases [n = 39]).

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<thead>
<tr>
<th>Table 1</th>
<th>Comparative findings for CT of the head and CT of the face</th>
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<tbody>
<tr>
<td>CT of the head</td>
<td>CT of the face</td>
</tr>
<tr>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>45</td>
<td>2</td>
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<tr>
<td>5</td>
<td>39</td>
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<th>Table 2</th>
<th>Test performance characteristics of CT of the head as compared with CT of the face in detecting clinically significant nonnasal midfacial fractures</th>
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</thead>
<tbody>
<tr>
<td>Characteristic</td>
<td>Estimate (95% confidence interval)</td>
</tr>
<tr>
<td>Sensitivity (%)</td>
<td>90.0 (78.6-95.7)</td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>95.1 (83.9-98.7)</td>
</tr>
<tr>
<td>Prevalence (%)</td>
<td>54.9 (44.7-64.8)</td>
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<tr>
<td>Positive predictive value (%)</td>
<td>95.7 (85.8-98.8)</td>
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<tr>
<td>Negative predictive value (%)</td>
<td>88.6 (76.0-95.0)</td>
</tr>
<tr>
<td>(\kappa)</td>
<td>0.85 (0.74-0.96)</td>
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Depending on institutional policy or radiologist practice, the requesting physician may need to explicitly ask for an interpretation for facial fractures to ensure that they are not missed or omitted from reports. This occurred on 2 of the 5 false-negative scans; in many of the true-positive scans, there was only a brief mention of facial fractures or intraconal or extraconal air. Computed tomographic scans of the head that do not include portions of the orbit would also limit the utility of this method. Lastly, it must be remembered that head CT is only a screening test and that a finding of bony abnormality or intraconal or extraconal air may require a formal facial CT to delineate the true extent of injury.

In our study, facial CT scan was used as the gold standard. Facial distortions caused by swelling and lacerations, pain, and altered mental status limit the usefulness of physical examination in detecting facial fractures. The 90% sensitivity of head CT to screen for fractures exceeds the test performance characteristics of the Waters view. In circumstances in which the emergency physician is obtaining a head CT, this test may have adequate sensitivity to diagnose midfacial fractures, obviating the need to obtain additional screening radiographs.

5. Limitations

Our study has several limitations. Because this was a retrospective review and the neuroradiologist interpreted both the head and facial CT scans in a nonblinded fashion, there may have been biases in the interpretation that could have led to an exaggeration of the sensitivity of the results. In addition, as a result of the small sample size, there is a possibility that we could have either overestimated or underestimated the positive findings identified. A larger prospective and blinded study would alleviate both of these issues. Lastly, we only examined blunt trauma cases. The performance of head CT in detecting facial injuries in penetrating trauma is unclear.

6. Conclusions

In cases in which head CT is being performed to evaluate a blunt trauma patient, a physician can effectively screen for facial fractures with only a single study. Further screening tests for upper facial and midfacial fractures with plain radiography or CT scan may often be unnecessary.

References