ASSESSMENT OF POSSIBLE EFFECT OF DIAGNOSTIC RADIATION (CBCT) ON ORAL HEALTH

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ABSTRACT

Background: Ionizing Radiation (IR) at high doses has a well-known risk factor, whether low and moderate doses (defined, respectively, as ≤ 100 mGy and 100 to 2000 mGy) for photon radiation, can also induce such detrimental effects is under debate.

Objectives: This study aimed to investigate the possible positive aspect of exposure to diagnostic ionizing radiation on oral health parameters.

Methodology: This study was performed to investigate the possible positive effect of diagnostic dental cone beam computed tomography on the oral health. This study was conducted on fifty adult patients suffering from gingival inflammation. The patient clinical oral condition was examined before and after exposure to radiation, salivary pH was examined before and after performing the radiographic examination.

Results: From the current study there is no health hazard, nor positive changes related to the use of conventional diagnostic Cone-Beam Computed Tomography (CBCT). That could be attributed to the low dose of new digital radiographic machines, and the extremely short exposure time. The change in acidity to alkalinity of seven cases could be related to change of salivary consistency after radiation. In the present study, there were no changes to the low dose radiation of the CBCT.

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Conclusion: Monitoring human individuals exposed to low-dose low dose of radiation is important but will not provide enough information about its possible Hormesis effects.
Recommendation: Further studies need to be done in order to examine the cumulative effect of radiation as well as long term effect of digital diagnostic CBCT on oral health.
Key words: Cone-Beam Computed Tomography, positive effect, oral health.

INTRODUCTION

In the past several years, the use of 3D CBCT has steadily increased in oral and maxillofacial surgery and implant dentistry compared with the medical CT technology. The greatest advantage of CBCT imaging is that it allows the surgeon to obtain the same vital 3 dimensions (3D) anatomic information without exposing the patient to high level of ionizing radiation (Cox and Ang, 2010).

Ionizing radiation is a widely accepted form of treatment for various types of cancer. Organ systems are more tolerant to low dose radiation exposure over a long period of time, as used in fractionated radiotherapy, compared with high local radiation exposure or total body irradiation and Ionizing Radiation (IR) at high doses have a well-known risk factor, whether low and moderate doses (defined, respectively, as ≤ 100 mGy and 100 to 2000 mGy) for photon radiation, can also induce such detrimental effects is under debate (Cox and Ang, 2010; Berry III and López-Martínez, 2020).

In order to study and compare radiation doses of different radiation, the effective dose of radiation exposure is utilized and measured in milisieverts (mSv)/ microsieverts (µSv). The effective dose is calculated by multiplying the absorbed organ dose with a weighting factor for a specific tissue or organ. The tissue/organ weighting factor depends on several factors, such as the type and sensitivity of the irradiated tissue and is provided and updated by the International Commission on Radiological Protection (ICPR) (The 2007 Recommendations of the International Commission on Radiological Protection. ICRP publication).

A panoramic radiograph may be associated with less effective dose than dental CBCT depending on the type of the machine and clinical protocol used. The size and distance from the object play important role on the estimated effects. The thyroid and salivary glands have higher effective dose of about 30% than adults (Theodorakou *et al*., 2012). Due to the increased radio sensitivity of children, the risks of harmful health effects are an additional 2 to 5 times higher compared to adults (Brenner *et al.,* 2001).

CBCT has applications in nearly all aspects of dentistry, CBCT may have higher sensitivity for the detection of periapical pathology (Muller and Meineke, 2011). Cone beam machines produce radiation in the form of a large cone covering the patient's facial area head surface to be examined. It uses a two-dimensional detector instead of the linear array of detectors as in the computed tomography machines. Cone beam irradiates a large volume area instead of a thin line. It rotates once giving all the information necessary to reconstruct the Region of Interest (ROI). This technique allows to obtain 2D reconstructed images in all planes, and reconstructions in 3 dimensions with low level exposure to x-radiation (Sanders, 2017).

