Original Article

Facial Fractures Pattern in Conventional Radiograph versus CT and 3D CT and their Clinical Relevance - An Institutional Study

Pawan K. Prasad*, Neelima Gehlot, K. V. Arunkumar, Swapnil Jain, Divya Archana

Department of Oral and Maxillofacial Surgery, Teerthanker Mahaveer Dental College and Research Centre, Moradabad, Uttar Pradesh, India.

Abstract

Background: Facial fractures can result in functional and cosmetic defect thus accurate diagnosis is of prime importance for correct treatment. In the past conventional radiograph were most commonly used for diagnosis. However, it has disadvantages of over lapping and chances of misdiagnosis were more. Computed tomography has overcome the disadvantages of conventional technique with added advantage of reconstruction. This study aims to identify and document different radiological fracture patterns seen on Conventional radiograph, computed tomography (CT) and 3D CT with pattern seen at surgical site. **Material and Methods:** A prospective study was conducted on total of 60 patients with facial trauma who was reported to our department. Study period ranged 18–24 months. Facial fractures cases were chosen from Conventional radiograph, CT, and 3D CT to reflect spectrum of facial trauma from simple localized fracture to complex facial injury. The best method for classification of fracture was determined. **Result:** This study group composed of 60 patients, age group ranged from 11 to 60 years, among which 21–30 age group was found to be most affected age group with male predilection was found to be more, which was around 95% and female 5%. Road traffic accident remains the commonest cause, comprising 96.66% of cases assault comprising 3.33%. The data for the present study was entered in the Microsoft Excel 2007 and analyzed using the SPSS Statistical Software 19.0 Version. The comparison between different groups was done using the Chi-square test. **Conclusion:** It is safe to state that pertaining to technological advances, improved level of precision achieved in CT and 3D CT imaging has made it possible to demonstrate accurate relationships of discontinuity fragments in maxillofacial trauma.

Keywords: Facial fractures, Conventional radiographs, Computed tomography, 3D computed tomography.

Introduction

Maxillofacial injuries most commonly occur following trauma. The psychosocial and functional activities of the patient are severely affected if maxillofacial injuries are poorly managed.[1-3] The injury to maxillofacial skeleton can occur as an isolated event or occur concomitantly with multiple injuries to head, chest, abdomen, spine, etc. Road traffic accidents (RTA) remain the topmost reason for maxillofacial trauma, the other etiology includes interpersonal trauma, work or sports related injuries.[4] RTAs are now considered as public health hazard of primary magnitude. Accidents are on the rise in India, according to the recent trends in the reports; it is almost 20 times more than any developed countries globally. In India, 8% people gets killed for every 100 accidents whereas in developed countries such as US, UK, and France this is 0.1% person for every 1000 accidents.[4,5]

For correct diagnosis thorough clinical examination, proper history taking and correct choice of investigation is important. Since many years physicians rely on 2D images, that is, Conventional plane radiographs for trauma patients to evaluate facial injuries. Unfortunately, the superimposition of bony landmarks and defects made it extremely difficult to interpret these radiographs.[6,7] There are lot of limitations in using conventional radiographs in diagnosis and treatment planning. In 1970, the diagnostic radiology was revolutionized with the advent of computed tomography (CT) which made available cross-sectional images. The superimposition of adjacent structures was eliminated in the cross-sectional images which was a major drawback with conventional radiography. In late 1970"s and early 1980"s many computer programmers were created to acquire cross sectional CT data to reconstruct 3D CT. Now, with

Access this article online

Website: www.jrad.co.in

DOI: https://doi.org/10.53064/jrad.2022.13.4.222

Address for correspondence: Dr. Pawan K. Prasad, Teerthanker Mahaveer Dental College and Research Centre, NH24 Delhi Road, Bagadpur, Moradabad – 244 001, Uttar Pradesh, India. Phone: +91-7001228857. E-mail: drpawanprasad1993@gmail.com

