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Original research

COMPARISON OF PANORAMIC, LATERAL SKULL PROJECTION AND CBCT IMAGES IN DETECTION OF MANDIBULAR CONDYLE FRACTURES

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ABSTRACT

Objectives: Condyle fractures constitute 17.5–52% of all mandibular fractures. Our first aim was to investigate whether Panoramic Radiography or Lateral Skull Projection images with lower radiation dose can be used instead of Cone Beam Computed Tomography in the diagnosis of vertical condylar fractures. The second aim of the study was to compare observers' capabilities in diagnosing these fractures.

Materials and Methods: A sample consisting of 15 fresh cadaver mandibles with 30 condyles frozen within 24 hours post-mortem was randomly selected. Vertical fractures from the lateral 2/3 of the condyle head with 0.5 (10 condyles) and 1mm (10 condyles) thickness were created using a fret saw. After creating condyle fractures, digital panoramic, LSP, and CBCT images were acquired. Two dentomaxillofacial radiologists with 15 years of experience, two dentomaxillofacial radiologists with five and seven years of experience, and two newly graduated dentists have evaluated the images. The success of the observers in diagnosing the vertical condyle fracture in each imaging method, intra-observer and inter-observer agreement was evaluated.

Results: The success of all dentists in determining the condyle fractures using LSP images was higher than the success they achieved using panoramic images, but the sensitivity values of LSP and panoramic radiographs for detecting vertical condyle fractures were found to be below 50%. Using different imaging options with CBCT, all diagnoses made by new graduates and dentomaxillofacial radiologists with five and 15 years' experience were 100% compatible with the gold standard (AC1: 1 (1–1)).

Conclusions: For the diagnosis of vertical condyle fractures, conventional techniques (panoramic and lateral jaw imaging methods) were found to be insufficient.

Keywords: Cone beam computed tomography, imaging, mandibular condyle, vertical fracture.

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INTRODUCTION

Condyle fractures have an important percentage of all jaw fractures. 80% of the cases are unilateral, occurring mainly between the ages of 20 and 39 years. The male/female ratio is 3:1. These fractures are mostly caused by indirect forces transmitted from a distant point to the condylar area.[1-3] According to Widmark[4] and Santler[5], fractures of the mandibular condylar process are the most common fractures in the mandible and maxillofacial region. Condyle fractures can occur as a result of direct or indirect trauma. The formation of bone displacement with the fracture depends on the direction, degree and region of the force during the trauma, as well as the current occlusion and dental condition of the patient.[1,4,5]

The diagnosis of mandibular condyle fractures is made by clinical and radiographic evaluations. Difficulty opening the mouth, malocclusion, and edema in the peripheral part of the auricula may be clinical signs of mandibular condyle fractures.[6]

The correct diagnosis of mandibular condyle fractures is made through radiographic evaluations. Conventional extraoral radiographic techniques such as panoramic and lateral skull projection (LSP) are used for the diagnosis and postoperative follow-up of condyle fractures. [7] However, the superimposition of structures could make fracture diagnosis difficult. This is a significant disadvantage in the imaging of high condylar fractures because the treatment outcome depends on the position of the fracture line, the comminution of the proximal fragments, and the shortening of the mandibular ramus.[8,9] Moreover, nondisplaced fractures of the mandibular condylar head may be difficult, if not impossible, to detect on a panoramic image.[10]

Computed tomography (CT) provides a clear visualization of maxillofacial structures without superimposition of anatomical structures. The clinical utility of the CT scan is particularly evident when evaluating condyle fractures, as the degree of displacement in these areas can be subtle.[11] However, CT has disadvantages; it can be unhealthy due to high radiation, overcosting, and large area requirement.[12-15] CBCT scanning is frequently used in dentistry and has advantages such as low radiation dose, low cost, time efficiency and high spatial resolution when compared to CT.[16]

There is only one study that has compared the diagnostic accuracy of CT and CBCT in experimentally created condylar fractures.[17] Three-dimensional imaging does not have a routine indication for every patient, therefore, in our study, we investigated whether panoramic radiography or LSP images with lower radiation dose can be used in the diagnosis of vertical condylar fractures. The second aim of the study was to compare observers' capabilities in diagnosing these fractures.

