ОРИГИНАЛЬНАЯ СТАТЬЯ

COMPARISON OF ORTHOPANTOMOGRAPHY AND CONE-BEAM COMPUTED TOMOGRAPHY DATA IN ENDODONTICALLY TREATED TEETH

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Diagnosis, treatment plan and evaluation of endodontic treatment are done with the help of radiographs. Radiographic imaging is essentially two-dimensional imaging of a three-dimensional structure.

The purpose. of this research was to evaluate and compare the accuracy of linear measurement of gutta percha in teeth with root canal treatment and periapical area in both orthopantomography and cone-beam computed tomography (CBCT).

Materials and methods. In this retrospective study, the collected sample consisted of 90 endodontically treated teeth; fifty teeth had single canal, 12 teeth with two canals, and 28 teeth with three canals. All images were randomly chosen from patient who visited the clinic of radiology, seeking different dental treatment. Each patient had orthopantomography and CBCT at the same time. Each image separately was evaluated by two examiners. The operator analyzed the linear measurement of each tooth with root canal treatment and periapical area in both orthopantomography and CBCT. The CBCT was evaluated in two cross sections with 0.5 mm thickness. The CBCT is evaluated with the corresponding orthopantomography. All the images were collected from the same device (SORDEX, CRANEX 3D) and analyzed by On Demand 3D software by using cross section view for CBCT and SCANORA software for image.

Results. It is notable that lesions on CBCT have higher values in comparison to OPTG but the standard deviation is approximately similar. Gutta percha on CBCT also had higher negative values and higher standard deviation than on OPTG. When the recorded values were compared between OPTG and CBCT with regard to lesions and gutta percha, a significant statistical difference was found for the lesions (P value of 0.000), while gutta percha showed a P value of 0.056. Lesions on CBCT had a higher value than on OPTG. Interestingly, comparisons between CBCT and OPTG for both BC and PC showed only one significant difference which is between CBCT and OPTG values for gutta percha of PC (P = 0.02) as CBCT values were negatively higher than on OPTG. Comparisons between the three canals with regard to CBCT and OPTG values yielded two significant differences. The first is related to MC canal with regard to gutta percha (P = 0.017) as higher negative values were noted on CBCT than OPTG. The second difference is related to DC canal also for gutta percha (P = 0.016) with higher negative values for CBCT. Comparisons for the three canals with regard to CBCT and OPTG showed three significant differences. The first is with regard to lesions of ML canal (P = 0.025) with lesions on CBCT having higher values than on OPTG. The second significant difference is in gutta percha of MB canals (P = 0.002) with higher negative values on CBCT than on OPTG. The last significant difference is in gutta percha of ML canal (P = 0.004) with higher negative values on CBCT than on OPTG.

Conclusion. CBCT scanning has been shown to be more accurate than digital radiographs in identifying the accuracy of linear measurements of periapical lesions and the length of gutta perch root canal fillings. The results of the present study showed the CBCT method has a higher diagnostic informative value in comparison with orthopantomography in the evaluation of teeth after endodontic treatment.

Keywords: endodontic, gutta percha, CBCT, orthopantomography, cone-beam computed tomography.

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For citation: Ban Mohammed Jasim, Majida K. Al-Hashimi, Resha Jameel Abdulsaheb. Compari-

son of orthopantomography and cone-beam computed tomography data in endodontically treated teeth. REJR 2023; 13(4):16-25. DOI: 10.21569/2222-7415-2023-13-4-16-25.

Received: **05.09.23** **Accepted:** **30.10.23**

СРАВНЕНИЕ ДАННЫХ ОРТОПАНТОМОГРАФИИ И КОНУСНО-ЛУЧЕВОЙ КОМПЬЮТЕРНОЙ ТОМОГРАФИИ ПРИ ОБСЛЕДОВАНИИ ЗУБОВ ПОСЛЕ ЭНДОДОНТИЧЕСКОГО ЛЕЧЕНИЯ

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Диагностика, план лечения и оценка эффективности эндодонтического лечения проводятся с помощью рентгенограмм. Рентгенограмма – это, по существу, двумерное изображение трехмерной структуры.

