

# Dentists' Perceptions and Methods Regarding the Radiographic Examinations and Radiation Protection: a 2022 Research in Thessaloniki, Greece

## SUMMARY

**Background/Aim:** Dentistry has made major progress due to modern advancements in radiology. It would be interesting to examine the correlation of dental science with the labor market, as well as to assess dentists' adaption to nowadays' scientific and financial circumstances. This research aims to investigate the opinions of dentists in Thessaloniki, Greece, with regard to choosing the appropriate radiographic examinations in various clinical cases, and to canvass their knowledge of radiation protection. **Material and Methods:** Our sample was comprised of 7% of private dentists working in the urban complex within the borders of Thessaloniki, Greece. Self-referential multiple choice questionnaires were distributed via email. For the statistical analysis, GoogleForms was utilized, and objectivity was guaranteed by ensuring participants' anonymity. **Results:** The replies underwent statistical analysis with the use of Google Forms, and through this process charts have been produced. Orthopantomograph is the most usual radiographic examination for new patients and for the evaluation of complications. Dentists' age and gender seem to affect their radiographic choices in everyday clinical practice. Regarding intraoral radiography, the paralleling technique is more usually applied. Moreover, the findings suggest the need for dentists' constant education on radiation protection. Last but not least, most participants choose digital intraoral radiography. **Conclusions:** Dentists tend to seek assistance from radiological laboratories for special radiographies, such as cone-beam computed tomography, as well as in cases of diagnostic dilemma. They also recognize digitalization's contribution to keeping health records. Consequently, clinicians' additional education, financial motives for the upgrade of radiological equipment and records' digitalization are fundamental prerequisites for modern dentistry.

**Key words:** Cone-Beam Computed Tomography, Digital Radiography, Orthopantomography, Radiation Protection, Radiography, Radiation Equipment

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## Introduction

Over the last years, the rapid technological development has influenced significantly the sector of Diagnostic Radiology. The gradual replacement of the conventional radiography by the digital technology and the introduction of advanced radiological techniques have opened a new era in dentistry. However, the effort of utilizing all these modern innovations rationally and safely has led to the requirement of updated guidelines,

which have introduced the term "radiation protection", also called "radioprotection", and its principles.

Radiation protection is a fundamental sector of the science of Radiological Physics dealing with the protection of human health and the reassurance of environmental integrity, through reducing the impact of factors that may set people, either involved in this sector or not, in danger<sup>1</sup>. In this way, radioprotection aims to guarantee the limited exposure to excess radiation and so, to avoid its hazardous consequences as much as possible<sup>2</sup>.

In dental radiology, three main principles have to be followed, so that the clinician guarantees the compliance with ethical and legal rules related to radiation protection. According to the International Commission for Radiation Protection (ICRP), those principles are justification, optimization and dose limitation<sup>3</sup>. The first principle requires that the chosen radiological examination or the radiation exposure should be beneficial for the patient offsetting the possible provoked harm<sup>4, 5</sup>. Optimization refers to minimizing the possible exposure and the number of exposed individuals as much as possible<sup>6</sup>. Initially, it was described by the acronym ALARA (As Low As Reasonably Achievable), but recently a refinement of this principle has been proposed. This new principle is ALADA (As Low As Diagnostically Acceptable) and its ultimate purpose is to result in diagnostically acceptable and interpretable radiographic images<sup>7</sup>. Finally, the principle of dose limitation is satisfied by limiting the radiation dose as low as minimally required in order to guarantee its beneficial influence on the human body<sup>5, 8, 9</sup>.

Today, there is a wide range of radiographic examinations that dentists may use to diagnose and treat their patients more effectively. Among the most fundamental and most usually applied ones in their armamentarium, orthopantomographs, targeted intraoral radiographs and computed tomography imaging stand out<sup>10</sup>. But, their use as a diagnostic tool and their interpretation requires specialized knowledge and training. This is the reason why dental professionals need to upgrade their radiographic equipment and update their knowledge of innovative methods and advancements, in order to fulfill the oral health demands of modern society. Regarding their perception on radiation protection, dentists' constant educational and practical training on radioprotection methods and principles would also be a substantial adaptation on scientific progress. Certainly, this is considered to be a challenge for dentists, who are still striving to adjust to the new circumstances after the severe global financial and health crisis<sup>11, 12</sup>. The present research aims to investigate the opinions of dentists in Thessaloniki, Greece, with regard to choosing the appropriate radiographic examinations in various clinical cases, and concurrently to canvass their perception and knowledge of radiation protection.

