JKAU: Med. Sci., **Vol. 19** No. 4, pp: 61-72 (2012 A.D. / 1433 A.H.)

DOI: 10.4197/Med. 19-4.4

Assessment of Mandibular Fractures by Multislice Computed Tomography and Reconstructed Three Dimensional Computed Tomography

Zeinab A. Mustafa, PhD**, Doria S. Salem[1],** PhD **Mary M. Farid[2],** PhD**, Farid M. Farid[3],** PhD**,** and **Durer F. Iskanderani,** BDS

Department of Oral Maxillofacial Radiology, Faculty of Dentistry
King Abdulaziz University, Jeddah, Saudi Arabia
[1]Department of Diagnostic Radiology, Faculty of Medicine, Cairo University,
[2]Department of Oral Radiology, Faculty of Dentistry, Ain Shams University,
[3]Department of Oral Radiology, Faculty of Oral & Dental Medicine,
Cairo University, Cairo, Egypt.
dr.z.abdelsalam@hotmail.com

Abstract. Panoramic radiography was the common technique in assessment of mandibular fractures. It is two dimensional and has a significant magnification that limit an accurate interpretation of images associated with traumatically injured mandible. The objective of this study was to assess the mandibular fractures by multislice computed tomography and reconstructed three-dimensional computed tomography. This study involved five Egyptian patients of different ages and sexes. All patients were complaining of traumatic facial injuries. They were subjected to clinical and radiological examinations, which they were submitted to panoramic radiography as well as multislice computed tomography with three dimensional reconstructions. It was found that multislice computed tomography and reconstructed three dimensional computed tomography images are more reliable in detecting and revealing many missed mandibular fractured fragments that are not seen on conventional radiography. This concludes that the combination of multislice computed tomography and reconstructed three dimensional computed tomography allowed several improvements and changes in the treatment plane, as well as operative management of mandibular fractures.

Keywords: Multislice computed tomography, Reconstructed three dimensional computed tomography, Mandibular fractures.

Correspondence & reprint request to: Prof. Zeinab A. Mustafa
P.O. Box 80209, Jeddah 21589, Saudi Arabia

Accepted for publication: 28 April 2012. Received: 30 October 2011.

Introduction

Maxillofacial injuries affect a significant proportion of traumatic patients either isolated or associated with other serious injuries[1]. The mandible fractures are the second most-frequent maxillofacial injuries treated at a trauma centre, they account for 15.5% to 59% of all facial fractures that is due to mandible position and prominence[2]. With increase frequency in Condyle, body, and angles followed by less occurrence in parasymphyseal region, ramus, coronoid, and alveolar process. Trauma to the mandible is often associated with assaults, falls, and sports injuries[3]. Imaging examination is an essential component of diagnosis and treatment planning for the management of traumatic patients[4].

Computed tomography (CT) is gaining increasingly more acceptance in the evaluation of facial trauma[5,6], as it can often visualize complex injuries with a precision unattainable by conventional radiography or clinical examination[7]. Furthermore, CT aids in evaluation of the fracture lines, patterns, and volume changes and comparison to the contra lateral or uninjured side. It can depict significant fractures that could be missed or incompletely diagnosed by plain radiography, and it should be added routinely to the initial screening for multiple traumatic patients[8].

The introduction of multislice computed tomography (MSCT) represented a fundamental evolutionary step in the development and ongoing refinement of CT imaging techniques[9]. It is faster than conventional helical CT and has decreased image noise[7].

Multislice computed tomography (MSCT) scan can yield multiple, thin, overlapping slices that can be rapidly reconstructed, resulting in higher-quality multiplanar reconstructed (MPR) images[10]. Multislice computed tomography (MSCT) is gradually replacing the conventional radiograph in assessment of maxillofacial trauma. Furthermore, it helps visualize the unrecognized non-displaced symphyseal and condylar fractures, and subsequently, applies a differentiated treatment strategy[1].