During a CBCT scan, x-rays may pass through various organs in addition to the area of interest in the patient face. X-rays may also be scattered off bony hard strictures like bone metallic restorations, plates and screws and also from different parts of the machine. Dose from CBCT scans can vary with field of view, desired image resolution, x-ray beam energy, filtration, exposure time, receptor technology, and human factors, including patient size and age (Kaludercic *et al*., 2018). Patient radiation effective doses resulting from CBCT examinations are greater compared to conventional dental imaging procedures where patient doses range from 18.5 to 1073 μSv per procedure based on the Field of View (FOV) and imaging protocol (Kaludercic et al., 2018; Scott and Di Plama, 2018).

It is widely accepted that high-dose radiation is carcinogenic. However, some researchers postulated that law dose of radiation could be harmless and even have a positive effect. Routine diagnostic X-rays (e.g., chest X-rays, mammograms, computed tomography scans) and routine diagnostic nuclear medicine procedures using sparsely ionizing radiation forms (e.g., beta and gamma radiations) stimulate the removal of precancerous neo-plastically transformed and other gnomically unstable cells from the body (medical

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radiation hormesis). The indicated radiation hormesis arises because radiation doses above an individual-specific stochastic threshold activate a system of cooperative protective processes that include high-fidelity DNA repair/apoptosis (presumed p53 related), an auxiliary apoptosis process (PAM process) that is presumed p53-independent, and stimulated immunity. These forms of induced protection are called adapted protection because they are associated with the radiation adaptive response (Scarfe and Farman, 2008).

Therefore, the main objective of this study is to investigate: the possible positive aspect of exposure to diagnostic ionizing radiation on oral health.

METHODOLOGY

Patients and Methods: 50 patients were involved in this study. They were aged between 18 and 55 years. They were selected from the Oral and Maxillofacial Surgery Department clinics of the Faculty of Dentistry, Ain Shams university in the period started from May 2018 to May 2020. They were subjected to ionizing radiation (CBCT) as diagnostic tool for various oral pathological conditions.

Inclusion Criteria: 50 adult participants were included in the study, suffering from gingivitis, and periodontal pathological condition.

Exclusion Criteria: Patients below 12 years and those with a medical condition that is manifested on their gingival and oral conditions, such as

Diabetes and autoimmune diseases. Patients who received radiotherapy were not included in this study.

Ethical Consideration: Prior to data collection, informed verbal consents were obtained from all participants included in the study after providing comprehensive information about the nature of the study.

Statistical Analysis:

- The data were collected, cleaned, filtered, coded and entered into the Microsoft Office, Excel Program (2010).
- SPSS statistics (Statistical Package for Social Sciences; version 12, 2004 program) was used for data entry and analysis.
- Data were analyzed and presented using tables and graphs. Descriptive data, frequency and percentage (mean ± SD) were used for analyzed statistics. A probability value (p-value) less than or equal to ($p \leq 0.05$) was considered significant. A $p \leq 0.01$ was considered highly significant.

To check for the subjective symptoms, patient questionnaire was filled by the patients to detect the various personal hygienic and pathological complaints.

- Itchy gum
- Swelling or redness of the gum
- Presence of bad odor from the mouth (Halitosis)
- Sensitivity when drinking cold water

I-Clinical examination, gingival, and periodontal checklist:

- Pocket depths
- Width of keratinized tissue
- Gingival recession
- Attachment level
- Bleeding on probing
- Presence of inflammation

II-pH measurement of the saliva:

Saliva collection:

Occur in two stages:

Before exposure to CBCT.

After exposure to CBCT.

Patients were instructed to wait at least 2 hours after eating. They had to fill their mouth with saliva and then swallow it. The patients were instructed to repeat this again to help ensure that the saliva is clean. After that patients were asked to put some saliva to a pH paper. After few seconds the pH paper stops changing color. When the pH paper turns blue, this indicates that the patient's saliva is alkaline which means that pH is above7.4. On the other hand, when the pH paper turns red, this indicates that the patient's saliva is acidic which means that pH is below 7.0.