MATERIALS AND METHODS

Sample: This study was performed with local ethical committee approval (……. University, Project no: D-DA19/05). A sample consisting of 15 fresh cadaver mandibles with 30 condyles frozen within 24 hours post-mortem was randomly selected. The sample was defrosted 24 hours before making the scans. A 1.5 cm red wax material was used as a soft tissue equivalent.

Creating Vertical Condyle Fractures: Vertical fractures from the lateral 2/3 of the condyle head with 0.5 mm (10 condyles) and 1 mm (10 condyles) thickness were created using a fret saw. The fracture line depths were 2 mm.

Panoramic, Lateral Skull and CBCT Assessments: All digital panoramic images were acquired using the same machine (Veraviewpocs 2D, Morita, Japan) with the following exposure parameters: 64–66 kVp; 6–9 mA; and 10 s. The isolated mandibles were positioned with the occlusal plane perpendicular to the floor.

All LSP images acquired using the image receptor were positioned parallel to the mandibles' midsagittal plane.

A CBCT system (3D Accuitomo 170, Morita, Japan) was used to scan the sample. The technical parameters for 3D Accuitomo 170 and Iluma were 90 kV, 5 mA, 17.5 s). Three different fields of view (FOV; 60x60, 80x80, 100x100 mm) were used. The isolated mandibles were positioned with the occlusal plane perpendicular to the floor.

Assessments of Images and Observers: As observers, two dentomaxillofacial radiologists with 15 years of experience, two dentomaxillofacial radiologists with five years of experience, and two newly graduated dentists evaluated the images. The images were re-evaluated at 1 month interval. The success of the observers in diagnosing the vertical condyle fracture in each imaging method, intra-observer and inter-observer agreement were evaluated.

Statistical Analysis: Statistical analysis of the data collected in the study was made with the SPSS (Version 22, SPSS Inc., Chicago, IL, USA) package program. Intra-observer agreement percentages will be calculated for three different imaging methods. Also, the inter-observer agreement level was evaluated with GWET AC1 statistics instead of Cohen's kappa statistics, which were affected by prevalence. The compliance levels of physician diagnoses with the gold standard for three different imaging methods were also evaluated with the GWET AC1 statistics. Also, sensitivity and selectivity values were calculated to evaluate the success of diagnoses made by the observers using three different devices. Compliance statistics were used to provide information on the distribution of diagnostic differences between observers. Sensitivity and specificity were used to provide information about the ability of the observers to diagnose vertical condyle fractures with 0.5 mm and 1.00 mm thickness. The GWET AC1 values were interpreted as follows: <0.01 means no compliance; 0.01–0.20 means insignificant agreement; 0.21–0.40 means poor agreement; 0.41–0.60 means moderate agreement; 0.61–0.80 means sufficient agreement; and 0.81–1.00 is interpreted as the existence of perfect fit. The statistical significance level was accepted as P<0.05.

RESULTS

The intra-observer agreement according to imaging methods is given in Table 1.

Table 1. The intra-observer agreement according to imaging methods.

		Panoramic	**LSP**	**CBCT (60x60)**	**CBCT (80x80)**	**CBCT (100x100)**
Newly graduated Dentists	%	73.3%	80%	100%	100%	100%
	Agreement*	0.65 (0.38–0.92)	0.62 (0.33–0.92)	1 (1–1)	1 (1–1)	1 (1–1)
Dentomaxillofacial Radiologists with 5-year experience	%	90%	93.3%	100%	100%	100%
	Agreement*	0.88 (0.75–1.02)	0.89 (0.73–1.04)	1 (1-1)	1 (1-1)	1 (1-1)
Dentomaxillofacial Radiologists with 15-year experience	%	90%	93.3%	100%	100%	100%
	Agreement*	0.88 (0.75–1.02)	0.89 (0.73–1.04)	1 (1-1)	1 (1-1)	1 (1-1)

*Gwet's AC1 coefficients and their 95% confidence intervals.
LSP: Lateral Skull Projection.

When the intra-observer agreement was evaluated according to imaging methods, the most successful compliance was the evaluations made using CBCT, followed by the evaluations made using LSP and panoramic images, respectively. The inter-observer agreement level of evaluations using CBCT, LSP and panoramic images was sufficient.

The compliance of physician diagnoses with the gold standard according to imaging methods is given in Table 2.

Table 2. The compliance of physician diagnoses with the gold standard according to imaging methods.