Computed tomography (CT) supplies relevant information for the diagnosis, treatment planning, and follow-up of patients with facial trauma[11]. Multislice computed tomography (MSCT) is a significant and latest advance in the technology of CT imaging, resulting in the opportunity to greatly increase the speed of data acquisition and reconstruction than the previous spiral CT generation[12]. It has been demonstrated that MSCT can obtain a greater range of anatomic

coverage during the scan. The continuous data acquisition and archiving occurs as the entire volume of interest is scanned[11].

Currently, several studies have reported the interpretation of three-dimensional (3D) CT and MPR images by CT as supplying more information than axial two-dimensional (2D) images, by providing more reliable diagnosis, effective therapeutics, evaluation of treatment, and consequently, reducing the manifestation of sequelae[11]. Furthermore, MPR can be associated with a workstation using 3D-CT as adjunct information, and producing relevant improvements in the diagnosis of fractures of the maxillofacial complex[11,13].

The purpose of this study is to evaluate the accuracy of MSCT with reconstructed three-dimensional CT (R3D-CT) in mandibular fracture assessment.

Material and Method

Patient Selection

Five Egyptian patients of different ages and sexes participated in this study were selected from the outpatient dental clinic, faculty of oral and dental medicine, Cairo University. They were complaining of traumatic facial injuries. All the patients were subjected to clinical and radiological examinations.

Radiographic Examinations:

1. Panoramic radiography.
2. Multislice computed tomography(MSCT)* and reconstructed three-dimensional computed tomography(R3D-CT|).

Multislice Computed Tomography

In the present study, the CT data acquisition was performed by the following protocol: 1 mm of slice thickness with 0.5 mm interval of reconstruction in 4 slices by 0.5 second time, using 120 KVp and 150 mA, matrix 512 X 512, with field of view 18 cm, and standard filter for bone tissues. The original data were transferred to an independent workstation using special software to generate automatic and simultaneous multiplanar and 3D volume rendering reconstructed images. Subsequently, the images were processed, manipulated, interpreted and analyzed[11].

**(Aquilion, Toshiba Medical Inc., Tustin, CA U.S.A.)*

Result (Case Presentation)

First Case: An 8-year-old child patient presented to outpatient dental clinic, Faculty of Oral and Dental Medicine, Cairo University. This patient was subjected to facial trauma and complained of pain, swelling, soft tissue laceration and bleeding. The panoramic radiograph revealed a possible fracture in the right angle of the mandible, as shown in Fig. 1. Axial CT scan bone window showed fracture of the right angle of the mandible with anterior displacement of the ramus (Fig. 2A). Coronal CT scan bone window showed fracture of the right angle of the mandible with medial displacement of the body of the mandible (Fig. 2B). R3D-CT scan showed fracture of the right angle of the mandible starting from the distal surface of the lower right wisdom tooth, and extending posteriorly and inferiorly till the angle of the mandible (Fig. 2C).

Second Case: A 33-year-old patient subjected to trauma and suffered from pain, malocclusion, bleeding and soft tissue swelling. The Panoramic radiograph revealed a right parasymphyseal fracture and intruded tooth #43 (Fig. 3). Axial CT scan bone window showed fracture of the right angle of the mandible with anterior displacement of the ramus (Fig. 4A). Coronal CT scan bone window showed fracture of the right angle of the mandible with medial displacement of the body of the mandible (Fig. 4B). R3D-CT scan showed fracture of the right angle of the mandible starting from the distal surface of the lower right wisdom tooth, and extending posteriorly and inferiorly till the angle of the mandible (Fig. 4C).

Fig.1. Panoramic radiograph showing a possible fracture of the right angle of the mandible.