Received: Apr. 02, 2022; **Accepted:** May. 18, 2022; **Published:** May 30, 2022

How to cite this article: Prasad PK, Gehlot N, Arunkumar KV, Jain S, Archana D. Facial Fractures Pattern in Conventional Radiograph versus CT versus 3D CT and their Clinical Relevance - An Institutional Study. J Res Adv Dent 2022;13(4):156-160.

advancement of radiology and new imaging modalities, facial fractures are easily detected. Not only detection, but localization and characterization of the facial fractures are now possible with Multidetector Computed Tomography which serves as a cornerstone in modern emergency radiology.[8-11]

This study aims at finding and documenting different radiological fracture patterns with eliminating the loopholes which lead to misinterpretation of proper surgical treatment option because of lack of clinical expertise to study radiograph or radiographic errors. Co-relating the radiographic analysis and surgical treatment option are very important as sometimes the surgical site specifications will differ from their radiographic view.

Materials and Methods

A prospective study was conducted on a total of 60 patients with facial trauma who were reported to our department of oral and maxillofacial surgery during the year 2019–2021. Informed consent was taken from the patient before the examination along with patient information sheet and ethical clearance was obtained from the Institutional Ethics Committee (TMDCRC/IEC/19-20/OMFS2). The fractures were primarily evaluated by clinical examination followed by conventional radiograph, CT and 3D CT (Figures 1-3). The data obtained from the conventional radiographs, CT and 3DCT were assessed under the headings of- fracture site detection, pattern of fracture extension, ease of assessment, and their clinical relevance.

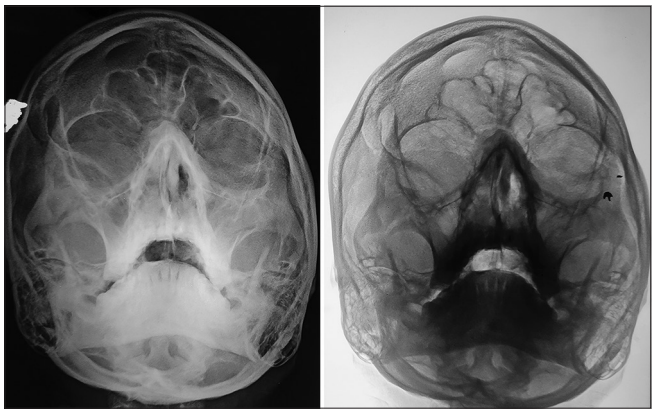

Figure 1: Conventional radiograph (paranasal sinus). Fracture line seen below frontonasal suture and infra orbital margin on right side

Inclusion criteria

The following criteria were included in the study:

1. All the patients admitted to our department with facial trauma in need of radiological investigations.
2. Patients of both the sexes were included.
3. Patients were selected irrespective of gender, cast, religion, and socioeconomic status.
4. Patients willing to participate in the study.

Exclusion criteria

The following criteria were excluded from the study:

1. Patients contraindicated for CT-example pregnancy.
2. Post-operative patients in need of repeat CT.
3. Patients with facial trauma and no positive CT findings and x-ray findings.

Statistical analysis

Descriptive statistics were carried out for the continuous variables by measuring the mean and standard deviation. Absolute numbers and percentages are viewed as categorical variables. SPSS (Statistical Package for Social Sciences) version 25.0 and MedCalc software was used for the statistical analysis. For comparison of mean value between 2 groups, Unpaired or Independent t-test is used when the data is according to normal distribution. Chi-square test is used to analyze whether categorical variable distributions vary from each other. The p-value was considered important when <0.05 ($P < 0.05$) and 95% confidence interval were taken.

Results

Age distribution

Age group ranged from 11 to 60 years, among which 21–30 age group was found to be most affected age.

Gender distribution

Male predilection was found to be more, which was around 95% and female was around 5%. In our region female ratio was very less compare to male.