Цель исследования. Оценить и сравнить точность линейного измерения гуттаперчи в зубах при лечении корневых каналов и периапикальной области как при ортопантомографии (ОПТГ), так и при конусно-лучевой компьютерной томографии (КЛКТ).

Материалы и методы. В данном ретроспективном исследовании выборка состояла из 90 эндодонтически обработанных зубов; 50 зубов имели один канал, 12 зубов – с двумя каналами и 28 зубов – с тремя каналами. Все изображения были случайным образом отобраны из базы данных пациентов, которые обратились в клинику лучевой диагностики за различным стоматологическим лечением. Каждому пациенту одновременно выполняли ортопантомографию и КЛКТ. Каждое изображение в отдельности оценивалось двумя экспертами. Оператор анализировал линейные размеры каждого зуба при лечении корневых каналов и периапикальной области как при ортопантомографии, так и при КЛКТ. КЛКТ оценивали на двух поперечных срезах толщиной 0,5 мм, после выполнения соответствующей ортопантомографии. Все изображения были взяты из одного и того же устройства (SORDEX, CRANEX 3D) и проанализированы с помощью программного обеспечения On Demand 3D с использованием поперечного сечения для КЛКТ и программного обеспечения SCANORA для визуализации.

Результаты. Примечательно, что повреждения при КЛКТ имеют более высокие значения по сравнению с ОПТГ, но стандартное отклонение примерно такое же. Гуттаперча на КЛКТ также имела более высокие отрицательные значения и более высокое стандартное отклонение, чем на ОПТГ. Когда зарегистрированные значения сравнивались между ОПТГ и КЛКТ в отношении поражений и гуттаперчи была обнаружена значительная статистическая разница для поражений (P=0,000), в то время как гуттаперча показала P=0,056. Поражения при КЛКТ имели более высокое значение, чем при ОПТГ. Интересно, что сравнения между КЛКТ и ОПТГ как для BC, так и для PC показали только одно значимое различие, которое заключается в значениях КЛКТ и ОПТГ для гуттаперчи ПК (P = 0,02), поскольку значения КЛКТ были отрицательно выше, чем при ОПТГ. Сравнения между тремя каналами в отношении значений КЛКТ и ОПТГ выявили два существенных различия. Первый связан с каналом MC в отношении гуттаперчи (P=0,017), поскольку при КЛКТ были отмечены более высокие отрицательные значения, чем при ОПТГ. Второе различие связано с каналом DC также для гуттаперчи (P=0,016) с более высокими отрицательными значениями для КЛКТ. Сравнения для трех каналов в отношении КЛКТ и ОПТГ показали три существенных различия. Первое относится к поражениям ML канала (P = 0,025), причем поражения при КЛКТ имеют более высокие значения, чем при ОПТГ. Второе значимое различие заключается в гуттаперче каналов MB (P = 0,002) с более высокими отрицательными значениями при КЛКТ, чем при ОПТГ. Последнее значимое различие заключается в гуттаперче ML канала (P = 0,004) с более высокими отрицательными значениями при КЛКТ, чем при ОПТГ.

Вывод. Было показано, что КЛКТ-сканирование является более точным, чем цифровые рентгенограммы при определении точности линейных измерений периапикальных поражений и длины пломбирования корневых каналов гуттаперчевыми материалами. Результаты настоящего исследования показали, что метод КЛКТ обладает более высокой диагностической информативностью по сравнению с ортопантомографией при оценке состояния зубов после эндодонтического лечения.

Ключевые слова: эндодонтия, гуттаперча, КЛКТ, ортопантомография, конусно-лучевая компьютерная томография.

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Для цитирования: Бен Мохаммед Джасим, Маджида К. Аль-Хашими, Реша Джамиль Абдул Сахиб. Сравнение данных ортопантомографии и конусно-лучевой компьютерной томографии при обследовании зубов после эндодонтического лечения. REJR 2023; 13(4):16-25. DOI: 10.21569/2222-7415-2023-13-4-16-25.

Статья получена: **05.09.23** **Статья принята:** **30.10.23**

Introduction.

