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Comparative Study on Conventional Radiography versus Cone Beam Computed Tomography for the Diagnosis of Mandibular Fracture

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Abstract

Background: ***The facial skeleton is a complex structure composed of five paired bones and four unpaired bones, with mandible fractures being among the most common injuries encountered in trauma centers. Panoramic imaging, also known as pan tomography (OPG), is a technique that provides a single, wide-view image of the facial structures.***

Methods: ***The study was a descriptive cross-sectional study which was carried out from 16 August 2016 to 16 May 2017 in the Department of Oral and Maxillofacial Surgery, Dental Wing, Combined Military Hospital, Dhaka and Dhaka Dental College and Hospital. A total 40 patients having mandibular fracture were included in this study and were evaluated radiologically by both conventional radiography (orthopantomography) and cone beam computed tomography (CBCT).***

Results: ***Among the 40 cases the mean age for the male patient with mandibular fracture were 25.16 $\pm$ 2.7 and for the female patient it was 29.80 $\pm$ 5.0. Most cases were male than female, RTA was found the most common cause of fracture mandible. Most of the cases were associated with other body part injury excluding head injury. Most commonly fractured anatomic region of mandible was found angle 18 (45%) followed by body 16(40%). CBCT detected more fracture sites than Orthopantomograph.***

Conclusion: ***CBCT was found more accurate than orthopantomography (OPG) in detecting fracture sites. Thus CBCT helped in early and proper management of fracture reduction and rehabilitation of the patients.***

Keywords: ***Mandible, Fracture, Orthopantomograph (OPG), Cone beam computed tomography (CBCT).***

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Introduction:

The facial skeleton is a complex structure formed by a combination of five paired bones and four unpaired bones.[1] According to reports of developing nations, road traffic accidents are the main cause of maxillofacial fractures.[2] Mandible fracture is among the most frequently encountered injuries in the trauma center setting and represents the second most commonly fractured bone in the facial skeleton.[3]

Mandibular fractures are classified according to their location. Higher incidence is encountered in the body and symphysis but condyle fractures are also of relatively high incidence . Clinically malocclusion, ecchymosis in the floor of the mouth and step defects involving the inferior border are included in the possible findings.[4] Mandibular fracture can be classified as simple or closed, compound or open depending upon their involvement of skin, mucosa or periodontal membrane communication with the break in the bone. Comminuted fracture is that in which the bone is splintered or crushed. In multiple fracture there are two or more lines of fracture on the same bone not communicating with one another. Angle fractures may be classified as vertically favorable or unfavorable and horizontally favorable or unfavorable.[5]

Mandibular fractures involving the condylar region warrant further attention. Children and young adults tend to exhibit better adaptability, with condylar

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remodeling and flattening of the mandibular fossa. These fractures can be classified based on their location as intracapsular, extracapsular, or subcondylar. Additionally, they may be categorized as undisplaced, displaced, or dislocated. The classic X-ray, the oldest and most fundamental method of imaging facial bone fractures, provides a two-dimensional summative reconstruction of anatomical structures.[6]

Panoramic imaging, also known as pantomography, is a technique that produces a single image encompassing the facial structures, including both the maxillary and mandibular dental arches and their supporting structures. In patients with mandibular fractures, conventional skull radiography is often supplemented with rotational panoramic radiography, which enhances diagnostic accuracy for detecting mandibular fractures. Cone Beam Computed Tomography (CBCT) represents an advancement in computed tomography (CT) imaging, emerging as a potentially low-dose cross-sectional technique for visualizing the bony structures of the head and neck. CBCT technology has significantly improved the efficiency of oral and maxillofacial surgeons in private practices, as access to cross-sectional imaging has become faster and more convenient compared to hospital-based facilities. With the ability to reformat CBCT slices and view them in multiple orientations (multiplanar views), anatomical structures are no longer superimposed, allowing for more precise and detailed visualization[10]

The aim of this study was to compare the clinical effectiveness of conventional radiography (Orthopantomograph) and cone beam computed tomography (CBCT) in the diagnosis of mandibular fracture and also to find out the easiest way for the detection of mandibular fracture.