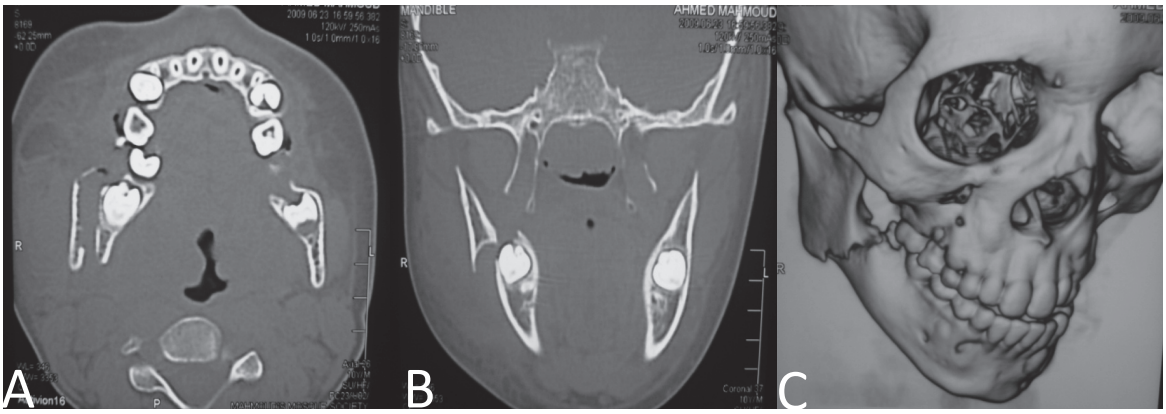

Fig. 2. (A) Axial CT scan bone window showing fracture of the right angle of the mandible with anterior displacement of the ramus. (B) Coronal CT scan bone window showing fracture of the right angle of the mandible with medial displacement of the body of the mandible. (C) R3D-CT scan showing fracture of the right angle of the mandible starting from the distal surface of the lower right wisdom tooth and extending posteriorly and inferiorly till the angle of the mandible.

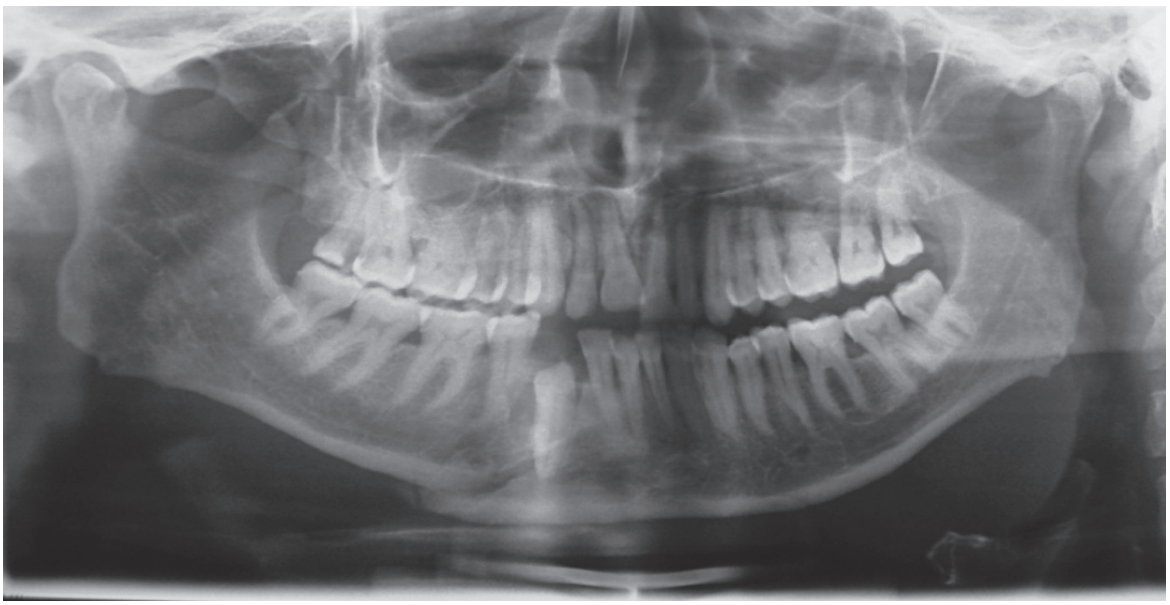

Fig. 3 Panoramic radiograph reveals a right parasymphyseal fracture and intruded tooth #43.