Diagnosis, treatment plan, and evaluation of endodontic treatment are done with the help of radiographs. Radiographic imaging is essentially two-dimensional imaging of a three-dimensional structure. The interpretation of radiographs may be influenced by several many factors, such as regional anatomy and superimposition of different structures which are also subjected to geometric distortions [1]. Such problems can be solved by the use of 3D imaging using computed tomography (CT) [2-4]. The application of CT scans in endodontics was first reported by Tachibana and Matsumoto [5]. Many studies concluded that CBCT is a desirable imaging tool for providing important information for the diagnosis and management of certain endodontic problems [6, 7]. 2D radiographic imaging: two-dimensional intraoral radiography is popularly used 2D imaging techniques for dental examinations and treatments.

During the intraoral radiography, the x-ray film is placed inside the patient's mouth which is used to have the clinical view (Periapical, Bite-wing, or Occlusal). This technique has many disadvantages such as the limited view of the dentition, radiography procedures; also many patients may experience some discomfort during the procedure [8-10]. In addition these disadvantages may include the possibility of cross-contamination due to the intraoral sensor placement; and a long time needed for full mouth series imaging [11].

2D radiographic imaging has important problems in medical examinations due to the overlapping of the complex osseous structures [12]. Using this technique, it is impossible to detect the root fractures unless the beam of the x-ray passes through the fracture line. It is very important to accurately diagnose the problem, to deicide the correct treatment plan. Two-dimensional radiographs are unable to reveal the three-dimensional complications which may result in incorrect diagnosis and poor prognosis [13].

CBCT imaging (Cone Beam Computed Tomography) is a low radiation 3D imaging which produces better images than that produced by the traditional 2D radiographs [14]. CBCT imaging decreases the radiation exposure and achieving high-quality 3D images, therefore; it is becoming more popular in dentistry [11, 15]. Kobayashi et al. reported that CBCT imaging revealed that the limited volume CBCT could measure distances more accurately [6]. Their experiment on cadaver mandibles showed that CBCT is a useful tool for preoperative evaluation in dental surgery since the small field of the images limits the exposure to radiation [6].

In a study conducted by Lascala et al. the accuracy of linear measurement was analyzed using dry skulls. Then the measurements obtained by CBCT were compared with digital calipers and the results were statistically similar to the original measurements thus, therefore; making it superior for the dental examinations and prognosis [16].

The purpose of this research was to eval-

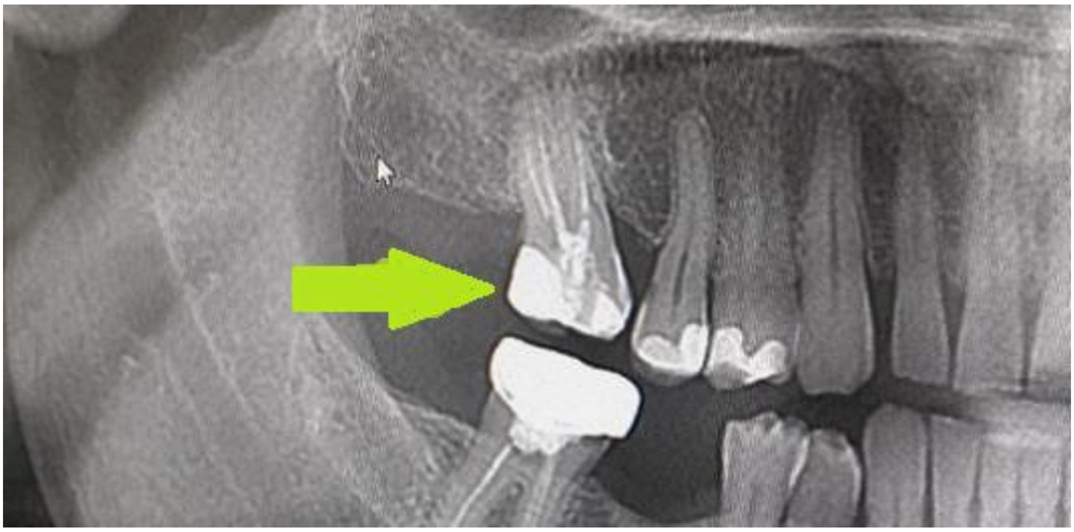

Fig. 1 (Рис. 1)

Fig. 1. Plain X-ray panoramic image.