Materials & Methods:

This study was a descriptive cross-sectional study which was conducted in the Department of Oral and Maxillofacial Surgery, Dental Wing, Combined Military Hospital Dhaka, and Dhaka Dental college and Hospital from August 2016 to May 2017. All patients with maxillofacial trauma (clinically diagnosed mandibular fracture) were included in the study, a total number of cases was 40. CBCT and Orthopantomograph (OPG) were done on every patient by a similar machine. The fractures detected on the radiological examination were correlated with known fractures as determined by each patient's operative report. Ethical clearance was taken from the ethical research committee of the Director General Medical Services, Bangladesh armed forces, and the ethical clearance committee of Dhaka Dental College and Hospital. An informed written consent was taken from every patient explaining the nature and objective of the study.

Results:

Patients were studied according to age and gender, causes of injury, distribution of other facial bone fractures, commonly fractured anatomical sites of mandible, signs and symptoms associated with mandible fracture, and associated other body part injury were also studied. Mandibular fracture site detection and cortical plate fracture and detection of their displacement by both OPG and CBCT including measurement of their sensitivity were also analyzed. Age-wise distribution of 40 patients, with the most common age group being 21-30 years (25%), followed by the 0-10 years group (22.5%). The least represented groups were 51-60 years and 81-90 years, each comprising 2.5% of the patients. The causes of mandibular fractures showed that road traffic accidents (RTA) were the most common cause (62.5%), followed by falls from height and assaults, each accounting for 12.5%. Distribution of fractured facial bones, with 65% of patients having only mandible fractures, 20% having fractures of both the mandible and zygomatic bone, and 15% having mandible and maxilla fractures. Detection of fracture sites by orthopantomography and CBCT, revealing that CBCT provided significantly better detection rates for most sites, except for coronoid process fractures. ighlights the detection of cortical plate fractures and displacement, where CBCT showed a significant advantage in identifying fractures and displacements across all sites. CBCT demonstrated a high level of sensitivity in detecting lingual and buccal cortical plate fractures and fracture segment displacements, with all findings showing statistically significant differences (p-value < 0.05). The sensitivity of Orthopantomography (OPG) and Cone Beam Computed Tomography (CBCT) in detecting mandibular fractures across various sites. CBCT demonstrated higher sensitivity than OPG for all fracture sites, with statistically significant differences in sensitivity for the symphysis, parasymphysis, body, condylar process, and coronoid process of the mandible. The results highlight CBCT's superior diagnostic performance in detecting mandibular fractures.

Table-I

Age wise distribution of patients (n=40)

Age Group	Number of Patients	Percentage
0-10	9	22.5
11-20	8	20
21-30	10	25
31-40	8	20
41-50	3	7.5
51-60	1	2.5
81-90	1	2.5

Table I showed that out of 40 patients the most common age group was 21-30 (25%) years followed by 0-10 (22.5%) years.

Table-II

Causes of injury (n=40)

Factors	Number of Patients	Percentage
RTA	25	62.5
Fall from height	5	12.5
Assault	5	12.5
Sports injury	4	10
Other causes	1	2.5

Table II showed that out of 40 patients most common causes of mandible fracture were RTA (62.5%) followed by fall from height and assault (12.5%) each.

Table-III

Distribution of fractured facial bone (n=40)

Bones	Number of Patients	Percentage
Mandible (only)	26	65
Mandible and Zygomatic bone	8	20
Mandible and Maxilla	6	15

Table III showed that out of 40 patients 26 (65%) had only mandible fracture, 8 (20%) patient had mandible with zygomatic bone fracture, 6 (15%) patient had mandible with maxilla fracture.

Table-IV

Distribution of fractures sites detected by both orthopantomography and cone beam computed tomography.

