Original

Assessment of Maxillary Fracture Risk Using Classification of the Mandibular Inferior Cortical Shape by Pantomography

Marie Noda, Yusuke Kawashima, Kotaro Ito, Naohisa Hirahara, Eri Sawada, Norihito Iizuka and Takashi Kaneda

Department of Radiology, Nihon University School of Dentistry at Matsudo, Chiba, Japan
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Abstract: Maxillofacial injuries remain a serious clinical problem because of the maxilla’s anatomical significance, with important organs, including the beginning of the digestive and respiratory systems, located in this area. The purpose of this study was to assess the risk of maxillary fracture by classification of the mandibular inferior cortical shape using pantomography. This prospective study was approved by the Institutional Review Board (EC15-12-009-1). Three-hundred and sixty-four patients (190 males, 174 females; age 20 - 91 years, mean age 48.0 years) with suspected maxillary fractures who underwent both pantomography and multidetector row computed tomography (MDCT) from April 2011 to December 2016 were included in this study. The mandibular inferior cortical shape was evaluated by pantomography on both sides of the mandible, distal to the mental foramen by specialist of two oral and maxillofacial radiologists, and classified into three types as follows; Type 1: normal cortex, Type 2: mildly to moderately eroded cortex and Type 3: severely eroded cortex. Moreover, the patients were divided into two groups; Group I: normal bone mineral density (Type 1) and Group II: low bone mineral density (Types 2 and 3). The presence of maxillary fractures and the classification of the mandibular inferior cortical shape were compared using pantomography. Of the 364 patients, fractures were seen in 219 patients (60.2%). Of the 219 patients with maxillary fractures, 51 patients were in Group I (23.3%) and 168 patients were in Group II (76.7%). Of the 145 patients without maxillary fractures, 120 patients were in Group I (82.8%) and 25 patients were in Group II (17.2%). There was a statistically significant difference between Groups I and II in the prevalence of maxillary fractures (p<0.05). Our results suggest that classification of the mandibular inferior cortical shape using pantomography may provide a risk assessment for maxillary fracture.

Key words: Maxillary fracture risk, Mandibular inferior cortical shape, Pantomography

Introduction

The facial bones serve the essential role of housing and protecting the airway as well as the organs of the special senses1. The maxilla represents the bridge between the cranial base superiorly and the dental occlusal plane inferiorly. Its intimate association with the oral cavity, nasal cavity and orbits, and the multitude of structures contained within and adjacent to it, make the maxilla a functionally and cosmetically important structure2. Maxillofacial injuries remain a serious clinical problem because of the maxilla’s anatomical significance, with important organs, including the beginning of the digestive and respiratory systems, located in this area3.

High-resolution computed tomography (CT) with multiplanar reformats and 3D postprocessing has become a standard part of the assessment of facial trauma because of the exquisite sensitivity of this imaging technique for fractures4. Conversely, pantomography is widely used to assess orofacial trauma and other disorders5. Some investigators have suggested that a thin or eroded inferior cortex of the mandible detected on pantomography, which is an indicator of alterations in the mandible, may be useful for identifying patients with undetected low bone mineral density6-10.

However, there have been few studies evaluating the risk of maxillary fracture by classification of the mandibular inferior cortical shape using pantomography.

The purpose of this study was to assess maxillary fracture risk according to the classification of the mandibular inferior cortical shape using pantomography.

Materials and Methods

This prospective study was approved by the Institutional Review Board (EC15-12-009-1).

Study population of the patients

Three-hundred and sixty-four patients (190 males, 174 females; age 20 - 91 years, mean age 48.0 years) with suspected maxillary fractures who underwent both pantomography and MDCT from April 2011 to December 2016 were included in this study. All patients read and signed an informed consent form prior to inclusion in this study.

Imaging protocol

CT imaging was performed with a 64MDCT (Aquilion 64, Toshiba Medical Systems, Tokyo, Japan) using the maxillofacial trauma protocol at our hospital: tube voltage,120kV; tube current, 100 mA; field of view, 240 mm×240 mm; rotation time, 1.0 s; mean effective dose, 1.6 mSv; mean CTDIvol value, 37.3 mGy; mean DLP value, 520.3 mGy cm. In this study, the k-factor used is the head neck factor 0.0031 mSv/ (mGy cm). The reference for the used conversion factor is International Commission on Radiological Protection (ICRP) publication 10211. The protocol consisted of axial acquisition (0.50 mm) with axial (3.0 mm), coronal (3.0 mm) and sagittal (1.0mm) MPR and 3D images.

The mandibular inferior cortical shape was assessed on digital
The MDCT images and pantomography images were interpreted using a medical liquid crystal display monitor (RadiForce G31; Eizo Nanami Ltd., Ishikawa, Japan).

Image analysis

The mandibular inferior cortical shape was evaluated on both sides of the mandible, distal to the mental foramen on pantomography by specialist of two oral and maxillofacial radiologists, and classified into three types as follows (Fig. 1).