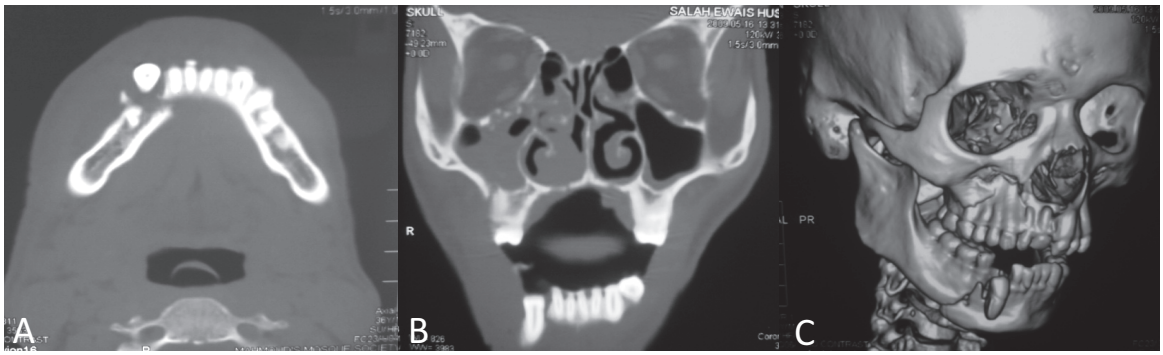

Fig. 4. (A) Axial CT scan bone window reveals two fracture lines extending mesial and distal to tooth #43. (B) Coronal CT scan bone window reveals fracture of inferior wall of right orbit and lateral wall of right maxillary sinus, as well as right hamosinus, two air locules and intruded tooth #43. (C) R3D-CT scan reveals fracture of anterior wall of maxillary sinus as well as right parasymphyseal fracture.

Discussion

One of the important factors determining the success of treatment of mandibular fractures is early and correct diagnosis[14,15]. The evaluation of the trauma of the mandible is based on clinical examination followed by the appropriate radiographs[15,16]. Panoramic radiography has been used for many years for detection of mandibular fractures. More recently, advanced imaging methods such as MSCT have been applied. While variable studies have established the clinical utility of MSCT, using of MSCT in mandibular fracture has not been subjected to assess its clinical effectiveness.

Panoramic tomography continued to be used in the identification of mandibular fractures. Yet, its traditional strong role in patients with isolated trauma to the mandible and the maxillofacial region is decreasing. The convenience of the panoramic tomography lies in having the entire mandible on a single radiograph. However, with the 3D technology of MSCT, this is no longer unique to panoramic tomography. New advances in bony facial surgery, including 3D modeling and computer-aided surgery, require MSCT.

Moreover, patients are required to be positioned in an upright position in panoramic tomography[1,17]. This precludes the acquisition of panoramic tomography in patients who are sedated, intubated, or unable to be positioned upright. In patients who have experienced multiple

traumas, these limitations may delay the identification and treatment of mandibular fractures.

Multislice computed tomography (MSCT) is progressively replacing the panoramic radiograph for mandibular trauma, and is increasingly being performed to detail and classify mandibular trauma. CT is being increasingly applied to define the fracture location and the degree of dislocation in mandibular trauma[1]. The great advantage of CT in comparison with panoramic is the ability to image soft tissue[14].

It is possible to scan a large volume of interest with high image quality, thin sections, and a low artifact rating in a short time, therefore, dramatically reducing respiratory motion problems[11,18]. Multislice computed tomography (MSCT) has brought about major advances in bone imaging. A volumetric image set with isotropic properties can be obtained in a single acquisition with a 0.5 mm slice width[19]. Furthermore, by using specific tools of an independent workstation, multiple overlapping slices can be reconstructed from a single examination permitting higher quality reconstructed images without additional patient irradiation, and facilitating management of traumatic patients.