Upper right 2nd molar with RCT all the 3 roots, with short gutta burcha with no periapical lesion.

Рис. 1. Ортопантомограмма.

Верхний правый 2-й моляр после эндодонтического лечения каналов (RCT) всех трех корней, с короткой гуттаперчей без изменений в периапикальной области.

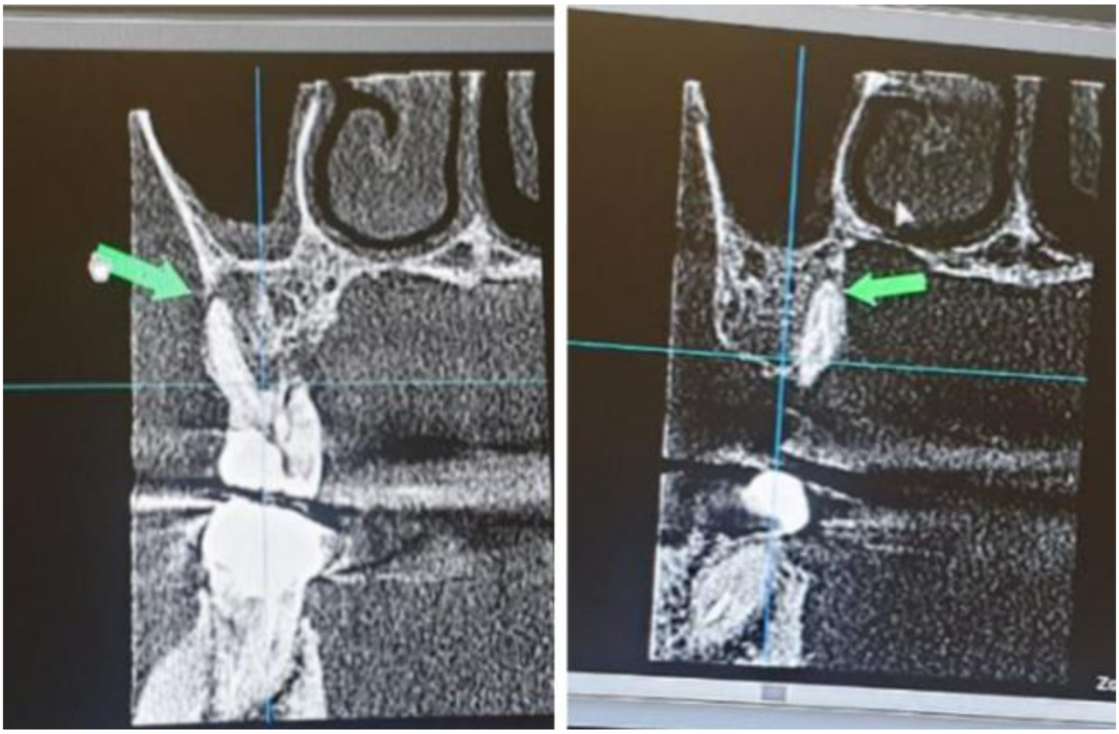

Fig. 2 (Рис. 2)

Fig. 2. CBCT, cross-sectional view.

Mesial root of upper right 2 with short gutta burcha and periapical lesion. The periapical changes in palatal root of the same tooth.

Рис. 2. КЛКТ, кросс-секция.

Мезиальный канал щечно-мезиального корня с короткой гуттаперчей и периапикальными изменениями. Периапикальные изменения небного корня того же зуба.

uate and compare the accuracy of linear measurement of gutta percha in teeth with root canal treatment and periapical area in both orthopantomography and CBCT.

Methods.

In this retrospective study, the collected sample consisted of 90 endodontically treated teeth; fifty teeth had single canal, 12 teeth with two canals, and 28 teeth with three canals. All images were randomly chosen from patient who visited the clinic of radiology, seeking different dental treatment. Each patient had orthopantomography and cone-beam computed tomography (CBCT) at the same time (fig. 1, 2, 3).

The sample was selected according to the following selective criteria:

1. Good image quality.
2. Both the orthopantomography and CBCT were taken for the same patient.
3. The evaluated teeth had root canal treatment.

