TECHNICAL REPORT

Compliance of Iranian dentists with safety standards of oral radiology

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Objectives: Dentists use radiographs in their daily practice. Their knowledge and behaviour towards radiographic examination can affect patients' exposure to radiation. The aim of this study was to survey the knowledge and behaviour of Iranian dentists regarding oral radiology safety standards.

Methods: 1000 questionnaires were given to the participants of the 48th Annual Congress of the Iranian Dental Association, of which 700 were returned. The participants were asked about demographic data, primary knowledge of radiation protection, selection criteria, radiographic equipment and technique, methods of patient and personnel protection and management of radiographic waste. Descriptive analysis of data was performed.

Results: 44% of respondents said the initial radiograph they took was of the periapical view of a limited area. 12% preferred the periapical paralleling technique. F-speed film was used by 9% and E-speed film by 62%. Only 2% had digital receptors. Proper exposure time was selected by 26.5%. The use of long and rectangular collimators was 15% and 6%, respectively. 34% occasionally covered their patients with both thyroid shields and lead aprons. 36% used the position and distance rule correctly for their own protection. Proper disposal of the used processing solutions and the lead foils were done by only 1% and 3%, respectively.

Conclusions: It can be concluded that the majority of dentists in the study group did not select the proper method, material and equipment in order to minimize the exposure of their patient to unnecessary radiation in dental radiography.

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Introduction

Dentists use radiographs more often than any other health professional. For this reason, compliance to as low as reasonably achievable (ALARA) principles becomes important in their practice in order to reduce patient exposure to ionizing radiation.¹ The ALARA principles in dental radiology are aimed mainly at selection criteria, equipment and quality assurance.^{1,2} Continuous advances in dental radiography equipment have resulted in dose reduction without quality impairment.^{3–5} Studies have shown that dentists do not

appreciate this technology advancement and still over-expose their patients.^{2,5–7}

Oral and maxillofacial radiology is taught in three theoretical and three practical courses in the dental schools of Iran. The first theory and practical course focuses on radiation physics, the potential biological hazards of ionizing radiation and methods of radiation protection. Radiation protection is also a part of mandatory continued education courses and 1h is allocated to the subject. Despite these teachings, some unpublished studies in Iran show that the patients are still subjected to unnecessary radiation exposure during dental radiography.

The purpose of this study was to investigate knowledge, attitude and behaviour of the Iranian dentists regarding the oral radiology safety standards by means

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of a questionnaire. By understanding the level of knowledge of our practising dentists and the way that they behave regarding patient protection in dental radiography, we can manage our future academic programming either in undergraduate or postgraduate courses.

Materials and methods

This study was conducted using 1000 dentists attending the 48th Annual Congress of the Iranian Dental Association. We considered radiation safety standards, mainly the methods applied to control patients' unnecessary exposure during dental radiography. The guidelines were derived from the American Dental Association 2006 recommendations⁸. Another consideration was the environmental pollution caused by dental radiography for which the Federal Resource Conservation and Recovery Act of 1976 was used.⁸ A questionnaire including 28 questions was given to the participating dentists (Appendix 1). To prepare the questionnaire, a review of the literature was performed and the variables were determined. Eight specialists in human behaviour research fields confirmed the validity of our questionnaire using the Delphi technique. To measure the reliability of the questionnaire, a pilot study was conducted by testing and retesting Shahed University faculty members in a 1-week period and the correlation coefficient of 0.75 was obtained. The dentists were assured about the anonymous processing of the questionnaire. The participants were asked about the following criteria:

1. demographic data
2. primary knowledge about the radiation protection
3. selection criteria
4. radiographic equipment and techniques
5. method of patient and personnel protection
6. management of radiographic waste.

The statistical analysis was performed by Statistical Package for the Social Sciences (SPSS 13 for Windows). Beside the descriptive analysis, our data were evaluated using the χ^2 analysis to determine the significance of differences between two independent groups. The level of significance was set at 5%.

Results

Demographic data

The response rate was 70%. Of the 700 respondents, 390 (56%) were male. 5.6% were specialists. A large number of the respondents (80%) were aged 25–45 years. 315 (45%) of them were aged <38 years and 385 (55%) were aged >38 years.

