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Parotid-Absorbed Doses: A Comparison Between Spiral Tomography and Panoramic

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Abstract

Background: Jaws spiral tomography and panoramic radiography have wide applications in dentistry, and the parotid gland is one of the most sensitive organs of the head and neck.

Objectives: The aim of this study was to evaluate and compare the parotid-absorbed dose in spiral tomography and panoramic radiographs using a thermoluminescent dosimeter.

Materials and Methods: A radiation analog dosimetry phantom was placed in a Cranex Tome radiograph device, and a parotid absorbed dose was measured in both techniques. Thermoluminescent dosimeters were placed bilaterally in the parotid region (on the tube side and the opposite side). Spiral tomography dosimetry was done for the upper and lower jaws in the anterior and posterior regions. Each region contained four slices of 2 mm and four slices of 4 mm in thickness. The results were analyzed by a Wilcoxon test.

Results: For the tube side parotid, the average absorbed doses in spiral tomography of the anterior and posterior parts of the maxilla and mandible, with the 2 mm slice thickness, were 1.70/1.40 and 1.65/1.60 mGy, respectively. The average absorbed doses with the 4mm slices were 1.65/1.70 and 1.75/1.57 mGy, respectively. For the opposite parotid, the average absorbed dose in spiral tomography of the anterior and posterior parts of the maxilla and mandible, with the 2 mm slice thickness, were 1.40/1.30 and 1.40/1.67 mGy, respectively. The average absorbed doses with the 4mm slices were 1.50/1.66 and 1.40/1.50 mGy, respectively. The average absorbed dose of the panoramic radiograph was 1.40 mGy.

Conclusions: There was no statistically significant difference in the parotid absorbed dose between spiral tomography and a panoramic radiograph (P value = 0.18). The overall results of this study were similar to other studies.

Keywords: Dosimetry, Panoramic Radiography, Spiral Tomography

1. Background

Dental radiography is one of the most popular diagnostic methods. Panoramic radiography is one of the most commonly used radiographs in dentistry, and can be used either alone or in combination with other radiographs. For example, it can be used before tomography as an image guide (1, 2).

Spiral tomography is another kind of X-ray technique which can be used to diagnose temporomandibular joint disease, to detect fractures, and to determine the location of dental implants, the buccolingual thickness of the bone, the bone quality, the position of important anatomical landmarks such as the mandibular canal and the mental foramen (3-6). Spiral tomography provides sharper images than other types of tomography, and superior to CT for patients with partially edentulous who just need to have a limited examination, because these patients' doses will be lower (7, 8).

There are concerns about the possible effects of X-rays used in diagnostic radiography. During panoramic radiography and tomography of the head, different structures are affected by the X-ray. The parotid gland is one of the most X-ray sensitive organs of the head and neck. Inflammation of the salivary glands is one side effect of X-rays, and can cause dry mouth, impaired nutrition, and tooth decay. Radiation is also one of the important physical stimuli that can cause cancer of the parotid. Studies have observed that the parotid is one of the high-risk areas for cancer in dental radiographs (1). Indeed, the greatest individual organ doses for any examination are in the salivary tissue (9). Some previous studies have measured the absorbed doses of the radiosensitive organs of the head and neck during imaging modalities (10-17).

2. Objectives

Given the wide application of panoramic radiography and spiral tomography in diagnosis and treatment, and the importance of biological effects of X-rays on the parotid glands, the objectives of this study are to determine and compare the parotid absorption dose during spiral tomography and panoramic radiography, using thermoluminescent dosimetry.

3. Materials and Methods

This is an experimental study, and the primary data collection method is observation. 36 lithium fluoride thermoluminescent dosimeter (TLD) chips (LiF: Mg, Ti made by Harshaw and known as TLD-100) were obtained from the cobalt center of Seyed Alshohada hospital. They were kept in special conditions during the transfer from the cobalt center to Isfahan University, under conditions with controlled atmospheric pressure, temperature, and humidity. A head and neck RANDO phantom (radiation analog dosimetry) was used for this study (Figure 1). The phantom was made of Plexiglas sheets, which are chosen in most studies as the material equivalent to soft tissue, with an effective atomic number of 6.8. Since bone and soft tissue are different in density, the phantom was filled with Teflon as a bone-equivalent material, to be more similar to the human body (18, 19).