Each image separately was evaluated by two examiners. The operator analyzed the linear measurement of each tooth with root canal treatment and periapical area in both orthopantomography and CBCT. The CBCT was evaluated in two cross sections with 0.5 mm thickness. The CBCT is evaluated with the corresponding orthopantomography. The detected teeth with root canal treatment and periapical area were evaluated regarding the:

1. Under or over extended gutta percha.
2. Non-treated canal.
3. Fractured root.
4. Resorbed root.

All the images were collected from the same device (SORDEX, CRANEX 3D) and analyzed by On Demand 3D software by using cross section view for CBCT and SCANORA software for image.

Results.

Descriptive results: a total of 90 teeth were included in the analysis. The means, medians and standard deviations for lesions and gutta percha linear values are shown in Tables 1, 2, 3, and 4.

It is notable that lesions on CBCT have higher values in comparison to OPTG but the standard deviation is approximately similar. Gutta percha on CBCT also had higher nega-

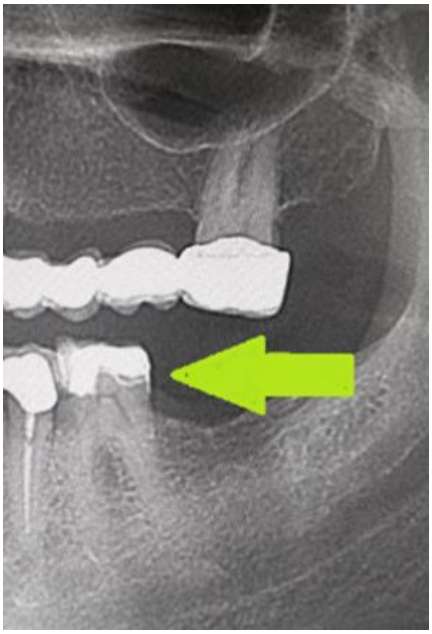

Fig. 3 a (Рис. 3 а)

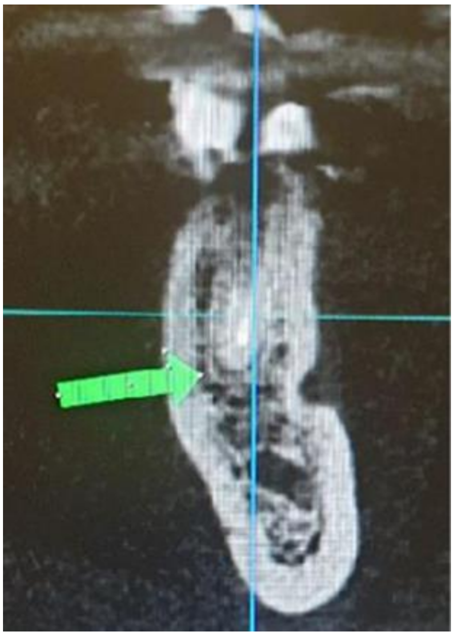

Fig. 3 b (Рис. 3 б)

Fig. 3. Panoramic view (a). CBCT (b).

a – RCT for lower left 2nd premolar with sufficient length of gutta percha

b – short gutta percha and thickening of lamina dura with PDL space widening.

Рис. 3. Ортопантомограмма (а). КЛКТ (б).

а –ортодонтическое лечение (RCT) канала корня 2-го нижнего премоляра слева с достаточной длиной гуттаперчи

б – короткая гуттаперча и утолщение твердой пластинки с расширением пространства пародонтальной связки (PDL).

Table №1. Descriptive statistics results of single canal teeth.

	Mean	SD	Median
Lesion (OPTG)	0.3800	0.49031	0.0000
Lesion (CBCT)	0.7000	0.46291	1.0000
Gutta percha (OPTG)	-0.6600	1.67344	0.0000
Gutta percha (CBCT)	-0.9500	2.33730	-0.6000

OPTG; orthopantomography, CBCT; cone-beam computed tomography

Table №2. Descriptive statistical results of two canaled teeth.