		Panoramic	**LSP**		**CBCT (60x60)**		**CBCT (80x80)**			**CBCT (100x100)**		
		Sens		**Spec**	**Sens**	**Spec**	**Sens**	**Spec**	**Sens**	**Spec**	**Sens**	**Spec**
Newly graduated dentist A	%	20%		90%	50%	100%	100%	-	100%	-	100%	-
	Agreement*	−0.28 (−0.68 – 0.11)	0.33 (−0.01 – 0.68)		1 (1–1)		1 (1–1)			1 (1–1)		
Newly graduated dentist B	%	5%		80%	50%	80%	100%	-	100%	-	100%	-
	Agreement*	−0.32 (−0.73 – 0.08)	0.20 (−0.16 – 0.57)		1 (1–1)		1 (1–1)			1 (1–1)		
Dentomaxillofacial radiologist with 5-year experience A	%	0%		90%	35%	90%	100%	-	100%	-	100%	-
	Agreement*	−0.28 (−0.71 – 0.15)	0.07 (−0.30 – 0.44)		1 (1–1)		1 (1–1)			1 (1–1)		
Dentomaxillofacial radiologist with 5-year experience B	%	10%		100%	40%	100%	100%	-	100%	-	100%	-
	Agreement*	−0.12 (−0.54 – 0.30)	0.20 (−0.16 – 0.57)		1 (1–1)		1 (1–1)			1 (1–1)		
Dentomaxillofacial radiologist with 15-year experience A	%	5%		100%	35%	100%	100%	-	100%	-	100%	-
	Agreement*	−0.16 (−0.59 – 0.27)	0.14 (−0.23 – 0.51)		1 (1–1)		1 (1–1)			1 (1–1)		
Dentomaxillofacial radiologist with 15-year experience B	%	10%		80%	40%	90%	100%	-	100%	-	100%	-
	Agreement*	−0.28 (−0.68 – 0.11)	0.13 (−0.23 – 0.50)		1 (1–1)		1 (1–1)			1 (1–1)		

*Gwet's AC1 coefficients and their 95% confidence intervals
Sens: Sensitivity, Spec: Specificity, LSP: Lateral Skull Projection.

According to imaging methods, when the agreement between all dentists' diagnoses and the gold standard was evaluated, the most successful agreement was that of the evaluations made using CBCT, followed by the evaluations made using LSP and panoramic images, respectively (Figure 1a, b, c).

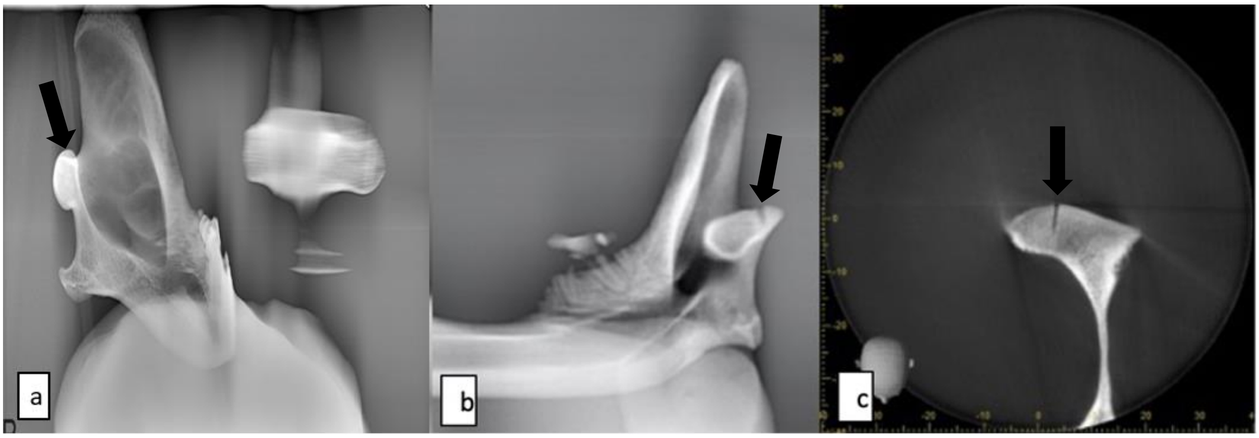

Figure 1(a,b,c). Panoramic, LSP and CBCT images with vertical condyle fractures were seen.

The consistency of the evaluations made with LSP and panoramic images with the gold standard were insufficient.

According to the vertical condyle fracture thickness, the compliance of physician diagnoses with the gold standard for panoramic and LSP images is given in Table 3.