RESULTS

50 patients were involved in this study. They were aged between 18 and 55 years and suffered from gingival problems ranging from halitosis, swelling, redness, itch, and pain while drinking cold water.

Clinical examination of the patient's gingival tissue was done before CBCT and then at the end of the ionizing radiation examination. Saliva were collected for pH determination before CBCT examination and then after. The clinical examination included propping pocket depths with periodontal probe, the average depth was recorded of 2-3 mm, width of keratinized tissue was measured of an average of 3 mm. Gingival recession was found in 5 patients mostly at the lower anterior region. Bleeding from their gums with probing was found in all patients. Pus was found at the gingival pocket depth in two patients. These findings were not changed before CBCT examination nor after performing the test.

The signs and symptoms of gingival inflammation of the patients includes: swollen gums in 28 patients (table 1), bleeding gums or bleeding after brushing and/or flossing in 37 patients, Gums that are tender or painful to the touch in 35 patients, Bad breath (Halitosis) in 12 patients (table 2). These findings were not changed before and after radiation exposure.

Table (1) bleeding gum before and after radiation exposure showing no changes regarding that condition

Bleeding Gums	Time				Chi-Square	
	Before Radiation		After Radiation			
	N	%	N	%	χ^2	P-value
Yes	37	74.00	37	74.00	0.000	1.000
No	13	26.00	13	26.00		
Total	50	100.00	50	100.00		

Table (2): Halitosis before and after radiation exposure showing no changes regarding that condition

Halitosis	Time				Chi-Square	
	Before Radiation		After Radiation			
	N	%	N	%	χ^2	P-value
Yes	12	24.00	12	24.00	0.000	1.000
No	38	76.00	38	76.00		
Total	50	100.00	50	100.00		

pH assessment of the saliva occurred in two stages: before and after exposure to CBCT. The pH of saliva of the patients included in the study were slightly alkaline. These findings were constant before or after radiation of CBCT. In 23 patients the salivary pH was acidic before exposure then after exposure, the salivary pH of 7 patients changed from acidic to alkaline (table3).

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Table (3): Salivary pH before and after exposure to radiation, showing significant increase in alkalinity and acidity after radiation exposure

pH	Time				Chi-Square	
	Before Radiation		After Radiation			
	N	%	N	%	χ^2	P-value
Acidic	23	46.00	16	32.00	2.060	0.151
Alkaline	27	54.00	34	68.00		
Total	50	100.00	50	100.00		

DISCUSSION

Changes caused by ionizing radiation have been scientifically documented. Radiation injury involves morphological and functional changes that occur in noncancerous or ‘‘normal’’ tissue as a direct result of ionizing radiation (Ludlow et al., 2015). Radiation can penetrate several centimeters into the skin, whereas g-radiation can penetrate through the skin and into the human body (Radiation UNSCO,2000).

The degree of radiation injury is related to the total radiation dose, proportion of body irradiated, volume of tissues irradiated, and the time interval of the radiation dose received over a long period of time (Benderitter et al., 2007; Jargin, 2015).

In the present study, there were no changes observed to the low dose radiation of the CBCT, regarding the changes in acinar cell secretion of the salivary gland, nor the gross appearance of the oral mucosa, this result comes in agreement with (Hall and Giaccia, 2006).

Higher doses of radiation could lead to degranulation of mast cells in the dermis. Mast cell–derived histamine, serotonin, tumor necrosis factor-a, and tryptase significantly alter the release of CCL8, CCL13, CXCL4, and CXCL6 by dermal fibroblasts (Radiation UNESCO, 2000).

Oxidative stress is generated at the time of radiation exposure, as well as days after irradiation, because of the propagation of free radicals (Benderitter *et al.,* 2007). In the present study there was no obvious changes in regards to the gingival mucosa pocket depth, swelling, and bleeding with propping.