In the present study, the acquisition of the images followed a protocol using MSCT in which the patients were submitted only to axial slices, with a thin interval of reconstruction (0.5 mm) and in 0.5 second time. Subsequently, the axial images were sent to an independent workstation where the specific tools of the computer graphic system were applied, to improve the visualization of the anatomic structures. It was a fast examination that obtained high imaging resolution, an essential condition for 3D reconstructed images, and the reconstruction of the images in the coronal and sagittal planes.

One of the great advantages of MSCT is that only axial cuts are taken with the patient lying comfortably in a supine position. Then, perfect coronal and 3D reconstruction can be performed using the computer software. There is an improvement in the interpretation without submitting the patients to another examination[11].

Two-dimensional CT presents limitations in the localization of bone fragments and the direction of bone displacement. For this reason, 3D-CT images were used to complement the interpretation. Rhea *et al.*[20]

observed that 3D images provided an easy detection of specific characteristics of facial asymmetries, and a clear localization of fractures associated with extensive bone displacement. R3D was helpful in the evaluation of comminutive fractures, displacement components, and complex fractures involving multiple planes.

Three-dimensional-CT improved our understanding of the nature of mandibular fractures. It provided more information regarding fracture and may visualize injuries that were otherwise missed. Schuknecht and Graetz[1] reported that 3D-CT makes a significant contribution in the diagnosis and treatment of up to 29% of patients. The combination of MSCT and R3D technique allowed several improvements, such as imaging interpretation, patient data entry, and study direction.

The present study showed that 3D images, when combined with axial and MPR images, could greatly increase speed (0.5 seconds per slice thickness and half interval of reconstruction) while improving, both image quality and productivity, therefore, increasing the diagnostic and treatment planning effectively. Moreover, Wilson *et al*., Chacon *et al.* and Dos Santos *et al.*[11,21,22] have reported the interpretation of 3D-CT and MPR images by CT allowing for more complete assessment of the fractures and a perfect planning of surgical treatment.

It was found that coronal and 3D reformatted views provide details of fractures that are not clearly delineated by MSCT in the axial plane alone. Thus, advocated by obtaining these reformatted views on an individual patient basis as they supply more information than axial 2D images. It provides more reliable diagnosis, effective therapeutics, evaluation of treatment, and consequently reduces the complications. The best results were found in the association of methods, demonstrating that they complemented each other and improved the identification of fractures.

Concerning the number and anatomical location of fractures identified by MSCT and panoramic tomography, MSCT is more considered in detecting mandibular fractures than panoramic modality. This result signifies the superiority of CT in detecting variable sites of mandibular fractures.

Roth *et al.*[17] found that consistently more mandible fractures were identified on Helical CT than on panoramic tomography, with the

exception of body and condylar fractures. All the fractures that they identified by CT and were not seen on panoramic tomography, were located at the angle, ramus, or sub-condylar region. This finding underlines the limited usefulness of panoramic radiography in mandibular traumatized patient.

The appearance of the fracture was another important issue regarding the interpretation of the radiographs. Appearance of fracture, like cortical discontinuity, abnormal angulation, absent or displaced bone, abnormal linear density (double density), haemosinus, free fractured bony segment, foreign body, sub-cutaneous haematoma, emphysema and teeth fracture, provide the maxillofacial surgeon with additional information that can affect the operative management of each case. MSCT showed higher value of detecting different appearance of trauma than panoramic radiography. Roth *et al.*[17] found that additional information, including displacement and comminution of the fractures, evident on Helical CT was not available on panoramic tomography.