## Material and Methods

The initial target group was intended to be all dentists, both those providing public dental care and those working at private dental offices, within the borders of the urban complex of the city of Thessaloniki, Greece. However, taking into account the circumstances under which public dentistry is practiced as well as the difficulty to contact them, all researchers ultimately agreed to focus

on dental professionals practicing dentistry privately, 1235 individuals in total. For the purposes of the research, self-referential close-ended 19-point multiple choice questionnaires were distributed to them during the period June 2022 – September 2022 via email. The formulation of the questionnaires was based on other recent researches with slight modification<sup>13, 14</sup>. The questionnaires included questions related to socio-demographic parameters, participants' knowledge and practices on radiation protection, and selection of the appropriate radiographic examinations. As soon as the replied questionnaires were accumulated, they were renamed and randomly distributed to the researchers. So, none of the researchers or participants could in any way find out the identity of each replying dentist, which guaranteed the anonymity of the responses. We received answered questionnaires by 86 dentists, who comprise our final statistical sample. A quantitative analysis was carried out, based on their responses, with the use of GoogleForms. In order to support and relate our findings to modern scientific progress, a review of the recent literature was conducted in the databases PubMed and Google Scholar, as well as in scientific textbooks.

## Results

We present the results of our analysis with respect to the sequence of the questions in the questionnaire, alongside with charts demonstrating participants' answers in a figurative way. From an epidemiological perspective, the two genders happen to be equally represented, thus allowing us to extract safe conclusions without bias in favor of one or another gender (Figure 1). Participants' ages follow the Gaussian distribution and seem to extend to a wide range from younger to older dental professionals (Figure 2).

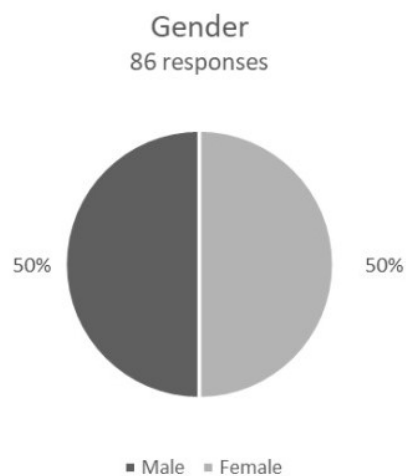


Figure 1. Distribution of participants' gender.

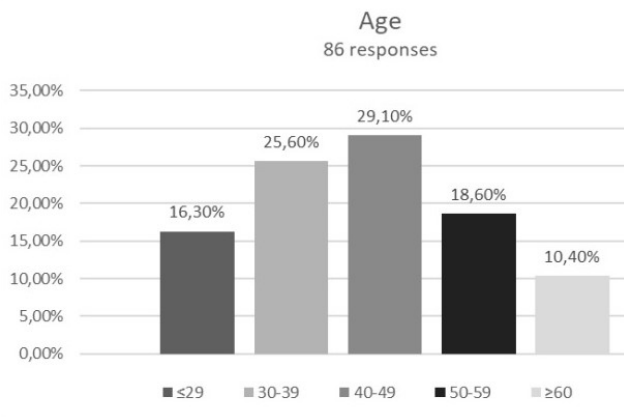


Figure 2. Participants' age divided in groups.

Questionnaires were distributed to dental professionals regardless of their clinical experience, and based on our findings, we noticed that nearly half of them have been practicing dentistry for less than 15 years (39 out of 86 participants) (Figure 3). Furthermore, almost 6 out of 10 dentists seem to have decided to continue with further academic studies after the acquisition of their Bachelor degree, fact that indicates their interest in enhancing their knowledge (Figure 4).

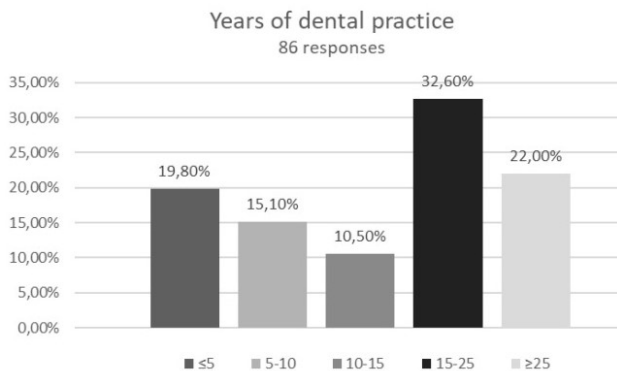


Figure 3. Years of professionally practicing dentistry.