Ionizing radiation injuries involve imbalances in antioxidant status and redox control of wound healing (Benderitter et al., 2007; Jargin, 2015). The immediate damage caused by ionizing radiation is a result of strong and in the same time transient production of reactive oxygen radicals (National Research Council of the National Academies, 2006). However, inflammatory cell recruitment and cytokine generation also lead to chronic generation of reactive oxygen species. Specific genes that have been implicated in oxidative stress following radiation exposures (Mendelsohn *et al.,* 2002).

Occupational exposure to low doses increases the frequency of micro nucleated cells in the oral epithelia of medical personnel that raise the alarm of cancer changing potentialities. Healthcare professionals who deal daily with IRs should observe radioprotection procedures, using all available protective equipment (Gudkov and Komarova, 2010).

The potential hormetic effects are of particular importance for the aerospace health and safety, where exposures to ionizing radiation is unavoidable, it should be estimated to be not harmful, even law dose of it could be beneficial. Hormesis is a biphasic dose response: low doses exert protective effects while higher doses are detrimental (Radiation UNSCEAR, 2000; Jargin, 2015). Questions about the amount of patient exposure dose in diagnostic dental CBCT examination remain an important issue. The increased usage of CBCT technology in dental and maxillofacial examinations has led to concern about radiation exposure. Moreover, the smaller body size of children infers a further potential increase in risk than that of adults because the adjacent organs receive larger doses of the scatter radiation (Vassileva and Stoyanov, 2010). Hormetic responses to therapeutics as compared to radiation hormesis should be briefly commented. Microorganisms may develop hormetic responses to antibiotics by a positive selection of resistant strains. All clinically significant effects, hormetic or not, should be tested according to the principles of evidence-based medicine (Hall and Giaccia, 2006). According to the Biologic Effects of Ionizing Radiation

Report, radiation has been demonstrated to increase the risk of diseases other than cancer, particularly cardiovascular disease, in patients exposed to high therapeutic doses. However, there is no direct evidence of increased risk of non-cancer diseases at low doses (Naitoh *et al.*, 2010). According to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (2006), existing evidence is not sufficient to establish a causal relationship between ionizing radiation and cardiovascular disease at doses ≤1–2 Gy.

Although workers in medical radiation were exposed predominantly to gamma rays, they have very rare premalignant having a relatively high penetration distance, so that the portion of energy absorbed by the skin must have very law incidence of pre malignant skin lesions and actinic keratoses (Azizova *et al.*, 2018). This in agreement with the current study, is no health hazard, nor positive changes related to the use of conventional diagnostic CBCT. That could be attributed to the low dose of new digital radiographic machines and the extremely short exposure time. The change in acidity to alkalinity of seven cases could be related to increase of salivary flow after radiation and decrease in stress of the procedure.

CBCT has been developed to replace the traditional panoramic and lateral cephalometric radiographs taken for Dental diagnosis and treatment planning. From a radiation-protection point of view, the effective dose is lower for the conventional radiographs than for CT. The effects of low-dose ionizing radiation from the medical imaging, like dental CBCT, are difficult to observe. Reports by the United Nations Scientific Committee on the Effects of Atomic Radiation argue that there is no evidence for hormesis in humans (Pow et al., 2003).

Very few published dosimetry data are available only for few of the CBCT machines. There is a need of studies regarding irradiation dose optimization that consider patient factors, image quality and acceptable dose levels in controlled settings (Yeh and Chen**,** 2018).

CONCLUSIONS

Monitoring human individuals exposed to low-dose low dose of radiation is important but will not provide enough information about its possible Hormesis effects. A well-organized large-scale animal experiments will be more beneficial. Low-dose exposures were reported to extend the lifespan of mice and some invertebrates. This study could not be applied to humans (Benderitter et al., 2007). In the present study, there were no changes observed to the low dose radiation of the CBCT. The cumulative effect of radiation to the patients could be examined in further research, as well as long term effect of digital diagnostic CBCT oral health.

