Comparison between Intraoral Radiography (IOR) and Cone Beam Computed Tomography (CBCT) for Furcation Assessment and Treatment Decision

การเปรียบเทียบการประเมินสภาวะปริทันต์บริเวณง่ามรากฟันกรามและการวางแผนการรักษาด้วยภาพรังสีในช่องปากและภาพรังสีโคนบีมคอมพิวท์โทโมกราฟี

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ABSTRACT

Aim: To compare the furcation assessment by IOR and CBCT. Material and Methods: Twenty-five subjects received clinical, IOR, and CBCT examinations. Three examiners gave the furcation assessment including degree of furcation involvement (FI) and treatment decision. The furcation assessment by IOR and CBCT was compared. Results: The concordance of degree of FI (presence/absence) between IOR and CBCT was fair to good (72.8-84.0%). For treatment decision, the concordance was very good for non-surgical treatment (94.0%),but was low for surgical treatment (56.8%). In addition, the examiner agreement of CBCT was excellent and higher than IOR. Conclusion: CBCT showed superior benefit over IOR in assessing the degree of furcaion bone loss and provided more detailed information for aggressive treatment plan.

บทคัดย่อ

วัตุประสงค์: เพื่อเปรียบเทียบการประเมินสภาวะปริทันต์บริเวณง่ามรากฟันกรามด้วยภาพรังสีในช่องปากและภาพรังสีซีบีซีที วัสดุและวิธีการ: ผู้ป่วย 25 คน ได้รับการตรวจทางคลินิก ภาพรังสีในช่องปาก และภาพรังสีซีบีซีที ผู้ให้การประเมิน 3 คน ให้การวินิจฉัยและวางแผนการรักษาฟันกรามที่มีการทำลายกระดูกบริเวณง่ามรากฟันด้วยข้อมูลจากภาพรังสีในช่องปากและภาพรังสีซีบีซีที ผล: ความสอดคล้องกันระหว่างภาพรังสีในช่องปากและภาพรังสีซีบีซีทีในการประเมินระดับการทำลายกระดูก (มี/ไม่มี) อยู่ในระดับปานกลางถึงดี (72.8-84.0%) และมีความสอดคล้องสูงในการวางแผนการรักษาโดยการไม่ผ่าตัด แต่มีความสอดคล้องกันต่ำในการวางแผนการรักษาโดยการผ่าตัด นอกจากนี้ ผลการประเมินของผู้ให้การประเมิน ทั้ง 3 คน มีความสอดคล้องกันสูงเมื่อประเมินด้วยภาพรังสีซีบีซีทีและสูงกว่าการประเมินด้วยภาพรังสีในช่องปาก สรุป: การใช้ภาพรังสีซีบีซีทีมีประโยชน์เหนือกว่าภาพรังสีในช่องปากในการประเมินระดับการทำลายของกระดูกบริเวณง่ามรากฟันกรามและให้ข้อมูลที่ละเอียดในการวางแผนการรักษาที่รุนแรง

Key Words: Cone-beam computed tomography, Molar furcation involvement, Treatment decision

คำสำคัญ: ภาพรังสีโคนบีมคอมพิวท์โทโมกราฟี สภาวะปริทันต์บริเวณง่ามรากฟันกราม การตัดสินใจวางแผนรักษา

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Introduction

Diagnosis and treatment of furcation-involved molar teeth has always been a challenge. Furcation involvement (FI) is defined as loss of periodontal bone support in the inter-radicular area of multi-rooted teeth. Presence of FI poses a risk of further periodontal attachment loss and it is considered an important parameter that worsens tooth prognosis (McGuire and Nunn, 1996). Molars with FI also respond less favorable to both non-surgical and surgical treatment (Kalkwarf et al., 1988, Nordland et al., 1987, Pihlstrom et al., 1984).

Periodontal examination is important for achieving accurate diagnosis, prognosis and treatment plan. For clinical assessment of furcation-involved molars, a Nabers probe is used to measure horizontal depth in furcation area. Radiographs are considered an important source of information, which complement the data obtained from the clinical examination. At present, intraoral radiography (IOR) including periapical and bitewing radiographs is commonly used because it is simple, relatively low-cost and low radiation dose (Mol, 2004). However, the major limitation is the two-dimensional nature of the images and anatomical structures may conceal the actual bone morphology in the inter-radicular area (Cattabriga et al., 2000).