Site	Orthopantomography	P-value	CBCT	p-value
Symphysis of mandible	9/13(69.2)	0.133	12/13(92.30)	0.0017
Parasymphysis of mandible	5/8(62.5)	0.363	7/8(87.50)	0.0351
Body of mandible	12/16(75)	0.038	15/16(93.75)	0.0002
Angle of mandible	13/18(72)	0.048	16/18(89)	0.0006
Ramus of mandible	0		0	
Condylar process of mandible	8/13(61.5)	0.290	12/13(92)	0.0017
Coronoid process of mandible	1/3(33)	0.875	2/3(66.6)	0.5000

Table IV revealed in detecting fracture sites orthopantomograph had significant p value < .05 in case of body and angle fracture on the other hand CBCT had significant p value in every sites except in case of coronoid fracture.

Table-V

Distribution of cortical plate fractures and displacement detected by orthopantomography and cone beam computed tomography.

Site	Orthopantomography	CBCT	p-value
Lingual cortical plate	0/38(00)	31/38(81.6)	0.0005
Buccal cortical plate	0/38(00)	30/38(79.0)	0.0002
Mesio/distal displacement of fracture segment	0/32(00)	26/32(81.2)	0.0002
Anterior/posterior displacement of fracture segment	0/20(00)	16/20(80.0)	0.005

Table-VI

Revealed in detecting cortical plate fractures and to see the displacement CBCT had significant p value < .05 in every sites.

Site	Orthopantomography (Sensitivity/Number)	CBCT (Sensitivity/Number)	95%CI	P-value
Symphysis of mandible	9/13(0.69)	12/13(0.92)	(0.063-0.396)	0.009
Parasymphysis of mandible	5/8(0.62)	7/8(0.87)	(0.067-0.432)	0.010
Body of mandible	12/16(0.75)	15/16(0.93)	(0.024-0.335)	0.028
Angle of mandible	13/18(0.72)	16/18(0.89)	(0.004-0.339)	0.055
Condylar process of mandible	8/13(0.61)	12/13(0.92)	(0.137-0.482)	0.001
Coronoid process of mandible	1/3(0.33)	2/3(0.66)	(0.123-0.536)	0.003

Table VI showed that CBCT is more sensitive than OPG in detecting mandibular fracture.

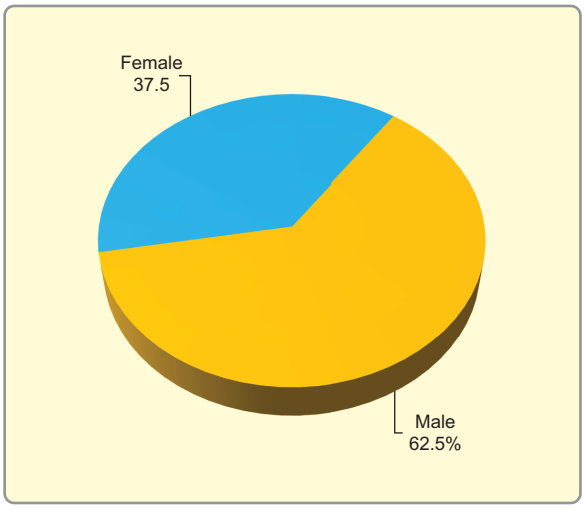

Figure 1: *Sex wise distribution of patients*

Figure -1 revealed that out of 40 patients male patient were 25(62.5%) and female patient were 15(37.5%).

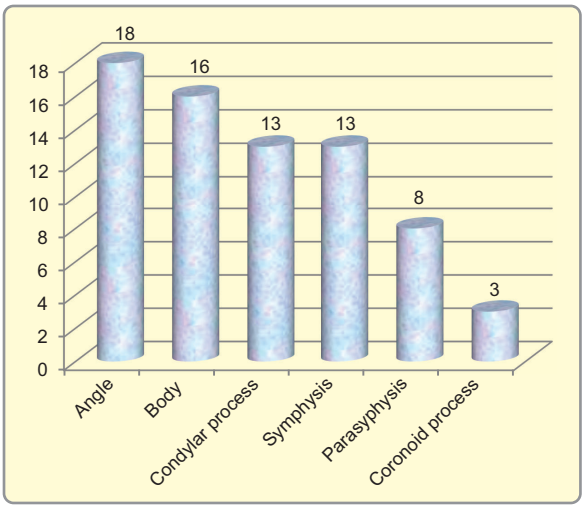

Figure 2: Commonly fractured anatomic region in mandible.

