


Comparative Measurement of Tooth Length: Actual vs. Orthopantomography and CBCT-Based Measurements

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Abstract

Objective: To compare the reliability of cone beam computed tomography (CBCT) in assessing the tooth length in comparison to orthopantomography (OPG). **Material and Methods:** Forty patients scheduled for extraction as result of caries or periodontal involvements were randomly selected. Panoramic radiographs and CBCT images were obtained and subsequently patients were subjected for extraction. Teeth with poor prognosis were extracted and stored in 10% formalin. Radiographic teeth measurements were carried out on OPG and CBCT images using a software and the actual tooth length (A-L) measurements were carried out with a digital vernier caliper. The data collected were statistically analyzed for paired “t” test significance of differences and Pearson’s correlation at 5% level of confidence. **Results:** There was significant difference comparing all three actual tooth length (A-L) and CBCT- and OPG-measured tooth lengths. A significant positive correlation was observed among all the measurements. **Conclusion:** CBCT images exhibited accuracy over panoramic images even though the measurements are still significantly different from actual anatomical tooth lengths.

Keywords: Cone-Beam Computed Tomography; Radiography, Panoramic; Tooth.

Introduction

A radiographic examination is an essential part of the diagnostic process in dentistry and it is also known that tooth length plays an important role in many branches of dentistry. Radiographic tooth length is useful in evaluating the orthodontic treatment effects such as root resorption, development and anchorage. Endodontically, it helps in assessing the working length. In prosthetics it helps in making better judgment about the selection of abutment and in periodontics it helps in comparing tooth length or root length and alveolar crestal levels [1-3]. Several methods of determining tooth length exists [2], but most preferred way of determining the root canal length is by radiographs mainly by the intraoral periapical radiography and orthopantomography. The major advantages of the orthopantomography (OPG) include less radiation exposure, decreased patient chair time, minimal operator time, better patient co-operation, and added benefit of visualizing of entire lower half of the face [4].

Although panoramic radiography is often used in diagnosis, a full mouth examination consisting of 14 or more periapical radiographs is performed occasionally as periapical radiographs are considered to be of higher image quality [5]. As a single panoramic film can provide same data with less radiation exposure OPG replaced periapical radiographs.

OPG images known to have some shortcomings like magnification, unsharpness, distortion, etc., and the CBCT images are to be free from these disadvantages. Therefore, this study was carried out to assess the reliability of cone beam computed tomography (CBCT) in assessing the tooth length in comparison to orthopantomography (OPG).

Material and Methods

Sample

Forty patients who were scheduled for extraction as a result of caries or periodontal involvement were selected randomly. Sixty-one extracted maxillary and mandibular posterior teeth were analyzed. Patients who were having tooth which were indicated for extraction, provided the tooth structure is sound, were included in the study. Patients having medical conditions, which are contraindications for extraction like thyrotoxicosis, patients with immediate post radiation therapy and those undergoing extraction of grossly destructed tooth were excluded from the study. Teeth with metallic restoration and severe attrition of the crown were not included in this study.

Data Collection

Panoramic imaging was carried out by Cranex (Soredex, Tuusula, Finland), the measurements were carried out on these images using the accompanying software by marking a highest point on the crown and lowest point on the root apex. The CBCT scans were obtained by Scanora 3D (Soredex, Tuusula, Finland) with 6 mA and 89 kVp and the evaluation of the scans were carried out with the accompanying software. The CBCT images were obtained at a field of view (FOV) of 5 × 8 cm and each tooth was individually localized in the multiplanar reconstruction view

in axial, coronal and sagittal planes and the tooth lengths were recorded on each respective section in the sagittal plane. The images were optimized by adjusting contrast and brightness with the aid of processing tool for better viewing. The extracted teeth were stored in 10% formalin and the actual tooth size was determined with a digital vernier caliper.

Statistical Analysis

The findings were statistically analyzed and compared in relation to accuracy and reliability of tooth measurements using Pearson's correlation and paired t test. A statistical significance was set at 5% level of significance ($p < 0.05$).

Ethical Aspects

Clearance was obtained from the institutional Ethical Committee (# 8-20-3/40) and all the patients were voluntarily participated in the study.

Results

The mean, standard deviation and standard error values of tooth length measurements by actual length, CBCT length and OPG length are presented in the Table 1.

Table 1. Mean and median values of tooth length measurements by Actual, CBCT and OPG.