Table 3. The compliance of physician diagnoses with the gold standard for panoramic and LSP according to vertical condyle fracture thickness.

Fracture thickness		Panoramic Sens	Spec	LSP Sens	Spec
0.5 mm	**Newly graduated dentist A**	20%	90%	50%	100%
	Newly graduated dentist B	0%	80%	50%	80%
	Dentomaxillofacial radiologist with 5-year experience A	0%	90%	30%	90%
	Dentomaxillofacial radiologist with 5-year experience B	0%	100%	40%	100%
	Dentomaxillofacial radiologist with 15-year experience A	0%	100%	30%	100%
	Dentomaxillofacial radiologist with 15-year experience B	10%	80%	40%	90%
1 mm	**Newly graduated dentist A**	20%	90%	50%	100%
	Newly graduated dentist B	10%	80%	50%	80%
	Dentomaxillofacial radiologist with 5-year experience A	0%	90%	40%	90%
	Dentomaxillofacial radiologist with 5-year experience B	20%	100%	40%	100%
	Dentomaxillofacial radiologist with 15-year experience A	10%	100%	40%	100%
	Dentomaxillofacial radiologist with 15-year experience B	10%	80%	40%	90%

1. Sens: Sensitivity, Spec: Specificity
2. LSP: Lateral Skull Projection

When the success of physician diagnoses in detecting 0.5 and 1 mm thick fractures according to imaging methods was evaluated, it was seen that LSP was more successful than panoramic, but the sensitivity values obtained as a result of both methods were at a very low level—below 50%. When the success of observers' diagnoses in detecting intact condyles compared to the gold standard was evaluated, it was seen that the specificity values were high, since the majority of both intact and broken condyles were diagnosed as intact.

DISCUSSION

The rate of condyle fractures among all jaw fractures is between 17.5% and 52%.[18] Sawazaki et al.[19] reported that 14% of maxillofacial trauma patients sustained at least 1 condylar fracture and, of all mandibular fractures, condylar fractures accounted for 50.09%. There are many different classifications and imaging methods for mandibular condylar fractures used in the literature. The anatomical level of the fractures can be divided into three regions: (A) condylar head (in the capsule), (B) condylar neck (extra-capsule), and (C) subcondylar zone.[3,20-23] There are two types of fractures in general: intra-capsular and extra-capsular. A fracture is classified as either not displaced, deviated, displaced (with medial or lateral overlap or complete separation) or dislocated (outside glenoid fossa), and condylar head fractures can be categorized by horizontal, vertical, and compression types.[3,21-25] The main theme of this report is vertical fractures.

While two different X-ray views can be performed for mandibular fractures: a postero-anterior view, generally used for angle and ramus fractures; bilateral oblique view, used to analyse the angle and horizontal branch of the mandible. For the diagnosis of condyle fractures CBCT, CT and other conventional extraoral radiographic techniques as panoramic, posteroanterior skull projection (PASP), LSP, an angled antero-posterior view called reverse Towne view, useful in case of displacement of condylar fragments; have been used in oral and maxillofacial radiology.[26] In our study, we compared three different imaging methods for condyle fractures.

Conventional radiographs are routinely used for the examination of the mandibular condyle. However, overlapping structures can prevent images from being interpreted properly.[27] Intracapsular fractures of the mandibular condyle and fractures in the higher part of the condylar process are difficult to see on plain films. Depending on the position, the image may overlook the displacement of bone fragments, distorting the correct diagnosis.[28] The LSP and panoramic images will provide the essential preliminary information, but these will not be sufficient for critical evaluation of the TMJ itself because of the superimpositions of surrounding structures. The mandibular condyle may be superimposed on panoramic radiographs by the zygomatic process, maxillary tuberosity, and the pterygoid process of the sphenoid bone.[29,30] In the present study, it was found that sensitivity values of LSP and panoramic radiographs were at a very low level below 50% for detecting vertical condyle fractures. We think that this may be due to the superimpositions formed in this region.