The majority of respondents (57%) had practiced dentistry for <10 years, 26% had 10–20 years of practice and 17% had practiced for >20 years.

Figure 1 describes the geographic distribution of respondents and shows that 51% of participants were from Tehran and the other participants came from the other parts of the Islamic Republic of Iran.

The number of radiographs taken per week was 3–36+ and 33% of respondents took 6–15 intraoral radiographs in 1 week (Figure 2).

Primary knowledge about the radiation protection

61% of respondents were unable to explain the rationale for radiation protection, 34% did not know that the thyroid gland is the most important organ in dental radiography protection and 30% believed that panoramic exposure gave more radiation dose to patients than full mouth periapical radiography. 39% knew that a pregnant woman should not have any periapical radiographs.

Selection criteria

Several combinations of radiographic views were considered for the initial visit of the patient and the periapical views of a limited area were used by 44% of respondents (Figure 3). 88% of the dentists requested previous radiographs of the patients prior to ordering new sets.

Equipment and technique

The majority of the dentists (61%) did not have regular maintenance check-ups of their X-ray machines. A statistically significant difference was found between the two age groups regarding the regular check-ups of their X-ray machine ($p < 0.05$). Dentists aged >38 years (55% of the participants) had a lower rate of regular check-ups.

Paralleling periapical technique using film holders was used by a minority of respondents (12%). No statistically significant difference was found between general practitioners and specialists regarding the use of film holders ($p > 0.05$). Only 6% used a rectangular collimator and 15% used the long cone.

The most commonly used film was the E-speed (62%). 8% used the D-speed film, 9% reported the use of the F-speed film, 8% used any available film speed and 13% did not know the speed of the film they used.

A small minority of dentists (2%) used a digital receptor. A statistically significant difference was found between the two age groups regarding the use of digital receptors. Dentists aged >38 years showed a higher use of the digital receptors ($p < 0.005$).

26.5% used proper exposure time, 30% changed the exposure time properly for different parts of the jaw and 49% changed the exposure time for different patients.

Methods of patient and personal protection

1% of respondents used both thyroid shields and lead aprons regularly in their practice and 34% used them occasionally. 27% never used them and 38% did not answer this question. No statistically significant

Figure 1 The geographic distribution of the practice of the studied group

difference was found between general practitioners and the specialists regarding the use of patient protective cover ($p > 0.05$).

36% of the dentists used the position and distance rule correctly for their own protection. No statistically significant difference was found between general practitioners and specialists regarding the correct use of position and distance rule ($p > 0.05$).

Management of radiographic waste

The used processing solutions were disposed of properly by only 1% of respondents.

3% of respondents disposed of the film covering and lead foils as hospital waste. No statistically significant

difference was found between the general practitioners and the specialists regarding proper disposal of the radiographic waste ($p > 0.05$).

Discussion

Today there are many pieces of equipment and techniques available in dental radiography that can result in patient dose reduction.³⁻⁵ However, many studies show that dentists are not loyal to the ALARA principles.^{2,5-7} To our knowledge, there are no internationally published data available from the Islamic Republic of Iran about radiation protection in dental radiography.

Figure 2 The number of periapical radiographs taken per week by the studied group

Figure 3 Type of radiography requested in the initial visit by participating dentists

The annual dental congress of the Iranian Dental Association is held in Tehran and many dentists participate from different parts of the country. The present study also confirmed this geographic distribution (Figure 1).

To adhere to ALARA principles it is very important to avoid ordering unnecessary radiographs. This study showed that the selected periapical radiographs were the dominant initial radiographs taken or ordered by the dentists. This may be beneficial for the patients exposed to radiation, but many incipient and occult conditions of the teeth and jawbones might thus remain undetected.

To ensure the optimum exposure conditions, quality assurance of the radiographic system should be performed. One of the basic steps of quality assurance is X-ray machine maintenance, and regular check-ups of the equipment are a necessity.⁸ Regulations in the Islamic Republic of Iran require oral and maxillofacial radiology centres to have a complete check up of their X-ray machines every 3 years to maintain their licence to practice. This rule does not apply to general dentists. Despite this fact, our study showed that 39% of the Iranian dentists perform regular check-ups of their X-ray machines, which seems to be a high percentage.