Mode of injury

The most common mode of injury is found to be road traffic accident, comprising 96.66% of cases, followed by assault, comprising 3.33%. No sports related injury was found.

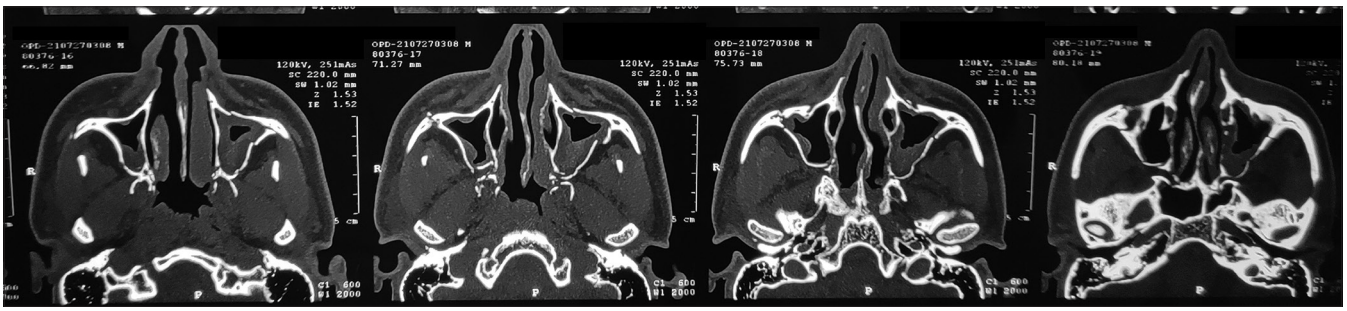

Figure 2: Computed tomography (axial section). Fractures are noted involving bilateral nasal bone, ethmoidal septae, bilateral medial, and lateral walls of pterygoid, bilateral greater wing of sphenoid and bilateral maxillary sinuses associated with hemosinus

In upper third fracture 3DCT, CT coronal and CT axial were the best diagnostic modality in the diagnosis as 100% of the cases were completely seen, followed by PNS (where 75% of the cases were partially seen). OPG was the worst of all the treatment modality as 100.0% of the cases were not seen. Lefort I fracture was completely seen followed by CT-Coronal and PNS view (66.6% of the cases were partially seen). OPG and CT-axial showed only 33.3% cases. Lefort II, III revealed that 3DCT was the best diagnostic modality followed by PNS.OPG had no role in diagnosis of middle third fracture. In mandibular fracture, 3DCT and OPG were good diagnostic images in the diagnosis of Mandibular fracture as 100% of the cases were completely seen followed by CT axial (93.54% cases partially seen) and CT Coronal (70.96% cases partially seen). PNS was the poor of all the treatment modality as 41.94% of the cases were not seen (Table 1).

Discussion

The injuries to face should be considered important when polytrauma is seen as a whole because of its extensive involvement in patient's emotional, psychological, and physical well-being. This disruption of soft tissue and bone cause facial disfigurement which harmfully affects the emotional and cosmetic concerns of the patient. The region of face, including jaws serves several important functions of daily living which severely gets affected by trauma and therefore needs urgent attention.[2,12-14] Early detection sometimes becomes the key for a good prognosis especially in fracture cases and helps in mitigating possible outcomes of delayed reductions. Complications such as nerve damage, brain injury, facial cosmetic changes, and infections can be direct or indirect results of facial trauma. It can cause difficulty in speaking, eating, hearing, vision, and even facial expressions.[15]

Table 1: Different diagnostic modalities for diagnosis of mandibular fracture

Mandibular fracture	Completely seen	Partially seen	Not seen	*P* value
OPG	31 (100.0%)	0 (0%)	0 (0%)	0.001 Significant
PNS	0 (0%)	18 (58.06%)	13 (41.94%)	
CT-Coronal	0 (0%)	22 (70.96%)	9 (29.04%)	
CT-Axial	0 (0%)	29 (93.54%)	2 (6.46%)	
3D CT	31 (100.0%)	0 (0%)	0 (0%)	