Teeth	Methods	Mean	Median	SD	SE
Mandibular Molars	Actual Value	19.16	19.20	2.12	0.42
	CBCT	18.44	18.99	2.37	0.47
	OPG	21.31	21.10	1.97	0.39
Mandibular Premolars	Actual Value	21.88	22.19	2.50	0.69
	CBCT	20.67	20.23	2.35	0.65
	OPG	23.44	23.65	2.68	0.74
Maxillary Premolars	Actual Value	17.32	16.58	2.93	0.78
	CBCT	15.16	14.50	2.97	0.79
	OPG	22.62	22.56	1.89	0.51
Maxillary Molars-Palatal	Actual Value	19.28	19.63	1.89	0.41
	CBCT	16.92	17.10	1.85	0.40
	OPG	22.19	22.90	2.02	0.44
Maxillary Molars-Buccal	Actual Value	18.51	18.65	1.47	0.32
	CBCT	16.83	16.90	1.48	0.32
	OPG	21.87	22.89	2.23	0.49

SD: Standard Deviation; SE: Standard Error.

A significant difference was observed between actual length and CBCT length ($t=7.6662$, $p=0.0001$), actual length and OPG length ($t=-10.3680$, $p=0.0001$); CBCT and OPG length measurement ($t=-11.7234$, $p=0.0001$) of mandibular molar.

A significant and positive correlation was observed between actual length and CBCT length ($r=0.9840$, $p=0.0001$), actual length and OPG length ($r=0.8734$, $p=0.0001$), CBCT length and OPG length ($r=0.8556$, $p=0.0001$) of mandibular molar. It signified that actual length, CBCT length of mandibular molar was highly correlated and dependent on each other, but CBCT and OPG length

are less correlated. However, a significant and positive correlation was observed between actual length and CBCT length ($r=0.8641$, $p<0.05$), actual length and OPG length ($r=0.9777$, $p<0.05$), CBCT length and OPG length ($r=0.7627$, $p<0.05$) of mandibular premolar. It implied that actual length, CBCT length and OPG lengths of mandibular premolar were dependent on each other.

Table 2. Co-relation and paired teeth test of mandibular tooth length measurements.

Teeth	Methods	Mean	SD	Mean Diff.	SD Diff.	Paired t	p-value	Pearson r
Mandibular Molar	Actual Length	19.16	2.12					
	CBCT Length	18.44	2.37	0.72	0.47	7.6662	0.0001*	0.9840*
	Actual Length	19.16	2.12					
	OPG Length	21.31	1.97	-2.15	1.04	-10.3680	0.0001*	0.8734*
	CBCT Length	18.44	2.37					
Mandibular Premolar	Actual Length	21.88	2.50					
	CBCT Length	20.67	2.35	1.21	1.27	3.4239	0.0050*	0.8641*
	Actual Length	21.88	2.50					
	OPG Length	23.44	2.68	-1.56	0.57	-9.7604	0.0001*	0.9777*
	CBCT Length	20.67	2.35					
	OPG Length	23.44	2.68	-2.77	1.76	-5.6637	0.0001*	0.7627*

*Statistically Significant.

A significant difference was observed between actual length and CBCT length ($t=9.8904$, $p=0.0001$), actual length and OPG length ($t=-5.4694$, $p=0.0001$); CBCT and OPG length measurement ($t=-7.6911$, $p=0.0001$) of maxillary premolars. A significant difference was observed between actual length and CBCT length ($t=14.9440$, $p=0.0001$), actual length and OPG length ($t=-9.2081$, $p=0.0001$); CBCT and OPG length measurement ($t=-13.7037$, $p=0.0001$) of maxillary molars- palatal.

A significant difference was observed between actual length and CBCT length ($t=10.1097$, $p=0.0001$), actual length and OPG length ($t=-10.2822$, $p=0.0001$); CBCT and OPG length measurement ($t=-11.6468$, $p=0.0001$) of maxillary molars- buccal.

A significant and positive correlation was observed between actual length and CBCT length ($r=0.9620$, $p<0.05$), actual length and OPG length ($r=0.7863$, $p<0.05$) and CBCT length and OPG length ($r=0.6783$, $p<0.05$) of maxillary premolar. This revealed that, actual length, CBCT length and OPG lengths of maxillary premolar were dependent on each other.

However, a significant and positive correlation was observed between actual length and CBCT length ($r=0.9257$, $p<0.05$), actual length and OPG length ($r=0.7278$, $p<0.05$), CBCT length and OPG length ($r=0.5887$, $p<0.05$) of maxillary molars- palatal. It implied that, actual length, CBCT length and OPG lengths of maxillary molars- palatal were dependent on each other.

Similarly, a significant and positive correlation was observed between actual length and CBCT length ($r=0.8660$, $p<0.05$), actual length and OPG length ($r=0.7463$, $p<0.05$), CBCT length and OPG length ($r=0.4888$, $p<0.05$) of maxillary molars- buccal. It implied that, actual length, CBCT length and OPG lengths of maxillary molars- buccal were dependent on each other. But a

significant and moderate positive correlation was observed between CBCT length and OPG lengths of maxillary molars - palatal and buccal sides.

Table 3. Co-relation and paired t test of maxillary tooth length measurements.