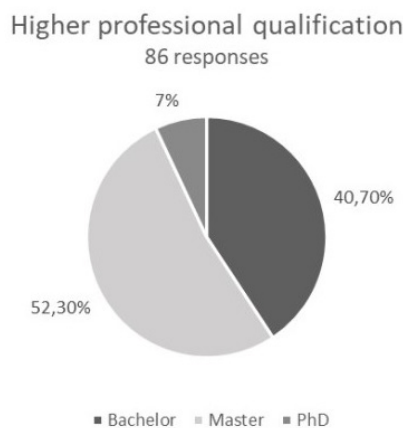


Figure 4. Participants' level of academic education.

Surprisingly, dental professionals seem to be confused or even not interested in expanding their knowledge on radiation protection, according to the results of our survey (Figure 5). However, it is hopeful that most dentists acknowledge the need to attend some kind of constant education related to radioprotection, in order to work effectively and professionally (Figure 6).

Have you attended courses/training programs on radiation protection?  
86 responses

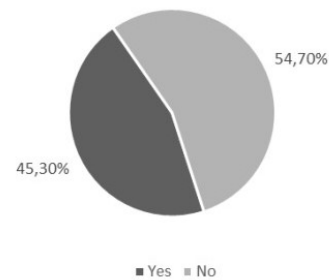


Figure 5. Participants' distribution based on their additional training on radiation protection.

If not, do you consider it useful for the future?

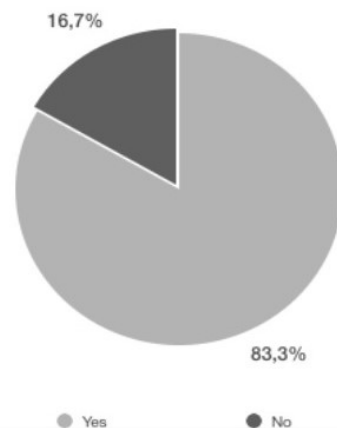


Figure 6. Dentists' perception regarding the need for additional education on radiation protection.

Moreover, digital radiography seems to be more common nowadays, as 7 out of 10 dentists use its technology in everyday clinical practice (Figure 7). Meanwhile, most dentists keep a digital record with intraoral radiographs (Figure 8).

With regard to the technique preferred when taking periapical radiographs, the paralleling technique seems to be more usual, as indicated by the results. It is unfortunate, but interesting, that one dentist was unaware of the technique he/she applies (Figure 9). When asked about the place in the dental office where intraoral radiographs are taken, only the minority of dentists stated that they have created a specially designed room for that purpose (Figure 10).

Do you use Digital or Conventional X-ray?

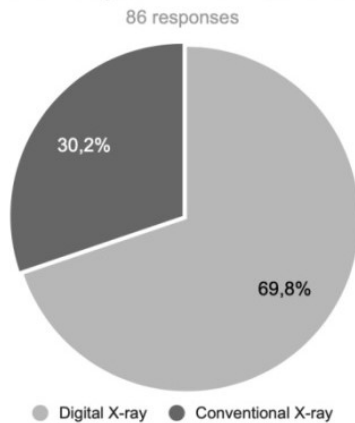


Figure 7. The relative ascendancy of digital technology in dental radiology.

Do you maintain a digital X-ray archive?

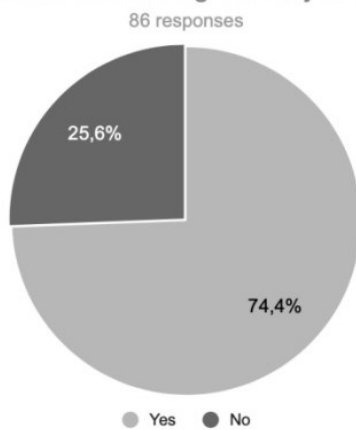


Figure 8. Dentists' clear tendency to maintain digital records for their patients.

Which periapical X-ray technique do you use?

