CONVENTIONAL RADIOGRAPHY AND INVERTED DIGITIZED IMAGING IN THE DETECTION OF MAXILLOFACIAL FRACTURES

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ABSTRACT
Objective: To evaluate agreement between conventional radiography and inverted digitized imaging in detecting maxillofacial fractures

Material and Methods: A total of twenty orthopantomograms and fifteen paranasal sinus (PNS) radiographs with evidence of undisplaced maxillofacial fracture were collected from the archives of maxillofacial radiology. High quality radiographs with maximum sharpness, ideal contrast, and density were only included. Digitization was done by a consumer grade digital camera. Brightness and contrast adjustment, as well as image inversion was done with the help of software (Adobe photo shop 7.0). The presence of a radiolucent line that depicted fracture line was classified according to a 4 point confidence scale. Both conventional radiographs as well as inverted digitized images were evaluated by 3 calibrated examiners twice with an interval of 10 days. Intra examiner agreement was calculated by kappa statistics by point (k) and by 95% confidence interval (CI).

Results: The results showed fair intra examiner agreement in most of the instances for the detection of maxillofacial fractures.

Conclusion: In conclusion, the diagnostic agreement of conventional radiographs and inverted digitized panoramic and PNS images for the detection of maxillofacial fractures were low.

Keywords: radiography, digital radiography, inversion, image enhancement.

INTRODUCTION

Trauma to maxillofacial region is not uncommon, and many of these may go undetected if not examined carefully.¹ Misdiagnosis of fracture constitute the primary cause of radiological malpractice lawsuits in the developed countries ² and is the most common source of diagnostic errors in hospital accidents.³ Moreover radiographic assistance becomes particularly valuable in cases where fractured segments are undisplaced or even overlapping.

It is well documented that the panoramic radiograph provides great diagnostic accuracy in detecting mandibular fractures,⁴ however as an isolated modality it is inadequate for the diagnosis of many fractures of the middle face region.⁵ Despite various specialized imaging modalities available, most of the authors still recommend only panoramic radiograph to be supplemented to conventional skull radiography for mandibular fractures,⁶ and even single Water’s projection for fractures of middle facial region for initial assessment.⁷,⁸ Inherent limitations of projection based images in assessment of fractures were recognized early and mainly include anatomic superimposition of structures requiring the use of multiple projections, effect of soft tissue edema on image contrast and processing errors.⁹ This gives rise to the need for faster and more detailed empirical diagnostic assessment of the maxillofacial trauma.

In response to this demand, the rapidly emerging direct and indirect digital imaging systems in dentistry have created a wide selection of computer based methods for diagnostic imaging. Indirect digital imaging systems using digital video cameras are the cheapest and most commonly used imaging modality. Post acquisition adjustments of image display are reported to be advantageous in compensating for visual limitation of the human observer and also for task dependent routines for specific diagnostic questions.⁵,¹⁰ It has been advocated that the choice of attributes and the way images are modified should be task-specific.¹¹

Studies pertaining to post acquisition application of inversion effects to images have not demonstrated unambiguous results. Optical contrast adjustment is reported to be better when a dark object was seen on a black background.¹² Also according to Paul F. et al ¹³ inversion of the order of gray scale values resulting in a reversal of the original image showed enhancement of contours and makes the image more easily recognized by human visual system”.

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In this context it might be hypothesized that image enhancement using inversion effects applied to radiographs with undisplaced maxillofacial fracture may result in a more clear presentation of the fracture. Studies concerning digitized panoramic radiographs with a view to improve the imaging of maxillofacial trauma radiographs are deficient in the literature. Therefore this study was carried out to explore this simple yet inexpensive procedure for analysis of these doubtful undisplaced fractures on panoramic and paranasal sinus radiographs, which are used as diagnostic aids of choice by all oral and maxillofacial radiologists and surgeons for the initial assessment of mandible and middle face region fracture respectively. Aim of our study was to evaluate the agreement between conventional radiographs and digitized imaging using inversion effects and to evaluate usefulness of inverted digitized images in detecting maxillofacial fractures.