Cone beam computed tomography (CBCT) is a new generation of CT that generates three-dimensional data at lower cost and lower absorbed doses than conventional CT. Moreover, CBCT provides high-resolution imaging with high diagnostic reliability (Hirsch et al., 2008). It has been shown that CBCT provides an accurate measurement and morphological description of periodontal bone defect (Mengel et al., 2005, Misch et al., 2006, Mol and Balasundaram, 2008, Noujeim et al., 2009, Vandenberghe et al., 2007). Regarding furcation assessment, degree of FI evaluated by CBCT and intra-surgical finding was compared (Qiao et al., 2014, Walter et al., 2010). The result showed that 82.4-84% of CBCT data was confirmed by the intra-surgical finding. In addition, CBCT can provide additional information for making a more definite surgical decision, especially in buccal and lingual defect (Noujeim et al., 2009). This superior information may justify the use of CBCT in diagnosis and treatment planning of furcation-involved molar teeth. At present, the evidence for the benefit of CBCT in furcation diagnosis and treatment planning is still limited. Therefore, the aim of this study is to compare the use of CBCT and IOR for diagnosis and treatment planning of furcation-involved molar teeth.

Objectives of the study

1. To compare IOR and CBCT assessment of furcation involved-molars.
2. To compare IOR and CBCT assessment for treatment planning of furcation involved molars.

Methodology

Study subjects

The study group comprised of 25 consecutive patients who attended the Graduate Periodontology Clinic and met the following inclusion criteria: 1) had moderate to advanced chronic periodontitis, 2) had at least 14 remaining teeth, and 3) had at least one molar with radiographic sign of furcation bone loss on an intraoral radiograph. The subjects were excluded if they were pregnant at the time of the study or had medical conditions that did not allow conventional periodontal treatment. The informed consents were given.

Clinical examination

All subjects received full mouth periodontal examination and periodontal chart were recorded. Probing depth (PD) and clinical attachment level (CAL) were recorded at 6 sites/ tooth, using a UNC-15 probe (Hu-Friedy, Chicago, Illinois, USA). Degree of FI was determined using a Nabers probe and classified using a modified Glickman's classification (Glickman, 1978) as followed: F0-intact furcation; F1-incipient lesion, detectable with probe tip, no furcation bone loss; F2-partially enter the furcation with probe, but not completely through and through; F3-through and through furcation bone loss. Tooth mobility was evaluated using two blunt instruments and classified according to the Miller's index (Miller, 1938).

IOR and CBCT acquisition

All subjects received full-mouth periapical radiographs and vertical bitewings of posterior teeth. The radiographs were obtained using a parallel long cone technique. The radiographs were taken with an intra-oral radiograph machine (Kodak 2200 intraoral X-ray system, Eastman Kodak Co, Rochester, New York, USA) at 70 kV, 7 mA, using F speed, sized 2 films (Kodak Insight, Carestream Dental LLC, Altanta, USA). The automatic film processor (Dent-X 810 plus, ImageWorks Co, New York, USA) was used for the film processing. Each intraoral radiograph was digitally converted on flatbed scanner with transparency adapter (Expression 10000XL, Epson, USA) at 600 dpi, saved as a JPEG, and put into a PowerPoint file to facilitate the evaluation process.

CBCT was performed using 3DX Accuitomo 170 machine (J. Morita, Kyoto, Japan). Cylindrical volumes of 100x100 mm, 85 kV, 5 mA, and voxel sizes of 0.25 mm were used. The 3D images were displayed with One Volume Viewer software (J. Morita, Kyoto, Japan). The CBCT images of each subject were evaluated in multi-planar reconstruction mode (buccal, lingual, and oblique view) and 3D volume rendering mode (3D view) using real time sculpting function.

Determination of FI by IOR and CBCT

For IOR, FI was classified as absence-no furcation bone loss (equivalent to F0 and F1) or presence-had furcation bone loss (equivalent to F2 and F3). For maxillary molars, three furcation sites on buccal (B), mesial (M), and distal (D) were individually assessed. For mandibular molars, B and lingual (L) furcations were evaluated together, due to the superimposition of both furcations. For CBCT, the degree of FI were classified as followed: absence (F0 and F1), F2, and F3.