Conclusion

The combination of MSCT with R3D allowed several improvements and changes to the treatment plan as well as operative management of mandibular fracture. They demonstrated many missed mandibular fractures that were not seen on conventional techniques; therefore, MSCT is more reliable in detecting mandibular fracture.

References

[1] **Schuknecht B, Graetz K**. Radiologic assessment of maxillofacial, mandibular, and skull base trauma. *Eur Radiol* 2005; **15**(3): 560-568.

[2] **Zix JA, Schaller B, Lieger O, Saulacic N, Thorén H, Iizuka T**. Incidence, aetiology and pattern of mandibular fractures in central Switzerland. *Swiss Med Wkly* 2011; **141**: w13207.

[3] **Emest WN. Lam T**. Trauma to teeth and facial structures. In: *Oral Radiology: Principles and Interpretation*. White SC, Pharoah MJ, ed. 6th ed. St. Louis: Mosby Year Book Inc, 2009. 548.

[4] **Shintaku WH, Venturin JS, Azevedo B, Noujeim M**. Applications of cone-beam computed tomography in fractures of the maxillofacial complex. *Dent Traumatol* 2009; **25**(4): 358-366.

[5] **Hopper RA, Salemy S, Sze RW**. Diagnosis of midface fractures with CT: what the surgeon needs to know. *Radiographics* 2006; **26**(3): 783-793.

[6] **Fanucci E, Fiaschetti V, Rotili A, Floris R, Simonetti G**. Whole body 16-row multislice CT in emergency room: effects of different protocols on scanning time, image quality and radiation exposure. *Emerg Radiol* 2007; **13**(5): 251-257.

[7] **Salonen EM, Koivikko MP, Koskinen SK**. Violence-related facial trauma: analysis of multidetector computed tomography findings of 727 patients. *Dentomaxillofac Radiol* 2010; **39**(2): 107-112.

[8] **Salvolini U**. Traumatic injuries: imaging of facial injuries. *Eur Radiol* 2002; **12**(6): 1253-1261.

[9] **Mahesh M**. Search for isotropic resolution in CT from conventional through multiple-row detector. *Radiographics* 2002; **22**(4): 949-962.

[10] **Cavalcanti MG, Ruprecht A, Vannier MW**. 3D volume rendering using multislice CT for dental implants. *Dentomaxillofac Radiol* 2002; **31**(4): 218-223.

[11] **Dos Santos DT , Costa e Silva AP, Vannier MW, Cvalcanti MG**. Validity of multislice computed tomography for diagnosis of maxillofacial fractures using an independent workstation. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2004; **98**(6): 715-720.

[12] **McCollough CH, Zink FE**. Performance evaluation of a multi-slice CT system. *Med Phys* 1999; **26**(11): 2223-2230.

[13] **Buitrago-Téllez CH, Schilli W, Bohnert M, Alt K, Kimmig M**. A comprehensive classification of craniofacial fractures: postmortem and clinical studies with two- and three-dimensional computed tomography. *Injury* 2002; **33**(8): 651-668.

[14] **Marciani RD, Gonty AA**. Principles of management of complex craniofacial trauma. *J Oral Maxillofac Surg* 1993; **51**(5): 535-542.

[15] **Tanrikulu R, Erol B**. Comparison of computed tomography with conventional radiography for midfacial fractures. *Dentomaxillofac Radiol* 2001; **30**(3): 141-146.

[16] **Manson PN.** Management of midface fractures. In: *Textbook of Plastic, Maxillofacial and Reconstructive Surgery.* Georgiade GS, Georgiade NG, Riefkohl R, Barwick WJ, eds. 2nd ed. Vol. I, Baltimore: Williams and Wilkins, 1992. 409-432.

[17] **Roth FS, Kokoska MS, Awwad EE, Martin DS, Olson GT, Hollier LH, Hollenbeak CS**. The identification of mandible fractures by helical computed tomography and panorex tomography. *J Craniofac Surg* 2005; **16**(3): 394-399.