A good alternative for such study in humans would be large-scale animal experiments where life span duration is known to be a sensitive endpoint attributable to radiation exposures, which could not be tested in humans. In well-organized animal study, low-dose exposures were reported to extend the lifespan of mice and some invertebrates (Benderitter et al., 2007). One of hot topics of study is to clarify in vivo, whether relevant doses cause an increase in cell death. The monitoring of populations exposed to low-dose low-rate radiation is important but will hardly add much reliable information on the health risks (Sergei, 2020).

From this study the time interval of the radiation dose received over a long period of time is needed to be investigated in future studies. Larger sample size and multicenter studies are recommended to study possible positive effect of single Digital CBCT images on oral health. This includes the cumulative effect of several CBCT on oral mucosa. It can be reasonably assumed that the screening, increased attention of exposed people to their health, and biased research will result in new reports on the elevated detection rate of cancer and other diseases in exposed populations. (Colceriu-Şimon *et al.,* 2019).

From this study, it is recommended to examine the delayed action of the diagnostic CBCT after several hours or days, as well as the effect of Diagnostic CBCT on normal flora and pathogenic microorganisms.

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تقييم التأثير العلاجي الإيجابي المحتمل للأشعة التشخيصية على صحة الفم

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المستخلص

المقدمة: الإشعاع المؤين (IR) عند الجرعات العالية له عامل خطر معروف جيدا، سواء كانت الجرعات المنخفضة والمتوسطة (المحددة، على التوالي، على أنها ≤ ١٠٠ mGy و١٠٠ إلى ٢٠٠٠ mGy) لإشعاع الفوتون، يمكن أن تحفز أيضا مثل هذه الآثار الضارة قيد المناقشة.

الأهداف: هدفت هذه الدراسة إلى التحقيق في الجانب الإيجابي المحتمل للتعرض للإشعاع المؤين التشخيصي على معلمات صحة الفم.

المنهجية: أجريت هذه الدراسة للتحقيق في التأثير الإيجابي المحتمل للتصوير المقطعي المحوسب بشعاع مخروط الأسنان التشخيصي على صحة الفم. أجريت هذه الدراسة على خمسين مريضا بالغا يعانون من التهاب اللثة. تم فحص الحالة الفموية السريرية للمريض قبل وبعد التعرض للإشعاع، وتم فحص درجة الحموضة اللعابية قبل وبعد إجراء الفحص الشعاعي.

النتائج: من الدراسة الحالية لا يوجد أي خطر على الصحة، ولا تغييرات إيجابية تتعلق باستخدام التصوير المقطعي المحوسب المخروطي التقليدي (CBCT). ويمكن أن يعزى ذلك إلى انخفاض جرعة آلات التصوير الشعاعي الرقمية الجديدة، ووقت التعرض القصير للغاية. يمكن أن يكون التغير في الحموضة إلى القلوية لسبع حالات مرتبطا بتغيير اتساق اللعاب بعد الإشعاع. في هذه الدراسة، لم تكن هناك تغييرات في الجرعة المنخفضة من الإشعاع من CBCT.

الملخص: إن مراقبة الأفراد البشريين المعرضين لجرعة منخفضة من الإشعاع أمر مهم ولكنه لن يوفر معلومات كافية حول آثاره المحتملة على هورميسيس.

التوصيات: هناك حاجة إلى إجراء مزيد من الدراسات من أجل فحص، يمكن دراسة التأثير التراكمي للإشعاع في مزيد من الأبحاث، وكذلك التأثير طويل الأجل للتشخيص الرقمي CBCT على صحة الفم.

الكلمات المفتاحية: التصوير المقطعي المحوسب بالأشعة المخروطية، التأثير الإيجابي، صحة الفم