Figure 1. the Head and Neck RANDO Phantom

Panoramic radiography and spiral tomography were done with a Cranex Tome (Soredex, Helsinki, Finland) radiograph device. The phantom was positioned in the radiograph device so that in all the sections the device marker was matched at the midline and lateral nose line (the canine area). All examinations were done at the same height. A rectangular collimator and a medium cassette (storage phosphor plate, Kodak Lanex, green screen, 15 $\times$ 30) were used. The X-ray was exposed from the right side. The settings of the spiral tomography were KVP = 70, Size = 5, MA = 12, and a 46-second exposure time. The settings of the panoramic radiograph were KVP = 70, Size = 5, MA = 10, and a 24-second exposure time. Before spiral tomography, a panoramic radiograph was taken to determine the precise location of the image slice using a tomography (Cranex Tome) ruler. A spiral tomography study was done for the upper and lower jaws in the anterior and posterior regions. Each region contained four slices of 2 mm and four slices of 4 mm in thickness (eight examinations). TLDs were numbered and randomly selected.

The position of dosimeters was chosen by comparing the phantom slices with the position of parotid glands in a cross-sectional anatomy atlas. A pair of TLDs was placed in the parotid region of the phantom, one of them on the right (tube side) and the other on the left (opposite side). After each exposure, the TLDs were read out by a Harshaw 5500 Series (Harshaw/Bicron, Solon, Ohio, USA). The examinations were repeated twice. The TLDs were in tablet form, with a diameter of 3.5 mm and a thickness of 1mm. Before each exposure, dosimeters were annealed at 300°C for 10 seconds, followed by rapid cooling to room temperature to remove the remaining signals on the detectors and eliminate the background dose. The TLDs were cleared of any contaminations such as dust and grease to avoid reading errors. Because TLDs are very sensitive, the chips were removed carefully with forceps to prevent bending and color changing, and they were kept in polyethylene sealed boxes under conditions that controlled atmospheric pressure, temperature, and humidity.

Next, the primary annealing calibration was done. To determine individual calibration factors, the TLDs were received 15 cGy by the cobalt-60 of the Seyed Alshohada hospital, and then were read out by a TLD reader so the individual calibration factors could be calculated. To determine the group calibration factors, the TLDs were divided into five groups. The first group stayed without exposure, while the second through fifth groups received 5 cGy, 10 cGy, 15 cGy, and 20 cGy respectively. Using an exposure method similar to the individual calibration factor determination procedure, the TLDs were read out. To check calibration accuracy, the TLDs were exposed to a special dose and then read out by the reader; the acceptable difference between the exposed dose and calculated absorbed dose should not be more than 5%.

The results were analyzed by a Wilcoxon test and the statistical package for social sciences (SPSS) (version 17, SPSS Inc., Chicago, IL).

4. Results

The results of the parotid-absorbed doses in mGy for spiral tomography are shown in Table 1.

According to Table 1, the maximum absorbed dose was related to the tube side parotid when the anterior part of the mandible with a slice thickness of 4 mm was exposed. The minimum absorbed dose was related to the opposite parotid, when the posterior part of the maxilla with a slice thickness of 2 mm was exposed. The result of the parotid absorbed dose during panoramic radiography was 1.42 mGy and 1.38 mGy for the right and left parotids, respectively.

The difference between the mean absorbed doses of the parotid in spiral tomography and panoramic radiography was not statistically significant (P = 0.18). The difference between the mean absorbed doses of the right and left parotid in panoramic radiography was also not statistically significant (P = 0.18). There were no statistically significant differences in pair wise comparison of the mean absorbed dose in each slice of spiral tomography between the right and left parotids (P = 0.18). Comparison of the mean absorbed dose of the parotid for each slice of spiral tomography with the same thickness in the anterior and posterior parts of the jaw showed no statistically significant difference (P = 0.18). Likewise, there were no statistically significant differences between the mean absorbed dose of the parotid in spiral tomography for the slice thickness of 2 mm compared to the 4 mm slice in the anterior vs. posterior parts of the jaw (P = 0.18). No statistically significant differences were found between the parotid mean absorbed dose of each slice of the anterior part of the mandible compared to the anterior part of the maxilla with same thickness (P = 0.18), and similar results were derived for the posterior parts of the maxilla and mandible

5. Discussion

According to the tables, the right side parotid had a higher absorbed dose in all examinations because it was nearer to the X-ray source, except for a 2 mm section in the posterior mandible which showed a higher absorbed dose than the opposite side. This might have happened because of some errors during the examination which were out of our control. There was no statistically significant difference between the absorbed dose of the right and left parotids in the panoramic examination because the tube rotates simultaneously with the detector in the panoramic technique. In the present study, there was no statistically significant difference between the parotid absorbed doses in the anterior and posterior sections of the spiral tomography examination in the maxilla and mandible, because in extra-oral radiography, the parotid is not positioned along the primary beam path and is thus mostly exposed to scattered radiation. The lack of statistically significant difference between the parotid absorbed dose of different sections in spiral tomography and panoramic technique probably resulted from the limited number of samples in this study.