[18] **Flohr T, Bruder H, Stierstorfer K, Simon J, Schaller S, Ohnesorge B**. New technical developments in multislice CT, part 2: sub-millimeter 16-slice scanning and increased gantry rotation speed for cardiac imaging. *Rofo* 2002; **174**(8): 1022-1027.

[19] **Cara AC, Gaia BF, Perrella A, Oliveira JX, Lopes PM, Cavalcanti MG**. Validity of single- and multislice CT for assessment of mandibular condyle lesions. *Dentomaxillofac Radiol* 2007; **36**(1): 24-27.

[20] **Rhea JT, Rao PM, Novelline RA**. Helical CT and three-dimensional CT of facial and orbital injury. *Radiol Clin North Am* 1999; **37**(3): 489-513.

[21] **Chacon GE, Dawson KH, Myall RW, Beirne OR**. A comparative study of 2 imaging techniques for the diagnosis of condylar fractures in children. *J Oral Maxillofac Surg* 2003; **61**(6): 668-672.

[22] **Wilson IF, Lokeh A, Benjamin CI, Hilger PA, Hamlar DD, Ondrey FG, Tashjian JH, Thomas W, Schubert W**. Prospective comparison of panoramic tomography (zonography) and helical computed tomography in the diagnosis and operative management of mandibular fractures. *Plast Reconstr Surg* 2001; **107**(6): 1369-1375.

تقييم كسور الفك السفلي بواسطة استخدام التصوير المقطعي بالحاسوب متعدد الشرائح و التصوير المقطعي بالحاسوب مع إعادة البناء ثلاثي الأبعاد

زينب مصطفي ، ودرية سالم[١]، وماري مدحت[٢] ، وفريد مدحت[٣]، ودرر إسكندراني[١]

قسم أشعة الفم والوجه والفكين، كلية طب الأسنان، جامعة الملك عبد العزيز، المملكة العربية السعودية

[١]كلية الطب، جامعة القاهرة، مصر

[٢]كلية طب الأسنان، جامعة عين شمس، مصر

[٣]كلية طب الفم والأسنان، جامعة القاهرة، مصر

المستخلص. كان التصوير الشعاعي البانورامي يعتبر التقنية الأكثر شيوعا في تقييم كسور الفك السفلي. إنها ثنائية الأبعاد، ولها خاصية تكبير الصورة واللتان تحدان من قراءة الصور الإشعاعية المرتبطة بإصابات الفك السفلي بدقة. الهدف من هذه الدراسة هو تقييم كسور الفك السفلي بواسطة التصوير المقطعي بالحاسوب متعدد الشرائح والتصوير المقطعي بالحاسوب مع إعادة البناء ثلاثي الأبعاد. ولقد اختير لهذه الدراسة خمسة مرضى مصريي الجنسية من الجنسين ومن مختلف الأعمار. كان جميع المرضي يعانون من إصابات بالوجه. وجميعهم تعرضوا لفحص سريري وتصوير إشعاعي والذي شمل على تصوير إشعاعي بانورامي بالإضافة إلى تصوير مقطعي بالحاسوب متعدد الشرائح مع إعادة البناء ثلاثي الأبعاد. ولقد وجد أن

التصـوير المقطعـي بالحاسـوب متعـدد الشـرائح والتصـوير المقطعـي بالحاسوب مع إعادة البناء ثلاثي الأبعاد يعد أكثر فعالية في الكشف عن العديد من حالات شظايا كسور الفك السفلي غير المقروءة والتي لا يمكن الكشف عنها بواسطة استخدام التصوير الشعاعي التقليدي. نستطيع أن نستنتج بأن المزج بين التصوير المقطعي بالحاسوب متعدد الشرائح والتصوير المقطعي بالحاسوب مع إعادة البناء ثلاثي الأبعاد يسمح بإدخال العديد من التحسينات والتغييرات على الخطة العلاجية بالإضافة إلى طريقة علاج كسور الفك السفلي.