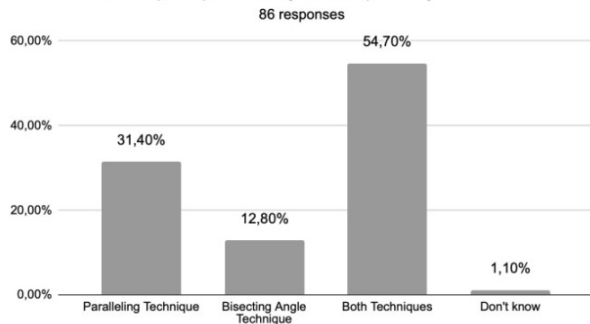


Figure 9. The prevalence of paralleling and bisecting technique in intraoral radiography.

Is there a specially designed room in your office for taking X-rays?

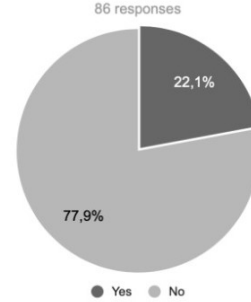


Figure 10. Dental office's arrangement regarding the existence of special room for radiographs.

One could support that taking intraoral radiographs with patient's fingers holding the x-ray film or sensor is not the appropriate methodology, but it seems to be part of the reality, according to our findings. Awkwardly, one dental professional uses his/her assistant's fingers for that purpose (Figure 11). Fortunately, more than half of the participants make good use of paralleling film holders regularly (Figure 12).

How is the x-ray film/sensor usually held in the patient's mouth during the exposure to radiation?

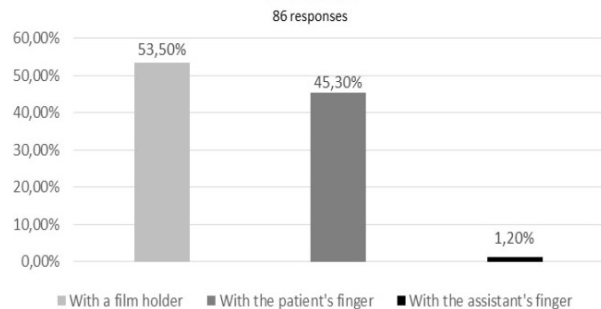


Figure 11. Assessment of the methodology applied when taking intraoral X-rays.

If there is a film holder, how often do you use it?

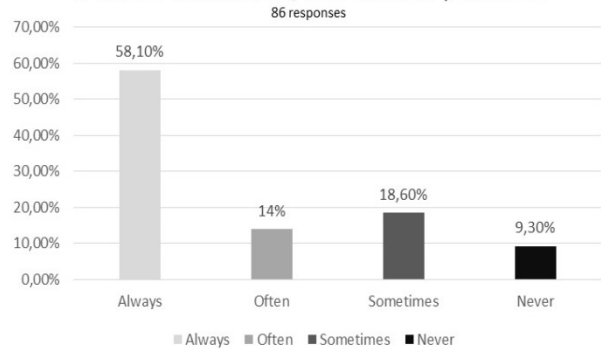


Figure 12. Frequency of applying paralleling technique by dentists in Thessaloniki.

When asked about the appropriate angle from the X-ray tube in order to avoid radiological exposure, the vast majority believes that the angle does not make any significant difference (Figure 13). Another interesting finding of the research is the fact that participants seem to be confused regarding which radiography is more harmful for patients (Figure 14).

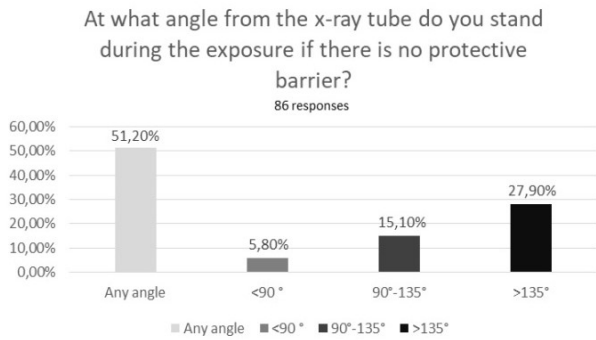


Figure 13. Evaluation of participants' radiology knowledge regarding the safety angle.