In the study by Kasswbaum et al. (1992) the parotid mean absorbed dose in a panoramic radiograph was 1.46 mGy, which was similar to this study (7). Research by Talaeipour et al. (2007) showed a parotid absorbed dose increase by increasing the exposure parameters in panoramic radiography. The highest absorbed dose for the parotid glands was 800 μGy (70 KVp, 8 mA, 18 seconds) (17). Their results were different from ours because of a difference in the panoramic device and the higher exposure parameters which were chosen in this investigation. Ekestubbe (1999) measured the absorbed doses in patients undergoing computed tomography exams of the maxilla and the mandible. The salivary glands received absorbed doses up to 30 mGy and proved to be the most irradiated organsm (8). Lecomber et al. (2001) compared patient doses for dental implant planning using conventional radiography and computed tomography, and likewise found that the salivary glands were the most irradiated organs, with absorbed doses up to 30 mGy (9). Both results are higher than the spiral tomography findings of this study.

Zenobio et al. (2007) measured absorbed doses in patients who were undergoing tomographic exams (panoramic, spiral conventional, and/or helical computed tomography) as part of pre-surgery planning for dental implants (20). The results for the right and left parotid may be considered to be similar to those presented in this paper. Zenobio et al. (2012) observed maximum doses near the parotid glands at 1.57 mGy on the right and 1.89 mGy on the left in the panoramic exam, in a human study, and the maximum dose for spiral tomography was 4.41 mGy near the right and left parotid glands (15), which are very similar to our findings. Bou Serhal et al. (2001) used a Cranex TOME with different exposure factors, and each examination consisted of 4 slices with a 2 mm slice thickness. They showed that the parotid gland on the side near the X-ray tube received the highest dose in conventional spiral tomography, with the parotid absorbed dose ranging from 0.6 to 2.6 mGy (13). These findings confirm the present study, and the small differences were due to different exposure factors.

In addition, Bou Serhal et al. (2001) (13) found that for spiral tomography in the maxilla, organ doses for both parotid glands were most elevated, and average doses per

Table 1. Parotid Mean Absorbed Dose in mGY for the Spiral Tomography of Maxilla and Mandible

Left Side Parotid (Opposite Side)								Right Side Parotid (Tube Side)								
Mandible				Maxilla				Mandible				Maxilla				
Posterior		Anterior		Posterior		Anterior		Posterior		Anterior		Posterior		Anterior		
4 mm	2 mm	4 mm	2 mm	4 mm	2 mm	4 mm	2 mm	4 mm	2 mm	4 mm	2 mm	4 mm	2 mm	4 mm	2 mm	
1.50	1.67	1.40	1.40	1.66	1.30	1.50	1.40	1.57	1.60	1.75	1.65	1.70	1.40	1.65	1.70	
0.0007 ±	0.0007 ±	0.0007 ±	0.0007 ±	0.0003 ±	0.0007 ±	0.0003 ±	0.0007 ±	0.0003 ±	0.00014 ±	0.00014 ±	0.00014 ±	0.00014 ±	0.0007 ±	0.0003 ±	0.0003 ±	SD

examination reached levels of 0.27 mGy for the right (opposite tube side) parotid gland with frontal tomography, and 3.89 mGy and 1.67 mGy for the parotid gland at tube-side for premolar and molar tomography. For spiral tomography of the frontal area in the mandible, the opposite tube side parotid gland received the highest dose (0.77 mGy), while in an analysis of the premolar and molar areas, the doses were more elevated for the tube side parotid gland (1.22 mGy and 1.72 mGy, respectively) (14), further confirming our results. Finally, in Bahreyni Toossi and colleagues' (2012) study, the parotid gland (right and left) doses were 367 and 319 μGy, respectively (1). The differences between these results show that there are differences between patient doses when examined by different panoramic systems.

Spiral tomography has wide application in dentistry. According this study, since there are no statistically significant differences between parotid absorbed doses in different examinations using spiral tomography and panoramic radiography, spiral tomography can be introduced as a low-dose technique, like panoramic radiography. Although these results are supported by many previous articles, further examinations with larger sample sizes and more sensitive dosimeters are suggested.

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