Conventional radiographs were the only image available after the discovery made by Roentgen. Conventional radiographic methods were used primarily in late 1940s, 1950s and were used in assessment of dentoalveolar, mid-facial, mandibular, and pan facial injuries.[16] Since 1940"s there was an immense upgradation in diagnostic imaging and has helped surgeons to assess and quantify the effects of facial trauma. This has increased the complexity in understanding the places of involvement and has resulted in additional demands to provide comprehensive assessment to assist in treatment planning.[16-18]

The period of 1970s and 1980s saw a significant improvement in radio diagnostic studies when Godfrey Hounsfield and Allan M. McCormack incorporated computer processing into tomography and thus introduced a new diagnostic, that is, CT.[19] By the process of image processing enhancement, CT enabled the clinician to visualize both soft tissue and hard tissue in one radiograph. As of today, CT has become the gold standard imaging modality along with its upgradation such as multislice CT. The use of conventional X-rays is now mostly narrowed down for imaging related to cranial vault and is almost obsolete for skull base and facial fractures due to its obvious drawbacks. CT is currently the modality of choice even though there is higher radiation dosage than conventional radiographs. The CT shows multiplicity of fragments, the degree of rotation and displacement or any skull base involvement. The clinical utility of CT with plane radiography was compared by Tanrikulu and Erol and proved the superiority of CT in diagnosis and classification of facial fractures.[20]

This study included 60 patients who came to our department with a history of maxillofacial injury and were found to have fractures involving the bones in the maxillofacial region. The study included the evaluation of these patients with clinical examination followed by conventional imaging (OPG, PA, AP, PNS, and SMV), CT (coronal and axial view), and 3D CT. The CT scan images of coronal and axial sections were supplemented by the reconstruction to 3D images.[12] The study population consisted of patients in the age group of 11 to 60 years. Most patients belonged to the 21–30 followed by

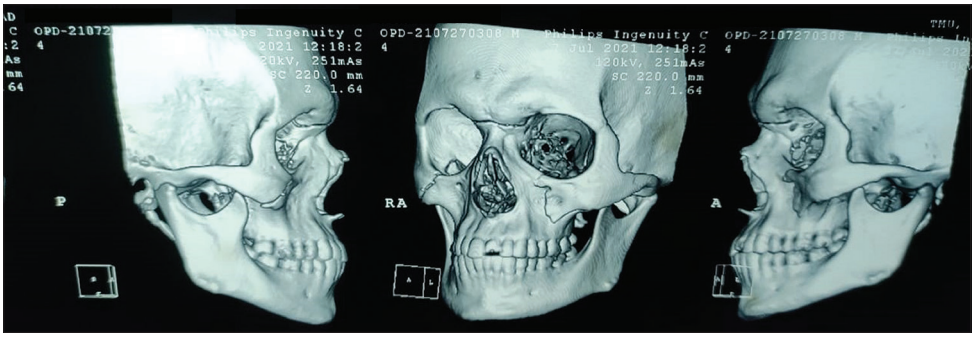

Figure 3: Computed tomography with 3D reconstruction showing fracture line below the frontonasal suture extending bilaterally to frontal process of maxilla, infraorbital margin, lateral wall of antrum, and pterygoid laminae

11–20 age groups with 30 and 14 patients, respectively. This study showed a male preponderance accounting for 95% of the case load. Similar study was conducted by Kieser *et al.* which showed that 80% facial fractures (of all injuries) were in males.[18,21] The most common mode of injury is found to be road traffic accident, comprising 96.66% of cases. Assault was the secondary cause, comprising 3.33%. In our study, no sports related injury were found. Even many authors have reported that road traffic accidents are the most frequent cause of facial fractures. Although, some studies reported that assault (fighting) was the most common cause.[4,5]