	Mean	SD	Median
Lesion of buccal canal (OPTG)	0.3333	0.49237	0.0000
Lesion of palatal canal (OPTG)	0.3333	0.49237	0.0000
Gutta percha of buccal canal (OPTG)	-0.0833	0.79296	0.0000
Gutta percha of palatal canal (OPTG)	-0.1667	0.83485	0.0000
Lesion of buccal canal (CBCT)	0.1667	0.38925	0.0000
Lesion of palatal canal (CBCT)	0.5000	0.52223	0.5000
Gutta percha of buccal canal (CBCT)	-0.2500	1.13818	0.0000
Gutta percha of palatal canal (CBCT)	-1.3333	1.68325	-1.7500

OPTG; orthopantomography, CBCT; cone-beam computed tomography, SD; standard deviation

Fig. 4 (Рис. 4)

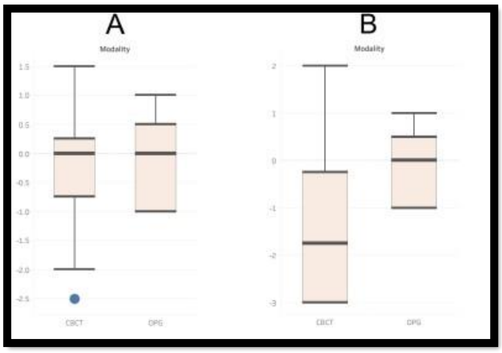

Fig. 5 (Рис. 5)

Fig. 4. Diagram.

Boxplot for single canal teeth comparing between CBCT and OPTG with regard to gutta percha.

Рис. 4. Диаграмма.

Графические изображения для зубов с одним каналом, сравнивающие КЛКТ и ОПТГ в отношении гуттаперчи.

Fig. 5. Diagram.

Boxplots of gutta percha for both BC (Pane A) and PC (Pane B) comparing between CBCT and OPTG.

Рис. 5. Диаграмма.

Графические изображения гуттаперчи как для BC (панель A), так и для PC (панель B), сравнивающие КЛКТ и ОПТГ.

tive values and higher standard deviation than on OPTG.

Inferential results.

Single canals. When the recorded values were compared between OPTG and CBCT with regard to lesions and gutta percha, a significant statistical difference was found for the lesions (P= 0.000), while gutta percha showed a P value of 0.056. Lesions on CBCT had a higher value than on OPTG (Table 1, Fig.4).

Two canals (BC and PC). Interestingly, comparisons between CBCT and OPTG for both BC and PC showed only one significant difference which is between CBCT and OPTG values for gutta percha of PC (P = 0.02) as CBCT values were negatively higher than on OPTG (Ta-

Table №3. Descriptive statistics results for three canaled (MC, DC, PC) teeth.

	Mean	SD	Median
Lesion of MC (OPTG)	0.4545	0.52223	0.0000
Lesion of DC (OPTG)	0.4545	0.52223	0.0000
Lesion of PC (OPTG)	0.4545	0.52223	0.0000
Gutta percha of MC (OPTG)	-0.2727	1.10371	0.0000
Gutta percha of DC (OPTG)	-0.3636	1.02691	0.0000
Gutta percha of PC (OPTG)	-0.2273	0.98396	-0.5000
Lesion of MC (CBCT)	0.0909	1.13618	0.0000
Lesion of DC (CBCT)	0.1818	0.87386	0.0000
Lesion of PC (CBCT)	1.0909	1.37510	1.0000
Gutta percha of MC (CBCT)	-1.5636	1.57307	-1.0000
Gutta percha of DC (CBCT)	-1.7273	1.61808	-2.0000
Gutta percha of PC (CBCT)	-0.5455	2.21872	-1.0000

OPTG; orthopantomography, CBCT; cone-beam computed tomography, SD; standard deviation