CT is a convenient method to diagnose the condylar process that is not seen in conventional radiographs.[31,32] In recent years, CBCT is a modern imaging technique with the advantages of low-level metal artifacts and low radiation dose, which may be more efficient and economical than CT.[18] Moreover, CBCT has been reported to be superior to panoramic radiography, especially in detecting condylar and coronoid fractures and fractures in the anterior part of the mandible.[30]

In the literature, there are many studies comparing 3-dimensional imaging with 2D imaging in detecting condyle fractures. Costa et al.[18] evaluated 2D-CT and 3D-CT examinations of patients with mandibular condyle fractures. They noted that 2D-CT and 3D-CT reconstruction images produced similar information for the diagnosis of mandibular condyle fractures, but 3D-CT was better than 2D-CT at imaging the position and displacement of bone fragments. Raustia et al.[6] reported that both the anteroposterior and mediolateral displacement direction of the fractured condyle were better seen on CT than conventional radiographs. Choudhary et al.[33] evaluated the diagnostic quality of CBCT images and compared them with conventional images from patients with maxillofacial trauma. They stated that the detection of fracture lines on the midface and mandibular condylar region is signifcantly enhanced using CBCT when compared with conventional radiographs.

Even Sukegawa et al.[34] offer a new approach. After their study, they reported that the use of intraoperative CBCT in the hybrid operating room for condylar fractures is the most beneficial approach because they requires more accurate intraoperative diagnosis.

The present study evaluated panoramic, LSP and CBCT imaging as effective techniques for the diagnosis of vertical condylar fractures. In our study, similar to other studies, we found that CBCT is the best imaging technique for the diagnosis of vertical fractures. When the success of physicians detecting 0.5 and 1 mm fractures according to imaging methods was evaluated, it was seen that the lateral imaging method was more successful than the panoramic method, but the sensitivity values obtained as a result of both methods were very low (below 50%).

Şirin et al.[17] compared CT and CBCT imaging of displaced and non-displaced fractures using sheep heads. The kappa values for the intra-observer agreement of Observer 1 varied between 0.56 and 0.92 (moderate to excellent) for CT and between 0.64 and 0.92 (good to excellent) for CBCT in their study. Observer 2 had similar scores for both imaging modalities: 0.57–0.92 for CT and 0.79–0.92 for CBCT. The kappa values for the two observers revealed good to excellent agreement for CT and CBCT (0.62–0.98 and 0.60–0.97, respectively).[17] In our study, the agreement between the diagnoses made by the newly graduated dentists using panoramic and LSP was substantial (AC1: 0.65, 0.62, respectively). The agreement between dentomaxillofacial radiologists with five years of experience using panoramic and LSP imaging was almost perfect (AC1: 0.88, 0.89, respectively). The consistency between the dentomaxillofacial radiologists with 15 years of experience using the panoramic imaging method was sufficient (AC1: 0.80), and the agreement between them using LSP was almost perfect (AC1: 0.89). Compliance percentages of new graduates and dentomaxillofacial radiologists with five years and 15 years of experience with panoramic images were 73.3%, 90%, and 90%, respectively; the agreement percentages of their diagnoses of LSP images were 80%, 93.3%, and 93.3%, respectively.

For Şirin et al.[17], the kappa values obtained in comparison with the gold standard were 0.69–0.97 for CT and 0.68–0.96 for CBCT. Furthermore, CT and CBCT were in good to excellent agreement, as the kappa values were 0.64–0.94 for the interpretation of the reconstructed images. In our study, all of the diagnoses made by new graduates and dentomaxillofacial radiologists with five and 15 years' experience using CBCT with different fields of view (60x60, 80x80, 100x100) were 100% compatible with the gold standard. On the other hand, Librizzi et al.[35] compared CBCT images using different voxel sizes and FOVs to identify condylar erosions. They reported that the CBCT images acquired with a 6-inch FOV at 0.2-mm voxel size were significantly better than the images acquired with a 12-inch FOV at 0.4-mm voxel size.

Although there are many studies on imaging condylar fractures in the literature, to the best of our knowledge this is the first study that focused on vertical fracture imaging. In this study the vertical condyle fractures were created experimentally and therefore patient related artefacts such as movement were not considered. It may be a potential limitation of the study.

CONCLUSIONS

For the diagnosis of vertical condyle fractures, conventional techniques (panoramic and lateral jaw imaging methods) were found to be insufficient. CBCT, which is frequently used in the three-dimensional imaging of the maxillofacial region, is excellent for the diagnosis of these fractures. Moreover, all observers accurately diagnosed all vertical condyle fractures using CBCT images. Therefore, it is recommended to use CBCT for the diagnosis of vertical condyle fractures, despite the high radiation disadvantage.

CONFLICTS OF INTEREST

No conflicts of interest.

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