More recent studies have shown that motor vehicle accidents remain the most frequent cause in many industrial and developing countries. These, result is consistent with the findings of our study as our hospital is situated on highway and in industrial city.[12,20-22] In the assessment of frontal bone fractures, detection and displacements were seen in 100% of Coronal, Axial and 3D CT and in conventional radiograph (PNS) partially seen in 75%. However, their extensions, especially into posterior wall of sinus or roof of orbit were not adequately visualized on the 3D images. Hence, coronal and axial sections found to be superior in linear or un-displaced fractures. At the same time conventional radiograph was not able to detect clearly due to superimposition of structures. In the assessment of Zygomatic maxillary complex, 3D images showed complete fracture pattern in 100% of cases and were found to be similar or better with coronal and axial for the detection and description of extent in most patients. Conventional radiograph (PNS) showed only in 37% cases. In displaced type of fracture 3D CT was found to be superior to axial images in most patients. In Naso-orbito-ethmoid region 3D CT was found to be inferior in the assessment of detection, extent and displacement of fractures when compared with axial images in most patients. Whereas, Coronal images was found to be superior to axial images in the detection of fractures in the region especially in the floor and medial wall of orbit.

In maxilla and dentoalveolar fracture, CT (Coronal and Axial) showed better result than conventional radiographs in the detection of fractures in maxillary region in most of the patients. CT showed clear fracture patterns in 100% of the cases and conventional showed fracture patterns only in 66% of cases. 3D CT images were also found to be superior in the detection of fractures in the maxilla especially with involvement of anterior wall of the sinus. However, the extent of involvement and its displacement was better seen on axial sections.[23] Similar study was conducted by Fox *et al.*, which showed that 3D CT were interpreted more rapidly and more accurately but was inferior to axial images for evaluating orbital fractures. Similar result is also described by other studies that 3D CT is being the most useful for imaging modality for comminuted fractures of the middle third of the face and the zygomatic-maxillary complex.[24] Study conducted by Hessel demonstrated that 3D scans enable clinicians to better assess the localization of bone fragments and their direction of displacement. However, Three-dimensional imaging is not indicated, for small fractures of the orbital floor or isolated fractures of the maxillary wall, in which the fracture is limited to one plane. Here, examining 3D CT scans alone can give false-negative results.[1,25,26] According to study conducted by Tanrikulu and Erol, axial and coronal CT scans are found to be adequate for diagnosis of medial orbital wall fractures, and they confirmed the benefit of coronal CT in the diagnosis of fractures of the orbital floor and blow-out fractures, especially in those patients who may develop diplopia or enophthalmos. These findings were reliable with our findings in this study with naso-orbito-ethmoid fractures where 3D CT was found to be inferior to axial images in detection of fractures, their extent and in assessing displacement.[27-32]

For detection and extent of involvement for mandibular fracture conventional, axial images and 3D CT showed equally 100% result. However, there was a definite advantage in assessment of displacement of fracture fragments with use of 3D CT. However, there was no statistical significant difference seen between conventional imaging and 3D CT for isolated mandibular fracture. In our study, mandibular injuries were most common in the body and the Parasymphysis of the mandible. Out of the 31 fractures that were detected in the mandible, 11 were noted in the condyle and sub condylar region. Study conducted by Sivalingam *et al.* showed dissimilar result, in which condyle and the body of the mandible were the most common site of fracture.[12] In this study associated finding was Hemosinus which is the most common finding in the patients who presented to our department with maxillofacial trauma. Hemosinus is the reliable criterion for excluding fractures involving the maxillary sinus walls. In this study, only one patient had absence of Hemosinus with associated injury to the sinus wall. Study conducted by Lambart *et al.* found that the absence of free paranasal sinus fluid (clear sinus sign) in facial CT is a highly reliable criterion for excluding fractures involving the paranasal sinus walls.