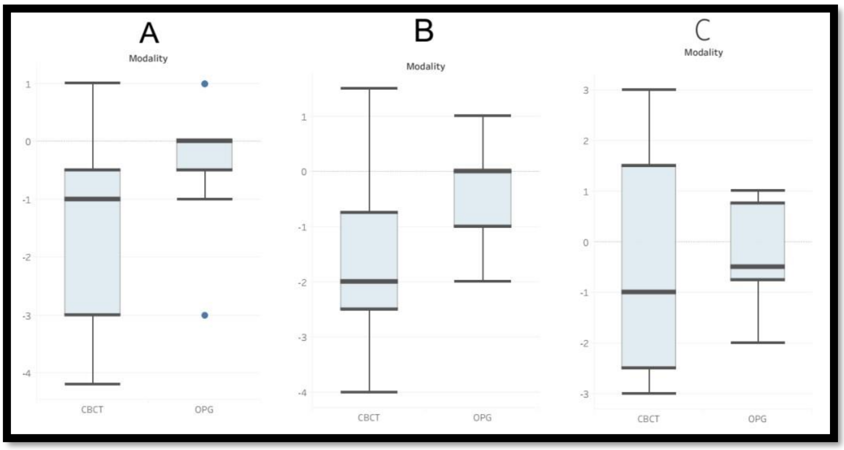

Fig. 6 (Рис. 6)

Fig. 6. Diagram. Boxplots for three canals (MC, DC, PC) teeth comparing between CBCT and OPTG.

a – pane is for MC, b – pane is for DC, c – pane is for PC.

Рис. 6. Диаграмма. Графические изображения для трех каналов (MC, DC, PC), сравнивающие результаты КЛКТ и ОПТГ.

а – панель для MC, б – панель для DC, в – панель для PC.

ble №2, fig.5). Other comparisons were non-significant (P > 0.05).

Three canals (MC, DC, and PC). Comparisons between the three canals with regard to CBCT and OPTG values yielded two significant differences. The first is related to MC canal with regard to gutta percha (P = 0.017) as higher negative values were noted on CBCT than OPTG. The second difference is related to DC canal also for gutta percha (P = 0.016) with higher negative values for CBCT (Table 3, Fig.6). Other comparisons with regard to lesions or gutta percha were non-significant (P > 0.05).

Three canals (MB, ML, and DC). Comparisons for the three canals with regard to CBCT

Table №4. Descriptive statistical results for three canaled (MB, ML, DC) teeth.

	Mean	SD	Median
Lesion of MB (OPTG)	0.3529	0.49259	0.0000
Lesion of ML (OPTG)	0.3529	0.49259	0.0000
Lesion of DC (OPTG)	0.3529	0.49259	0.0000
Gutta percha of MB (OPTG)	-0.8235	1.13111	0.0000
Gutta percha of ML (OPTG)	-0.8824	1.79869	0.0000
Gutta percha of DC (OPTG)	0.3529	1.32009	0.0000
Lesion of MB (CBCT)	0.4706	0.51450	0.0000
Lesion of ML (CBCT)	0.6471	0.49259	1.0000
Lesion of DC (CBCT)	0.3529	0.49259	0.0000
Gutta percha of MB (CBCT)	-1.7941	1.75943	-1.0000
Gutta percha of ML (CBCT)	-1.7059	1.98478	-1.0000
Gutta percha of DC (CBCT)	0.1471	1.63712	-0.5000

OPTG; orthopantomography, CBCT; cone-beam computed tomography, SD; standard deviation

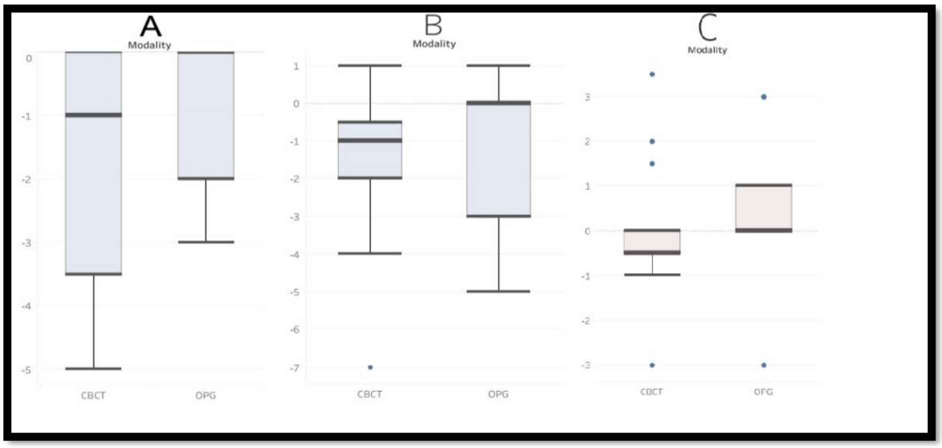

Fig. 7 (Рис. 7)

Fig. 7. Diagram. Boxplots for three canals (MB, ML, DC) teeth comparing between CBCT and OPTG.

a – pane is for MB, b – pane is for ML, c – pane is for DC.