Fig -2 showed that among studied patients most commonly fractured anatomic region of mandible was found angle 18 (45%) followed by body 16 (40%).

Discussion:

Various radiographic methods have been used for diagnosing maxillofacial trauma. Panoramic tomography is widely used for the screening of orofacial trauma.4 The cone-beam technique is the most recent advance in computer-assisted tomography.[11] Among the patients there were 25 male and 15 female. Age of the youngest patient was 6 and oldest patient was 90. Among 40 patients the mean age for the male patient with facial bone fracture was 25.16±2.7 and for the female patient it was 29.80±5.0, the most common age group was 21-30 (25%) years. A study in Bangladesh carried out by Ahmed M, Hasan M, Rahman AFMS et al found that in case of jaw fracture most commonly involved age group were 21-30 (37%) years followed by 31-40 (18%) years and 0-12 (15%) years.[12] Among 40 patients 25(62.5%) had the history of road traffic accident, 5 (12.5%) patients each had history of assault and fall from height which were second leading causes of mandible fracture. In a study carried out by Myga-Porosilo J et al. found that most frequent causes of the facial bone fracture include transportation injuries (up to 80%) of cases.[6] In Bangladesh a study carried out by Molla MR, Shaheed I, Bhuiyan RA et al found that the major cause of mandible fracture was road traffic accident (58.4%) , the other causes were falls (13.6%) , work related (12.8%), sports related (4.8%) assault (0.8%) and pathological fracture (1.6%).[13] Adeyemo stated that road traffic crashes remain the major cause of maxillofacial injuries, unlike in most developed countries where assaults/interpersonal violence has replaced road traffic crashes as the major cause of the injuries.[14] In the context of our country urbanization is rapidly progressing and the number of motor vehicle specially motorbike and three wheelers has increased a lot, so road traffic accident (RTA) has become the leading cause of maxillofacial trauma. In present study it was found that among 40 cases all had mandibular fracture but 14 cases had associated other facial bone fracture which included 8 (20%) zygomatic bone and 6 (15%) maxillary fracture. A study in Bangladesh carried out by Ahmed M, Hasan M, Rahman AFMS et al revealed that among 422 cases only mandible fracture were 227 (54%) , mandible with maxillary fracture were 14 % , mandible with zygomatic bone fracture were 3% and rest of the cases were either isolated maxilla or zygomatico maxillary complex fracture.[12] Another study by Matos FP et al. found that among 126 patients several maxillofacial fractures were associated with mandibular fractures. The distribution of other maxillofacial fracture were zygomatic bone fracture were 3 (2.4%) , Le Fort fracture were 3 (2.4%), nasal bone fracture were 2 (1.6%).[15] The patients reported with concomitant either zygomatic bone fracture or maxilla fracture, they almost all had associated head injury, inability to open the mouth adequately and severe malocclusion. According to our study most commonly fractured anatomic region of mandible was angle 18 (45%) followed by body 16(40%), condylar region13 (32%), symphysis 13(32%) and para symphysis 8 (20%). In a study by Ogundare BO et al. found the most common location of fracture was in the angle region 36%, followed by the body 21% and para symphysis region 17% and 52% presented with more than one fracture site.[16] Another study carried out by Cardenas JL et al. found that the distribution of anatomical locations of the 139 fracture lines of mandible were 60 (43.17%) condylar fractures, followed by 26 (18.70%) parasymphysis fractures, body and angle with 21 (15.11%) fractures each, 9 (6.47%) fractures of the symphysis and 2 (1.44%) fractures of the mandibular ramus.[17] According to this study in symphysis orthopantomography (OPG) identified 9 (69%) and CBCT 12 (92%) out of 13 fractures, in para symphysis OPG 5 (62%) and CBCT 7 (87%) out of 8 fractures, in body OPG detected 12 (75%) and CBCT 15 (93%) out of 16 fractures, in angle OPG found 13 (72%) and CBCT 16 (89%) in 18 fractures, in condylar process OPG detected 8 (61%) and CBCT 12 (92%) out of 13 fractures, in coronoid process OPG identified 1(33%) and CBCT detected 2(66%) out of 3 fractures. In detecting fracture sites orthopantomograph had significant p value less than .05, in case of body and angle fracture on the other hand CBCT had significant p value in every sites. In a study by Kaeppler G et al. found that with regard to the sites (as one patient could have several sites suggestive of a mandibular fracture) CBCT confirmed the diagnosis of suspected fracture based on conventional imaging in 63.2% of the sites (n = 146 sites, total n = 231). For 33% (75 sites, total n = 231) CBCT identified 75 fractures in addition to those suspected by clinical examination or observed on conventional images. For 4.33% of the sites (n = 10, total n = 231) CBCT could not confirm the estimated diagnosis.[18] In present study it revealed incase of buccal and lingual plate fractures OPG could not give any valid