Teeth	Methods	Mean	SD	Mean Diff.	SD Diff.	Paired t	p-value	Pearson r
Maxillary Premolar	Actual Length	17.32	2.93					
	CBCT Length	15.16	2.97	2.15	0.81	9.8904	0.0001*	0.9620*
	Actual Length	17.32	2.93					
	OPG Length	22.62	1.89	-5.30	3.63	-5.4694	0.0001*	0.7863*
Maxillary Molars-Palatal	Actual Length	19.28	1.89					
	CBCT Length	16.92	1.85	2.36	0.72	14.9440	0.0001*	0.9257*
	Actual Length	19.28	1.89					
	OPG Length	22.19	2.02	-2.91	1.45	-9.2081	0.0001*	0.7278*
Maxillary Molars-Buccal	Actual Length	18.51	1.47					
	CBCT Length	16.83	1.48	1.68	0.76	10.1097	0.0001*	0.8660*
	Actual Length	18.51	1.47					
	OPG Length	21.87	2.23	-3.36	1.50	-10.2822	0.0001*	0.7463*
	CBCT Length	16.83	1.48					
	OPG Length	21.87	2.23	-5.04	1.98	-1.6468	0.0001*	0.4888*

*Statistically Significant.

Discussion

The reliability of radiographic estimation of the tooth length has always been of concern to a dentist. The objective of this study was to assess the reliability of tooth length determination by OPG and CBCT in a clinically relevant manner. By selecting teeth scheduled for extraction a benefit of confidently measuring the actual tooth length was obtained. Anterior teeth were excluded from this initial phase of study because in an OPG image the anterior teeth are more susceptible to be distorted, unsharp and unclear representation. Despite of its limitations, OPG is replacing full mouth IOPA's as a preoperative screening radiograph and it is widely available and economical than CBCT [6].

Studies were carried out in literature to know the reliability of OPG for the other applications other than measurement of tooth length. A previous research compared panoramic and intra-oral radiographs for to assess the alveolar bone levels in a periodontal maintenance population and found that the OPG measurements may, at any rate to some extent, substitute for full-mouth periapical radiographic assessment [7]. Another study investigated the reliability of periapical radiographs and orthopantomograms to determine the tooth root protrusion in the maxillary sinus by associating the outcomes with CBCT and found that that both the methods were not reliable to identify the exact correlation between the apex of tooth root and the floor of maxillary antrum. Periapical radiographs were slightly more dependable than panoramic radiographs in identifying this relationship [8].

CBCT is a latest imaging technique that has been regarded as a dependable diagnostic modality in recent dental practice as it overcomes numerous shortcomings of conventional radiographic techniques by giving precise details [9-13]. Images with good resolution and lack of superimposition are some of the additional benefits of CBCT imaging [14-18].

Different results exist in the literature regarding the accuracy of the measurements obtained from CBCT images [19]. Few studies report the underestimations of the measurements, and some claim proposed that the measurements match the actual measurements [20]. Previous, a study was carried out to know the accuracy of CBCT in measuring the tooth lengths of only single rooted premolar teeth [21], hence in the present study the molar teeth length were analyzed.

In the present study, in comparison with actual lengths, OPG lengths were relatively inaccurate, overestimating by 12.11% and 7.67% in mandibular molars and premolars followed by maxillary premolars (37.91%) and for maxillary molar-palatal (17.79%) and maxillary molar-buccal (20.16%) measurements. The CBCT images underestimated the lengths by 2.31% in mandibular premolars but overestimated the lengths in mandibular molar (3.93%), maxillary premolars (5.51%) and for maxillary molar-palatal (7.48 %) and maxillary molar-buccal (4.29%) measurements. It has been observed that CBCT underestimated tooth length by 1.2% and panoramic radiographs underestimated tooth length by an average of 3.9% [21]. A previous study demonstrated that tooth lengths were 29% overestimated on OPG images overestimated the tooth and underestimated by 4% on CBCT panoramic reconstructed images [2]. These differences may be due to different CBCT device used and the difference in the methodology. Some researchers carried out an in-vitro comparative study by using NewTom Giano Extra-Oral CBCT Imaging System and KODAK 8000C Digital Panoramic and Cephalometric device [21]. A previous study used 12-bit i-CAT CBCT imaging system and the conventional panoramic radiographs with an Instrumentarium Orthopantomograph OP100 which were later digitized and evaluated [2].

In the present study, even though the tooth length measured from CBCT images showed a statistically significant difference from actual tooth lengths, these images provided improved clarity and accuracy compared to the measurements obtained from conventional panoramic images.

Conclusion

CBCT images exhibited accuracy over panoramic images even though the measurements are still significantly different from actual anatomical tooth lengths.

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Conflict of Interest: The authors declare no conflicts of interest.

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