- **Type 1. Normal cortex:** the endosteal margin of the cortex was even and sharp on both sides (arrowheads).
- **Type 2. Mildly to moderately eroded cortex:** the endosteal margin showed semilunar defects (lacunar resorption) or appeared to form endosteal cortical residues (arrowheads).
- **Type 3. Severely eroded cortex:** the cortical layer formed heavy endosteal cortical residues and was clearly porous. Moreover, the patients were divided into two groups; Group I: normal bone mineral density (Type 1) and Group II: Tripod fractures in a 78-year-old female

(A) Pantomography showing that the cortical layer forms heavy endosteal cortical residues and is clearly porous.

(B) 3D image showing orbital, zygomatic and anterior maxillary wall fractures (arrows).

(C) Axial image showing maxillary wall (anterior and posterolateral) and zygomatic fractures (arrows).

(D) Sagittal image showing orbital, zygomatic and posterolateral maxillary wall fractures (arrows).

(E) Coronal image showing orbital and zygomatic fractures (arrows). Tripod fractures were the most common type of fracture in Group II.

Figure 1. Classification of the mandibular inferior cortical shape on pantomography.

(A) Normal cortex: the endosteal margin of the cortex is even and sharp on both sides (arrowheads).

(B) Mildly to moderately eroded cortex: the endosteal margin shows semilunar defects (lacunar resorption) or appears to form endosteal cortical residues (arrowheads).

(C) Severely eroded cortex: the cortical layer forms heavy endosteal cortical residues and is clearly porous (arrowheads).

Figure 2. Patients with or without maxillary fracture according to the classification of the mandibular inferior cortical shape.

There was a statistically significant difference between Groups I and II in the prevalence of maxillary fractures ($p<0.05$).

Figure 3. Group II: Tripod fractures in a 78-year-old female

(A) Pantomography showing that the cortical layer forms heavy endosteal cortical residues and is clearly porous.

(B) 3D image showing orbital, zygomatic and anterior maxillary wall fractures (arrows).

(C) Axial image showing maxillary wall (anterior and posterolateral) and zygomatic fractures (arrows).

(D) Sagittal image showing orbital, zygomatic and posterolateral maxillary wall fractures (arrows).

(E) Coronal image showing orbital and zygomatic fractures (arrows). Tripod fractures were the most common type of fracture in Group II.

With fracture Without fracture

<table>
<thead>
<tr>
<th></th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>With fracture</td>
<td>76.7%</td>
<td>82.8%</td>
</tr>
<tr>
<td>Without fracture</td>
<td>23.3%</td>
<td>17.2%</td>
</tr>
</tbody>
</table>

Figure 2. Patients with or without maxillary fracture according to the classification of the mandibular inferior cortical shape.

There was a statistically significant difference between Groups I and II in the prevalence of maxillary fractures ($p<0.05$).
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Table 1. The frequency and sites of multifocal fractures (166 patients) based on the mandibular inferior cortical shape

<table>
<thead>
<tr>
<th>Fracture Type</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>LeFort I</td>
<td>1 (2.9%)</td>
<td>9 (6.8%)</td>
</tr>
<tr>
<td>LeFort II</td>
<td>0 (0.0%)</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>Zygomaticomaxillary fractures</td>
<td>12 (35.3%)</td>
<td>29 (22.0%)</td>
</tr>
<tr>
<td>Tripod fractures</td>
<td>3 (8.8%)</td>
<td>40 (30.3%)</td>
</tr>
<tr>
<td>Alveolar ridge fractures</td>
<td>7 (20.6%)</td>
<td>21 (15.9%)</td>
</tr>
<tr>
<td>Other</td>
<td>11 (32.4%)</td>
<td>32 (24.2%)</td>
</tr>
<tr>
<td>Alveolar ridge + Nasal fractures</td>
<td>0 (0%)</td>
<td>8 (6.1%)</td>
</tr>
<tr>
<td>Alveolar ridge + Orbital floor fractures</td>
<td>0 (0%)</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>Alveolar ridge + Palatal fractures</td>
<td>0 (0%)</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>Unifocal anterior maxillary wall + Posterior maxillary wall fractures</td>
<td>2 (5.9%)</td>
<td>8 (6.1%)</td>
</tr>
<tr>
<td>Multifocal anterior maxillary wall + Posterior maxillary wall fractures</td>
<td>1 (2.9%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Unifocal anterior maxillary wall + Posterior maxillary wall</td>
<td>2 (5.9%)</td>
<td>8 (6.1%)</td>
</tr>
<tr>
<td>+ Alveolar ridge fractures</td>
<td>0 (0%)</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>Multifocal anterior maxillary wall</td>
<td>0 (0%)</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>+ Posterior maxillary wall + Alveolar ridge fractures</td>
<td>2 (5.9%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Unifocal anterior maxillary wall + Nasal fractures</td>
<td>0 (0%)</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>Multifocal anterior maxillary wall + Nasal fractures</td>
<td>3 (8.8%)</td>
<td>2 (1.5%)</td>
</tr>
<tr>
<td>Unifocal anterior maxillary wall + Orbital floor fractures</td>
<td>0 (0%)</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>Unifocal anterior maxillary wall + Medial maxillary wall fracture</td>
<td>0 (0%)</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>Unifocal anterior maxillary wall + Alveolar ridge + Nasal fractures</td>
<td>0 (0%)</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>Unifocal anterior maxillary wall + Posterior maxillary wall fractures</td>
<td>1 (2.9%)</td>
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</tr>
</tbody>
</table>

<table>
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<tr>
<th>Fracture Type</th>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>34</td>
<td>132</td>
</tr>
</tbody>
</table>

Group II: low bone mineral density (Types 2 and 3). The designated location of the maxillary fracture pattern was based on the classification schemes proposed by Rosenbloom et al.11 We compared the presence of maxillary fractures with the classification of the mandibular inferior cortical shape using pantomography.