Рис. 7. Диаграмма. Графические изображения для трех каналов (MB, ML, DC), сравнивающие результаты КЛКТ и ОПТГ.

а – панель для MB, б – панель для ML, в – панель для DC.

and OPTG showed three significant differences. The first is with regard to lesions of ML canal (P = 0.025) with lesions on CBCT having higher values than on OPTG. The second significant difference is in gutta percha of MB canals (P = 0.002) with higher negative values on CBCT than on OPTG. The last significant difference is in gutta percha of ML canal (P = 0.004) with higher negative values on CBCT than on OPTG (Table 4, Fig.7). Other comparisons for lesions and gutta percha with regard to CBCT and OPTG were non-significant (P > 0.05).

Discussion.

Successful endodontic therapy depends on thorough canal debridement and effective filling of the root canal system, for which knowledge of the morphology of root canals is critical [17]. The methods commonly used for analyzing the root canal morphology are conventional radiographs, digital and contrast medium-enhanced radiographic techniques, and more recently, CT techniques [18-21]. An ideal technique would be one that is accurate, simple, non-destructive.

Two-dimensional intraoral and cone-beam CT (CBCT) radiography are at present the most commonly used imaging techniques for dental examinations. The objectives of this research were to evaluate and compare linear accuracy of the applications of the traditional two-dimensional intraoral radiography and CBCT in endodontics. CBCT scan may be an important role in the analysis of root canal anatomy, detection of apical lesions, and extension of the length of gutta percha final filling. Cone-beam CT (CBCT) has been used in endodontic research to study the root canal anatomy and its variations.

CBCT scanning uses an extraoral imaging scanner to produce 3D scans with a considerably lower radiation dose than that required for two-dimensional intraoral radiography. CBCT scanning has been shown to be more accurate than digital radiographs in identifying the accuracy of linear measurements of periapical lesions and the length of gutta perch root canal fillings [22].

During intraoral radiography, the image receptor is placed inside the patient's mouth, which is used to achieve the clinical view. With the offering limited view of the dentition, there are many other disadvantages of such radiography procedures. These include the likelihood of cross-contamination due to intraoral sensor placement.

The results of the present study showed that the CBCT method has a higher diagnostic information value in comparison with orthopantomography in the evaluation of teeth after endodontic treatment [16].

In the single canals the recorded values between OPTG and CBCT a significant statistical difference was found for the lesions (P = 0.000), while gutta percha showed a P value of 0.056. Lesions on CBCT had a higher value than on OPTG. It means that CBCT images gave correct three-dimensional representations of the linear measurements. While comparisons between CBCT and OPTG for BC and PC in two canaled teeth showed only one significant difference, which is between CBCT and OPTG values for gutta percha of PC as CBCT values were negatively higher than on OPTG.

Three canals (MC, DC, and PC), comparisons between the three canals with regard to CBCT and OPTG values yielded two significant differences. The first is related to MC canal with regard to gutta percha as higher negative values were noted on CBCT than OPTG. The second difference is related to DC canal also for gutta percha with higher negative values for CBCT. Three canals (MB, ML, and DC). The result showed three significant differences. The first regarding lesions of ML canal on CBCT scored higher values than on OPTG. The second significant difference is in gutta percha of MB canals with higher negative values on CBCT than on OPTG. The last significant difference is in gutta percha of ML canal with higher negative values on CBCT than on OPTG. Other comparisons for lesions and gutta percha with regard to CBCT and OPTG were non-significant. These documented finding may be very important in the future prognosis of the endodontic treatments.

Conclusion.

CBCT scanning has been shown to be more accurate than digital radiographs in identifying the accuracy of linear measurements of periapical lesions and the length of gutta perch root canal fillings. The CBCT method has a higher diagnostic informative value in comparison with orthopantomography in the evaluation of teeth after endodontic treatment.

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