The use of standard and accurate techniques reduces the number of retakes and indirectly reduces patients' unnecessary exposure. In this study, a minority of the dentists (12%) used paralleling periapical technique with the use of film holders and the majority preferred to use the bisecting angle technique. This is similar to findings in Turkey,³ Uganda⁹ and Belgium.⁶ Other studies report a higher use of film holders in different countries—37% in England and Wales¹⁰ and 43% in Syria.¹¹

Restricting the X-ray beam to the receptor area can prevent unnecessary patient exposure.^{3,6,8} Rectangular collimation ensures that the emitted X-ray is slightly larger than the receptor area. By replacing the round

collimation with rectangular collimation, the effective dose will be reduced by almost 60%.⁸ The results of the present study show that only 6% of respondents use rectangular collimation, which is similar to the findings in Belgium (6%),³ Turkey (5.5%)⁶ and Canada (8%).⁷ Higher rates of use were reported in Sweden (36%).⁵ The low rate of rectangular collimation use may be attributed to the low rate of film positioning devices used (12% in our research) as well as the concern of cone cutting.

To reduce patients' exposure, increasing the distance of the source to skin by the use of a long cone is recommended. The use of a long cone results in less divergent X-ray beams and a reduction of the patient's exposure volume.⁸ We found that only 15% of the respondents in our study used long cones. Findings from other studies such as Turkey (52.3%),³ England and Wales (63%)¹⁰ and faculty members of the USA (50.5%)¹¹ showed higher use of long cones. The low rate of long cone use may be owing to the fact that many X-ray machines are equipped with short-to-medium collimators and the long cone has to be purchased separately. Many dentists do not find this extra spending a necessity. Another problem in using long collimators is the inevitable increase in exposure time. The increased exposure time increases the possibility of patient movement and may also give the misconception of increased patient exposure.

Advances in film manufacturing technology have resulted in the development of faster films. By replacing the D-speed film with the E-speed film, the radiation dose can be reduced by up to 50%.^{7,8} The use of the F-speed film results in a 20% dose reduction compared with the E-speed film.¹² Researchers have shown that the image quality is not impaired by using the faster films;¹³ however, some dentists do not always choose the fastest receptors.^{3,11,13,14} Regarding the receptor type, the present study showed that the majority of respondents used the E-speed film (62%) which is higher than

findings in Uganda (22%),⁹ Belgium (40%),⁶ Turkey (10.2%),³ Spain (0.8%),¹⁴ Denmark (25%),¹⁵ Canada (25%),⁷ and Finland (24%).¹⁶ Studies in Greece (66%)² and in North American dental schools (86%)¹⁷ showed higher use of the E-speed films. 9% of respondents reported the use of the F-speed film, which is similar to the finding of other studies such as Turkey (2.3%),³ Belgium (5%)⁶ and Spain (9.6–12%).^{18,14} The reason for the high use of the E-speed films in the present study is probably owing to the fact that most of the film-distributing companies in the Islamic Republic of Iran provide the E-speed films and the availability of this type of film in the market affects the dentists' choice. Therefore, it would be wise to persuade the companies to import the fastest available film type.

The digital intraoral receptors need significantly lower radiation than conventional films to produce high quality images.^{3,14,19} The present study showed that a small minority of the respondents (2%) used digital receptors. 14% of the dentists used digital imaging in Turkey.³ Reports from Spain indicated that 19.3% choose the digital sensor installation with an annual increase of 4%.¹⁴ Two reports from Belgium showed a higher use of digital intraoral imaging (34% and 38%, respectively).^{6,20} Low rates of digital receptor use for intraoral radiography may be attributed to several factors such as the high cost of equipment,^{3,14,19} patient discomfort owing to inflexible receptors^{14,19} and a small active area of some receptors.⁸ Other problems may be a lack of knowledge and difficulty in mastering digital image acquisition and processing.¹⁹

Selecting an appropriate exposure time is very important in minimizing patients' radiation exposure. We selected 1 s as the maximum acceptable exposure time to. By accepting this limit, only 27% of the studied group exposed their patient properly. We also found that only 30% of respondents changed the exposure time according to the location of the tooth and 49%

changed the exposure time for different patients. These results show that the dentists in the present study do not consider the optimum exposure time for periapical radiographs. In our opinion this may be owing to several factors such as using old and exhausted processing solutions and compensatory overexposure, underdevelopment of overexposed film, factory pre-setting of some X-ray timers that are based on slower film speeds, dentists' own experience with slower films and not upgrading to new faster film exposure settings.