Treatment decision for molar furcation

Treatment decision was determined based on clinical and radiographic data. The treatment was categorized as nonsurgical treatment, surgical treatment or extraction. Surgical treatment included open flap debridement, regeneration, and root resection. In general, non-surgical treatment was selected for molars with F0, F1, or PD <5 mm at furcation. Surgical treatment was selected for molars with F2, F3, or PD ≥5 mm at furcation. Extraction was selected for molars with F3 or inadequate attachment to support the tooth (Al-Shammari et al., 2001).

Furcation assessment

Furcation assessment, including degree of FI and treatment decision was given by three periodontists. The radiographic images were displayed on a 22-inch LCD monitor (ThinkVision L2250p, Lenovo, Quarry Ba, Hong Kong). The digitized intraoral radiographs were put into a PowerPoint presentation to facilitate viewing. Each PowerPoint slide contained the periapical and bitewing radiographic images of one tooth sextant. One operator, trained by an experienced radiologist used the One Volume Viewer software (J. Morita, Kyoto, Japan) to show the CBCT image of each tooth in the coronal, sagittal, and transversal views to the examiners. All examiners viewed the radiographic image together. First, the examiners were asked to determine the degree of FI from the radiographic data only. Then, the clinical data was given and the examiners made the treatment decision. Each examiner gave his/her periodontal assessment independently. An agreement of at least 2 out 3 examiners was considered as consensus. An agreement of 3 out 3 examiners was considered as a complete agreement. When each examiner gave a different assessment, a discussion was required to reach consensus. There was no time restriction for image viewing and assessment. All examiners were blinded to the identity of the study subjects. IOR of each subject was evaluated at least one week prior to CBCT image evaluation.

Statistic analysis

Commercially available statistical software (SPSS, IBM Corp, New York, USA) was used to analyze the data. The concordance of furcation assessment between IOR and CBCT were calculated. The inter-examiner agreement of furcation assessment was analyzed using Fleiss' kappa (Fleiss, 1971).

Table 1 Distribution of FI assessed by IOR and CBCT and concordance between IOR and CBCT on the presence or absence of furcation bone loss

		IOR		CBCT			Concordance* (%)	Under-estimation† (%)	Over-estimation‡ (%)
		Absence (F0/1)	Presence (F2/3)	Absence (F0/1)	Presence F2	Presence F3			
Upper	B	65.4	34.6	64.2	19.8	16.0	84.0	8.6	7.4
	M	65.4	34.6	53.1	21.0	25.9	75.3	18.5	6.2
	D	44.4	55.6	46.9	25.9	27.2	72.8	12.3	14.8
	All	58.4	41.6	54.7	22.2	23.1	77.3	13.2	9.5
Lower	B	-	-	70.1	14.9	14.9	-	-	-
	L	-	-	60.9	24.1	14.9	-	-	-
	All	62.1	37.9	65.5	19.5	15.0	80.5	14.9	4.6

*The assessment by intraoral radiographs agreed with CBCT.

†The assessment by intraoral radiographs was underestimated compared to CBCT.

‡The assessment by intraoral radiographs was overestimated compared to CBCT.

Results

Twenty-five subjects with an average age of 48.84 years old (34-75 years) participated in the study. Of 192 molars, 24 teeth with fused root were excluded. A total of 168 molars were included in the analysis (81 upper and 87 lower molars).

The distribution of FI assessed by IOR and CBCT is shown in Table 1. The proportion of furcations of furcation with no bone loss (F0/F1) assessed by IOR and CBCT was quite similar. CBCT was able to differentiate the degree of furcation bone loss into F2 and F3 as well as discriminate buccal and lingual furcation bone loss of lower molars. The concordance for the absence or presence of furcation bone loss between IOR and CBCT ranged from 72.8-84.0%.

Table 2 Concordance between IOR and CBCT on furcation treatment

	IOR		CBCT		Concordance
	N	%	N	%	(%)
Non-surgical	103	61.3	92	54.8	94.6
Surgical	36	21.4	44	26.2	56.8
Extraction	29	17.3	32	19.0	71.9

The treatment decision assessed by IOR and CBCT was also compared (Table 2). The concordance was excellent for non-surgical treatment (94%) whereas it was low for surgical treatment (56.8%). Of 44 teeth planned for surgical treatment by CBCT, 14 teeth (31.8%) were planned for non-surgical treatment and 5 teeth (11.4%) were planned for extraction by IOR. Conversely, 7 of 36 teeth (19.4%) planned for surgical treatment by IOR was planned for extraction by CBCT (Table 3).