MATERIALS AND METHODS

A total of twenty orthopantomograms and fifteen paranasal sinus (PNS) radiographs with the evidence of maxillofacial fracture were collected from the archives of diagnostic department files. The panoramic radiographs and PNS radiographs were taken with Proline panoramic PM 2002 EC (Planmeca, Helsinki, Finland), operated at 4–12 mA with a peak tube potential of 60–80 kV depending on the subject’s jaw size using Kodak regular screen. Radiographs were selected on the basis of nonprobabilistic sampling with the selection criteria of high quality radiographs which present maximum sharpness, ideal contrast, and density.

IMAGEDIGITIZATION

The conventional film radiographs were digitized with the help of a consumer grade digital camera (Sony DSC70 8.1 mega pixel) maintaining a constant distance of (10 cm) between view box and camera using a tripod. The digitized panoramic and PNS images were displayed on a 15 inch and 24 bit video monitor (Acer Travelmate 290E). Monitor resolution was kept constant for all the images at 1024 x 786 pixels. Digitization was performed in grey scale. The digitized images were inverted with the help of software image tool (Adobe photoshop 7.0). The digital images were placed in random order and independent, blinded investigators determined the presence/absence of fracture.

IMAGE OBSERVATION

Three calibrated examiners evaluated the conventional panoramic and PNS radiographs with a standard view box of uniform illumination under reduced room lighting. Masks were used so that extraneous light should not reach the retina. The examiners assessed the images under reduced room lighting and at a viewing distance 50 to 70 cm from the screen. Inverted digitized panoramic and PNS images were displayed on the laptop screen separately. Brightness and contrast were adjusted in accordance with the examiners’ individual demand. To minimize bias, the same examiner assessed the images twice on two different occasions, independently and under blind conditions. The interval between two readings was 10 days. Evaluation of fracture on conventional and inverted digitized image was graded according to the criteria of a four point scale: 4 à clearly evident, 3 à evident, 2 à questionable and 1 à unidentified.

STATISTICAL ANALYSIS

Intra and inter observer agreement considering the fracture detection was evaluated. The inter observer agreement would be estimated if it had reached a good level of intra observer agreement. Intra examiner agreement was calculated by kappa statistics by point (k) and by 95% confidence interval (CI) by using the statistical software STATA.

RESULTS

Panoramic radiographs

Table 1 shows › and 95 % values for the diagnosis of the maxillofacial fractures on the panoramic radiographs. Kappa values to all observers (conventional as well as inverted) were positive, indicating intra examiner agreement for panoramic radiographs. Out of the three observers, the second observer had shown intra examiner agreement to the extent of 60% between initial and later images which denoted fair agreement.

PNS radiographs

Table 2 shows › and 95 % values for the diagnosis of the maxillofacial fractures on the PNS radiographs. Inverted method seems to be more reliable as one of the three observers had exhibited ‘fair’ agreement.

DISCUSSION

Few reports demonstrated advantages of inverted images (inverted intensity images also known as grey scale reversal or bones black) whereas others recommended the conventional modes (also known as standard or bones white or negative image). The purpose of post acquisition image enhancement algorithms is to optimize the transfer of radiographic information to the observer. Conventional radiographs can only be displayed in negative mode, whereas the grey scale polarity of digitized images can be inverted. Usefulness and reliability of inversion effects have been studied rarely in dental radiology. Some examples from general medical and radiology field are the detection of...
pulmonary nodule by Sheline et al \(^\text{15}\) and Kheddache et al \(^\text{16}\) where area under curve was reported to be greater for grey scale inverted images as compared to negative images. Their findings contradict studies of Macmohan\(^\text{18}\), Oestman \(^\text{19}\). Differences between these studies were attributed to the quality of the digitized images, the algorithm of grey scale reversal and the familiarity in radiographic diagnostic. \(^\text{16}\) Further detectability of subtle lung cancer and bullous lung disease was also impaired by grey scale reversal, \(^\text{16}\) despite of controversy among authors, it is noted interestingly that majority of the examiners preferred use of inverse mode, though the diagnostic outcome was evaluated as inferior. \(^\text{18, 19, 21}\)

In our study the differences observed for the third observer in relation to other observers may be attributed to the subjectivity of the method and intrinsic characteristics of the examiner, such as emotional, visual and neurological features as learning effects, habituation and experience in pattern recognition seem to have a significant influence on contrast perception in radiology as described by Barbat J, \(^\text{22}\), Dwyer III SJ \(^\text{23}\). The difficulty to identify the fracture line on the radiographs might be explained by the fact that for a fracture to be clearly evident on the radiograph X-rays should pass through the fracture line, so differences in the positioning and pattern of fracture can not be underestimated.