In our study, patterns of fractures seen on imaging were found to me similar in most of the case, in total only in six cases the radiological and clinical fracture patterns was found to be different.

This study demonstrates the valuable role of different types of imaging methods in the evaluation of maxillofacial fractures. According to this study CT with coronal, axial sections and 3D CT are found to be of crucial importance compare to conventional imaging in the assessment and diagnosis of fracture pattern. In all suspected displaced and comminuted fractures CT and 3D CT can be preferred. However, 3D imaging has a limited role in fractures involving the linear fracture and also when there is minimal displacement of fracture. Hence, according to the suspected case the choice of imaging should be tailored.

Conclusion

Based on the results obtained of this study, it is concluded that depending on the level of discontinuity, the most accurate

imaging modality can be advocated. The critical importance of axial, coronal and 3D-CT for assessing location, extent, pattern of the injuries associated with maxillofacial trauma has been demonstrated in this study. Hence, it is safe to state that pertaining to technological advances, improved level of precision achieved in CT and 3D-CT imaging has made it possible to demonstrate accurate relationships of discontinuity fragments in maxillofacial trauma.

References

1. Shah S, Uppal SK, Mittal RK, Garg R, Saggar K, Dhawan R. Diagnostic tools in maxillofacial fractures: Is there really a need of three-dimensional computed tomography? Indian J Plast Surg 2016;49:225-33.
2. Saheeb BD. Influence of positions on the incidence and severity of maxillofacial injuries in vehicular crashes [corrected]. West Afr J Med 2003;22:146-9.
3. Johnson DH Jr. CT of maxillofacial trauma. Radiol Clin North Am 1984;22:131-44.
4. Mayer JS, Wainwright DJ, Yeakley JW, Lee KF, Harris JH Jr., Kulkarni M. The role of three-dimensional computed tomography in the management of maxillofacial trauma. J Trauma 1988;28:1043-53.
5. Lone P, Singh AP, Kour I, Kumar M. A 2year retrospective analysis of facial injuries in patients treated at department of oral and maxillofacial surgery, IGGDC, Jammu, India. Natl J Maxillofac Surg 2015;5:2.
6. Frame JW, Wake MJ. Evaluation of maxillofacial injuries by use of computerized tomography. J Oral Maxillofac Surg 1982;40:482-6.
7. North AF, Rice J. Computed tomography in oral and maxillofacial surgery. J Oral Surg 1981;39:199-207.
8. Madkour NA. Reliability of multidetector computed tomography in rational analysis of midface fractures. J Oral Maxillofac Radiol 2018;6:21-5.
9. Gassner R, Tuli T, Hächl O, Rudisch A, Ulmer H. Cranio-maxillofacial trauma: A 10 year review of 9,543 cases with 21,067 injuries. J Craniomaxillofac Surg 2003;31:51-61.
10. Obimakinde OS, Ogundipe KO, Rabiu TB, Okoje VN. Maxillofacial fractures in a budding teaching hospital: A study of pattern of presentation and care. Pan Afr Med J 2017;26:218.
11. Kaur J, Chopra R. Three dimensional CT reconstruction for the evaluation and surgical planning of mid face fractures: A 100 case study. J Maxillofac Oral Surg 2010;9:323-8.
12. Sivalingam J, Kumar VA, Yennabathina K, Rajasekhar KV. Evaluation of maxillofacial injuries using multislice computed tomography. J Dent Med Sci 2016;15:49-57.
13. Turner BG, Rhea JT, Thrall JH, Small AB, Novelline RA. Trends in the use of CT and radiography in the evaluation of facial trauma, 1992-2002: Implications for current costs. AJR Am J Roentgenol 2004;183:751-4.