Statistical analysis

Statistical analysis was performed using the χ² test with Fisher’s exact test. These analyses were performed with the statistical package SPSS version 21.0 (SPSS Japan, Tokyo, Japan). P-values <0.05 were considered statistically significant.

Results

Of the 364 patients, fractures were seen in 219 patients (60.2%). Of the 219 patients with maxillary fractures, 51 patients were in Group I (23.3%) and 168 patients were in Group II (76.7%). Of the 145 patients without maxillary fractures, 120 patients were in Group I (82.8%) and 25 patients were in Group II (17.2%). There was a statistically significant difference between Group I and II in the prevalence of maxillary fractures (p<0.05) (Fig.2).

Of the 190 males, 85 patients were in Group I (44.7%) and 105 patients were in Group II (55.3%). Of the 174 females, 86 patients were in Group I (49.4%) and 88 patients were in Group II (50.6%).

Unifocal fractures occurred in 53 of 219 (24.2%) patients and multifocal fractures were seen in 166 of 219 (75.8%) patients. Of the Group I patients with maxillary fractures, 33.3% (17/51) demonstrated unifocal fracture patterns and 66.7% (34/51) demonstrated multifocal fracture patterns. Of the Group II patients, 21.4% (36/168) demonstrated unifocal fracture patterns and 78.6% (132/168) demonstrated multifocal fracture patterns.

The most common site of unifocal fracture in Group I was at the anterior alveolar ridge location, which was seen in 15 of 17 (88.2%) patients, followed by the anterior maxillary wall, which occurred in 2 of 17 (11.8%) of patients. The most common site of unifocal fracture in Group II was at the anterior alveolar ridge location, which was seen in 34 of 36 (94.4%) patients, followed by the anterior maxillary wall, which occurred in 2 of 36 (5.6%) patients.

The most common site of multifocal fracture type in Group I was at the zygomaticomaxillary fractures (seen in 12/34 (35.3%) patients) followed by the alveolar ridge (which occurred in 7/34 (20.6%) of patients). The most common site of multifocal fracture in Group II was at the tripod fractures seen in 40/132 (30.3%) fractures followed by the zygomaticomaxillary fractures which occurred in 29/132 (21.2%) fractures (Table 1) (Fig. 3).

The prevalence of tripod fractures in Group II was higher than in Group I. There was a statistically significant difference between Groups I and II in the prevalence of tripod fractures (p<0.05).

Discussion

Our study showed that patients with Group II mandibular inferior cortical shape more frequently sustained maxillary fractures compared to patients with Group I morphology. Patients with Group II mandibular inferior cortical shape have a higher risk of the maxillary fracture compared to patients with Group I morphology.
In our study, the most common site of unifocal fracture was at the anterior alveolar ridge location. The anterior maxilla is the most common site for alveolar fractures because of the location and vulnerability of this anterior region. The maxillary anterior teeth are the most commonly affected and the central incisors present the highest risk of dentoalveolar trauma. In our study, the second most common site of unifocal fracture was at the anterior maxillary wall (7.5%). Isolated fractures of the maxillary sinus are uncommon and generally consist of depressed fractures of the anterior wall of the maxillary sinus.

In our study, the zygomaticomaxillary site was the most common site for multifocal fractures in Group I and the second most common site in Group II. Zygomaticomaxillary fractures are almost always associated with fractures of the internal orbit. Inferior and posterior displacement of the zygoma produces varying degrees of disorganization of the soft tissues of the orbital cavity with bony expansion causing enopthalmos.

In our study, the prevalence of tripod fractures of Group II are higher than Group I. The principal lines of tripod fractures involve the three processes of the malar bone (orbital, zygomatic and maxillary). As the zygoma becomes separated from its three attachment points, there is a widening of the zygomaticofrontal suture, and fracture of the inferior orbital rim involving the posterolateral wall of the maxillary sinus and the zygomatic arch. Patients with tripod fractures often present with tenderness, ecchymosis and edema over the malar prominence, lateral orbit and upper and lower eyelids, and loss of malar projection and blunting of the lateral canthus relative to the unaffected side.

In conclusion, patients with Group II mandibular inferior cortical shape have a higher prevalence of maxillary fractures compared to patients with Group I mandibular cortical shape. Our results suggest that classification of the mandibular inferior cortical shape on pantomography may provide a risk assessment of the maxillary fractures.

Acknowledgments

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Conflict of Interest

The authors have declared that no COI exists.

References