E. Alpoz et al \(^\text{24}\) in their study stated that the agreement of the difference in the number of perceived details for negative adjustment of the images amongst the observers was statistically significant while increasing the exposure from low to middle level.

Even though this algorithm has been shown to improve the visualization of file tips and accuracy of endodontic files, \(^\text{25}\) Haak and Witch \(^\text{26}\) advocated that reversing the radiograph does not optimize detection of approximal carious lesions. An endodontic file is a high contrast object; however, the holes of the aluminium test object that was used in the study by E Alpoz et al \(^\text{24}\) represented low contrast details. More over tooth demineralization and hence radioluency seen on the radiographs due to approximal carious lesions are also affected by many parameters and may range from low contrast area to high contrast area seen on the radiographs.

In our study, it was felt by the observers that identification of fracture was clear on inverted digitized PNS images for middle face region fractures. This may be attributed to the fact that middle face region is a complex of multiple bones and inversion effect helped to visualize fracture of the superimposed bones easily in bones black images. However individual radiographic quality and individual image perception by the examiners also would have affected fracture identification.

One important aspect of this research was to study the intra examiner agreement in the interpretation of two types of resultant images. The results may show agreement level by a single observer during the radiographic interpretation at two distinct occasions, so it is difficult to state which examiner was correct or to determine the best radiographic method or diagnosis. Such evaluation would require study of validity of interpretations and diagnosis including the comparison of the methods with a gold standard.

In conclusion, conventional panoramic radiography was found to be more reliable for mandibular fracture detection as compared to inverted digitized radiography, and inverted method seems to be more reliable for middle face region fracture detection as compared to conventional PNS radiographs. The diagnostic agreement of conventional radiographs and inverted digitized panoramic and PNS images for the detection of maxillofacial fractures were low.

<table>
<thead>
<tr>
<th>Method</th>
<th>Observer</th>
<th>K</th>
<th>95% CI</th>
<th>% Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPR</td>
<td>I</td>
<td>0.02</td>
<td>-0.22 to 0.25</td>
<td>20.0</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>0.30</td>
<td>-0.08 to 0.67</td>
<td>60.0</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>0.17</td>
<td>-0.19 to 0.54</td>
<td>50.0</td>
</tr>
<tr>
<td>IPR</td>
<td>I</td>
<td>0.16</td>
<td>-0.18 to 0.49</td>
<td>45.0</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>0.18</td>
<td>-0.12 to 0.47</td>
<td>40.0</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>0.11</td>
<td>-0.21 to 0.43</td>
<td>40.0</td>
</tr>
</tbody>
</table>
Table 2- Kappa values and 95% of Confidence Interval (CI) for the detection of fracture on the conventional PNS radiograph (CPR) and inverted PNS radiograph (IPR)

<table>
<thead>
<tr>
<th>Method</th>
<th>Observer</th>
<th>K</th>
<th>95% CI</th>
<th>% Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPR</td>
<td>I</td>
<td>0.04</td>
<td>-0.20 to 0.29</td>
<td>20.0</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>-0.01</td>
<td>-0.32 to 0.30</td>
<td>26.7</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>0.13</td>
<td>-0.35 to 0.60</td>
<td>53.3</td>
</tr>
<tr>
<td>IPR</td>
<td>I</td>
<td>-0.18</td>
<td>-0.41 to 0.06</td>
<td>13.3</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>0.37</td>
<td>-0.03 to 0.76</td>
<td>60.0</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>-0.18</td>
<td>-0.54 to 0.18</td>
<td>26.7</td>
</tr>
</tbody>
</table>

Fig-1 Conventional Opg Image Showing Fracture Of Left Body Of Mandible

Fig-2 Inverted Digitized Opg Image Showing Fracture Of Left Body Of Mandible

Fig-3 Conventional Pns Image Showing Fracture Of Right Zygomatico-complex Region

Fig-4 Inverted Digitized Pns Image Showing Fracture Of Right Zygomatico-complex Region
REFERENCES


7. Rogers SN, Bradley S, Michael SP. The diagnostic yield of only one occipitomental radiographs in cases of suspected mid facial trauma- or is one enough? Br J Oral Maxillofac Surg 1995; 33: 90-2.


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