14. Fox LA, Vannier MW, West OC, Wilson AJ, Baran GA, Pilgram TK. Diagnostic performance of CT, MPR and 3DCT imaging in maxillofacial trauma. Comput Med Imaging Graph 1995;19:385-95.
15. Salonen EM, Koivikko MP, Koskinen SK. Multidetector computed tomography imaging of facial trauma in accidental falls from heights. Acta Radiol 2007;48:449-55.
16. Ali I, Gupta A. Imaging in maxillofacial trauma. Central India J Dent Sci 2012;3:4.
17. Saigal K, Winokur RS, Finden S, Taub D, Pribitkin E. Use of three-dimensional computerized tomography reconstruction in complex facial trauma. J Facial Plast Surg 2005;3:21.
18. Baek HJ, Kim DW, Ryu JH, Lee YJ. Identification of nasal bone fractures on conventional radiography and facial CT: Comparison of the diagnostic accuracy in different imaging modalities and analysis of interobserver reliability. Iran J Radiol 2013;10:140-7.
19. Rodt T, Bartling SO, Zajaczek JE, Vafa MA, Kapapa T, Majdani O, *et al.* Evaluation of surface and volume rendering in 3D-CT of facial fractures. Dentomaxillofac Radiol 2006;35:227-31.
20. Tanrikulu R, Erol B. Comparison of computed tomography with conventional radiography for midfacial fractures. Dentomaxillofac Radiol 2001;30:141-6.
21. Rogers SN, Bradley S, Michael SP. The diagnostic yield of only one occipito-mental radiograph in cases of suspected midfacial trauma-or is one enough? Br J Oral Maxillofac Surg 1995;33:90-2.
22. Santos DT, Oliveira JX, Vannier MW, Cavalcanti MG. Computed tomography imaging strategies and perspectives in orbital fractures. J Appl Oral Sci 2007;15:135-9.
23. Levy RA, Kellman RM, Rosenbaum AE. The effect of computed tomographic scan orientation on information loss in the three-dimensional reconstruction of tripod zygomatic fractures. Invest Radiol 1991;26:427-31.
24. ELFiky I, Abd El Aziz El Sammak D, El Sammak A, Abdelhady M. Diagnostic performance of multi-slice computed tomography using 2D and 3D images in the assessment of Le Fort fractures. Egypt J Radiol Nuclear Med 2017;48:415-24.
25. Manson PN, Markowitz B, Mirvis S, Dunham M, Yaremchuk M. Toward CT-based facial fracture treatment. Plast Reconstr Surg 1990;85:202-12.
26. Alder ME, Deahl ST, Matteson SR. Clinical usefulness of two-dimensional reformatted and three-dimensionally rendered computerized tomographic images: Literature review and a survey of surgeons' opinions. J Oral Maxillofac Surg 1995;53:375-86.
27. Ian FW, Lokeh A, Benjamin CI, Hilger PA, Hamlar DD, Ondrey FG, *et al.* Prospective comparison of panoramic tomography (Zonography) and helical computed tomography in the diagnosis and operative management of mandibular fractures. Plast Reconstruct Surg 2001;107:136.
28. Johnston CC, Doris PE. Clinical trial of pantomography for the evaluation of mandibular trauma. Ann Emerg Med 1980;9:415-8.
29. Moilanen A. Primary radiographic diagnosis of fractures in the mandible. Int J Oral Surg 1982;11:299-303.
30. Chayra CA, Meador LR, Laskin DM. Comparison of panoramic and standard radiographs for the diagnosis of mandibular fractures. J Oral Marillofac Surg 1966;44:677-9.
31. Markowitz BL, Jordan S, Henry K, Kris S, Farhad K. Prospective comparison of axial computed tomography and standard and panoramic radiographs in the diagnosis of mandible fractures. Ann Plast Surg 1999;42:163-9.
32. Reiner SA, Schwartz DL, Clark KF, Markowitz NR. Accurate radiographic evaluation of mandibular fractures. Arch Otolaryngol Head Neck Surg 1989;115:1083-5.