information but CBCT identified 31lingual and 30 buccal cortical plate fracture among 38 lingual and buccal cortical plate fractures. Incase of mesio- distal displacement and anterior posterior displacement of fracture segments OPG could not give any information but CBCT identified 26 (81%) out of 32 mesiodistal displacement and 16 (80%) out of 20 anteroposterior displacement of fracture segments. In detecting cortical plate fractures and to see the displacement CBCT had significant p value less than .05 in every sites which were statistically significant.

CBCT at compare to orthopantomograph (OPG) in detecting symphysis fracture was more sensitive 92% versus 69% with p value of 0.009 which is statistically significant, CBCT performed better in case of para symphysis fracture of mandible than OPG with sensitivity 87% versus 62% and p value is 0.010 which was also statistically significant. Incase of body fracture CBCT had sensitivity 93% versus 75% and p value is 0.028 this p value was also statistically significant. CBCT was more accurate than OPG incase of detecting fracture angle of mandible with sensitivity 89% versus 72% and p value was 0.055 which was statistically significant. In case of fracture condylar process of mandible CBCT had sensitivity 92% versus 61% and p value was 0.001, this p value was statistically significant. CBCT performed better in case of coronoid process fracture of mandible than OPG with sensitivity 66% versus 33% and p value was 0.003 which was also statistically significant. In symphysis and para symphysis region anterior posterior displacement of the fracture fragments frequently occurs which cannot be identified by orthopantomograph alone it requires occlusal view of mandible. In these cases CBCT can easily diagnose the anterior or posterior displacement of fracture fragments which enhance the treatment outcome a lot. A cost analysis of CBCT versus panoramic tomography was not part of this study however additional data provided by CBCT improves our understanding of mandibular fractures preoperatively may result in cost savings by reducing the amount of time spent in operation theatre and by reducing post operative complications. A single conventional plain film compared with CBCT needs the lowest level of radiation but when limited information is obtained by these films and further details are required for diagnosis and treatment planning or postoperative evaluation, CBCT should be considered instead .[4]

Conclusion:

The findings of this study highlight the importance of using multiple imaging modalities when evaluating certain anatomical regions of the the mandible, such as the symphysis and Para symphysis areas. These regions cannot be clearly visualized using panoramic tomography alone. Cone Beam Computed Tomography (CBCT) provides additional information that is not available with orthopantomography (OPG), such as detailed fracture lines, distribution, and the degree of comminution and displacement of bone fragments. This level of detail is crucial for surgeons to ensure proper reduction and fixation of the fractures. CBCT proves to be an excellent tool for the comprehensive evaluation of mandibular fractures. Based on the results of this study, and supported by existing literature, CBCT offers several advantages over conventional radiography in the diagnosis and management of mandibular fractures.

Conflict-of-interest: None

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