1% of our respondents used both thyroid shields and lead aprons for their patients regularly in their practice and 34% used them occasionally. Since there is general agreement about the routine use of a thyroid collar in certain patients, the present study indicates a high rate of neglect in this regard.

The preferred method for operator protection is to use a protective barrier or to leave the room during radiographic exposure. However, if this is not possible, the operator should stand in the proper position and at a distance (the position and distance rule).⁸ The present study shows that when the protective barrier was absent, only 36% of the dentists used the position and distance rule correctly for their own protection.

This study showed that the proper disposal of processing solution and the lead foil was 1% and 3%, respectively. Regarding this issue, there is considerable environmental pollution imposed by the dental community through dental radiographic procedures. Dentists can be persuaded to recycle silver and lead through selling used fixer solutions and lead foils to the local vendors and scrap metal dealers.

In conclusion, the results show that the dentists' knowledge and behaviour regarding oral radiology safety standards are not satisfactory. Considering these standards, the faculty members have the responsibility of designing new and more efficient methods of education in undergraduate and postgraduate levels.

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Appendix 1

Questionnaire (translated from Persian)

1. Gender: Male ☐ Female ☐
2. Age:
3. Date of graduation:
4. University of graduation:
5. City of practice:
6. Do you work as: General practitioner ☐
Specialist ☐
7. Do you work in a dental school as a faculty member?
8. Do you have an X-ray machine in your office?
Yes ☐ No ☐
9. What is the age of your X-ray machine?
10. Do you have periodic check up for your X-ray equipment? Yes ☐ No ☐
11. How many radiographs do you take in your office weekly?
12. Which type of radiographic examination do you usually prescribe in the initial visit?
Bite wing ☐ Selective periapical view ☐
Panoramic ☐ Full mouth periapical view ☐
13. In your opinion, how important is the role of imaging in dentistry?
Very low ☐ Low ☐ Moderate ☐ High ☐
Very high ☐
14. What is the aim of radiation protection in dental radiography?

15. What is the most important organ in radiation protection in dental radiography?

Gonads ☐ Bone marrow ☐ Thyroid ☐ Skin ☐

16. In your opinion, which of the following radiographic techniques delivers more radiation to the patient?

Panoramic ☐ Full mouth ☐

17. Can you take any periapical radiographs from a pregnant woman?

Yes ☐ No ☐ How many? ☐

18. Which technique do you use for periapical radiography?

Paralleling technique ☐

Bisecting angles technique ☐

19. Do you use film holder while taking radiographs?
Yes ☐ No ☐

20. Which type of collimator do you use? Round ☐
Rectangular ☐

21. What is the length of your collimator?

No collimator (pointed cone) ☐ 20 cm ☐ 30 cm ☐
40 cm ☐

22. Which type of radiographic receptor do you use?
Film ☐ Digital receptor ☐

23. Which film speed do you use for periapical radiography? D ☐ E ☐ F ☐

24. How much exposure is required for the periapical view of the following areas?

Maxillary molar ----- s

Mandibular incisor ----- s

25. How do you adjust exposure time in the following conditions?

A. From fat patient to thin patient: Increase ☐
Decrease ☐ No change ☐

B. From anterior teeth to posterior teeth: Increase ☐
Decrease ☐ No change ☐

C. From maxilla to mandible: Increase ☐
Decrease ☐ No change ☐

26. Do you use leaded apron and thyroid shield for patient protection?

Yes, always ☐ Yes, occasionally ☐ No ☐

27. How do you manage your radiographic waste?

Film lead -----

Old developer and fixer solutions

28. If there is no barrier between you and patient, in which area do you stand according to the X-ray tube and what is your distance from the patient?