Table 3 Furcation treatment assessed by IOR and CBCT

		CBCT		
		Non-surgical	Surgical	Extraction
IOR	Non-surgical	87	14	2
	Surgical	4	25	7
	Extraction	1	5	23

The percentage of complete agreement and the inter- examiner agreement of furcation diagnosis and treatment decision is shown in Table 4. Overall, the percentage of complete agreement and inter-examiner agreement of CBCT was excellent and higher than IOR.

Table 4 Complete agreement and inter-examiner agreement of furcation assessment

			Complete agreement		Inter-examiner agreement[*]	
			IOR[†]	CBCT[‡]	IOR	CBCT
Furcation diagnosis	Upper molar	B	81.5	92.6	0.73	0.91
		M	71.6	97.5	0.59	0.97
		D	85.2	97.5	0.80	0.97
	Lower molar	B-L	96.3	-	0.86	-
		B	-	96.6	-	0.90
		L	-	93.1	-	0.96
Treatment	Upper		86.4	90.1	0.86	0.90
	Lower		86.2	94.3	0.79	0.93
	All		86.3	92.3	0.85	0.92

[*] Fleiss' kappa

[†] FI classified as absence (F0/F1) or presence (F2/F3)

[‡] FI classified as F0/F1, F2, F3

Discussion

IOR has been generally accepted for evaluating the periodontal bone support (Mol, 2004). Clinical examination together with IOR is important for furcation diagnosis and treatment planning. CBCT has been shown to provide accurate measurement of periodontal bone morphology when compared to direct measurement from cadaver specimens (Fuhrmann et al., 1997) and intra-surgical measurement (Qiao et al., 2014, Walter et al., 2010). Therefore, the assessment by CBCT was used as a reference to which IOR was compared in this study.

The present study showed that the concordance between IOR and CBCT on the furcation diagnosis was fair to good (72.8-84.0%). There was no clear trend toward underestimation or overestimation. The treatment decision in this study was classified as non-surgical, surgical and extraction. We did not classify types of surgical treatment because of small sample size in each type of surgical treatment. IOR and CBCT had excellent concordance for non-surgical treatment (94.6%), but poor concordance for surgical treatment (56.8%). We also found that approximately 20% of the teeth planned for surgical treatment by IOR were considered for extraction by CBCT. This means that by using information from IOR, one-fifth of the teeth were planned for surgical treatment while they should actually be extracted if more detailed information from CBCT was available. This was in accordance with Walter 2009 (Walter et al., 2009). The study showed that clinical examination and IOR-based approach was insufficient to make a surgical treatment decision, which resulted in discrepancies of treatment recommendation in 59-82% of the teeth comparing to clinical examination and CBCT-based treatment approach.

Regarding the examiner's agreement, both IOR and CBCT showed high agreement for both complete agreement and inter-examiner agreement. However, CBCT agreement was higher than IOR for all furcation diagnosis and furcation treatment. It should be noted that agreement of IOR was based on the presence/absence of FI, which is cruder than that of CBCT. Excellent agreement among examiners using CBCT suggested that CBCT is a good tool for evaluation of FI and treatment.

It is obvious that CBCT provide superior information over IOR, however there are some limitations. First of all, CBCT interpretation requires more time and skill to use the software than IOR. Second of all, the metal artifact, which occur when the teeth has metal restorations, may interfere with the viewing of the bone level in volume rendering mode. This artifact can be adjusted, but at the expense of thin bone crest and may result in overestimation of periodontal bone destruction. The most important limitation is the radiation dose. The new generation of CBCT provides a relatively low radiation dose. However, the dose depends mainly on the size of field of view (FOV); dose increases with larger FOV used. Therefore, selecting the appropriate FOV is recommended to reduce the radiation dose as much as possible (Pauwels et al., 2012).

In conclusion, we showed that IOR might not provide adequate information for identifying the degree of FI, which in turn result in inaccurate treatment decision for furcation involved molars. Therefore, CBCT images may give more detailed information that facilitates precise diagnosis and treatment planning especially in complicated furcation defects.

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