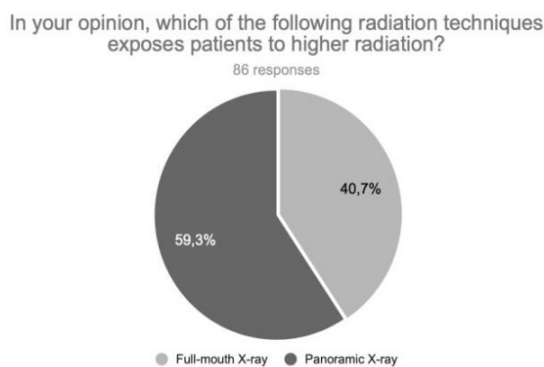


Figure 14. Evaluation of participants' radiology knowledge regarding radiation exposure doses of the two most common radiographs applied in dentistry.

At the same time, dentists usually tend to request an orthopantomograph in case of new patients, due to its easiness and the useful information that it provides them with (Figure 15). Remarkably, dentists' vast majority avoids requesting a new panoramic radiograph from all patients, regardless of their oral health issue, in accordance with the principles of avoiding radiation overexposure (Figure 16).

In case of a diagnostic challenge, it is worth mentioning that almost every 1 out of 4 dentists refer their patients to the Radiological Laboratory of the School of Dentistry in Aristotle University of Thessaloniki, acknowledging its academic and scientific expertise (Figure 17). Radiodiagnostic laboratories are essential for radiographs that cannot be taken in the dental office. So, dentists refer their patients to laboratories for either only CBCTs or both CBCTs and orthopantomographs (Figure 18).

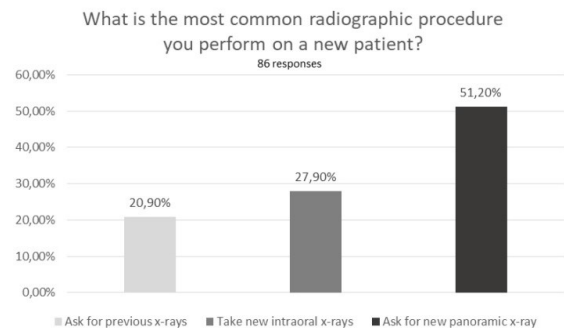


Figure 15. Orthopantomographs most frequently requested in case of new dental patients.

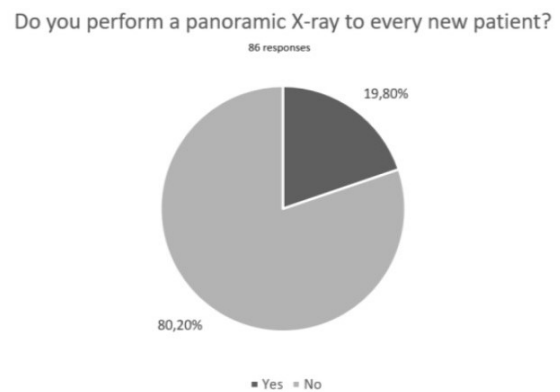


Figure 16. Dentists' perception regarding the exposure of every new patient to unnecessary radiation dose.

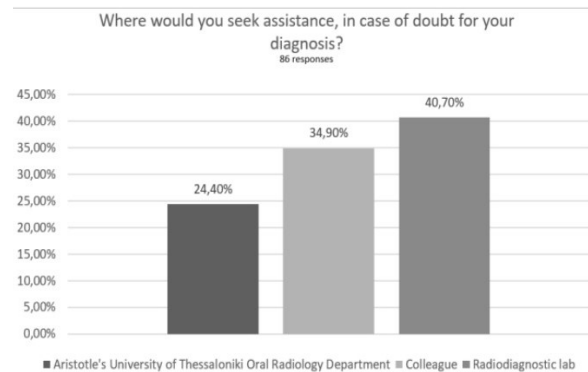


Figure 17. Most usual sources of assistance when facing a diagnostic challenge or dilemma.

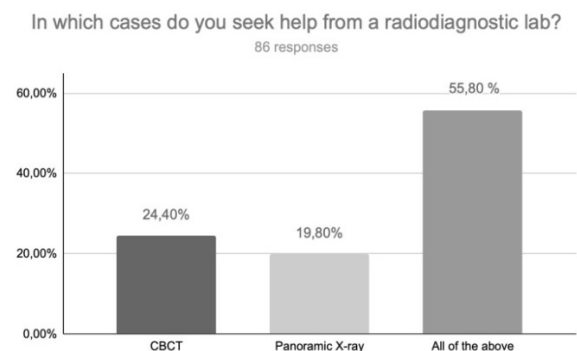


Figure 18. Radiographs usually requested from radiological laboratories.

## In which cases is CBCT required?

86 responses

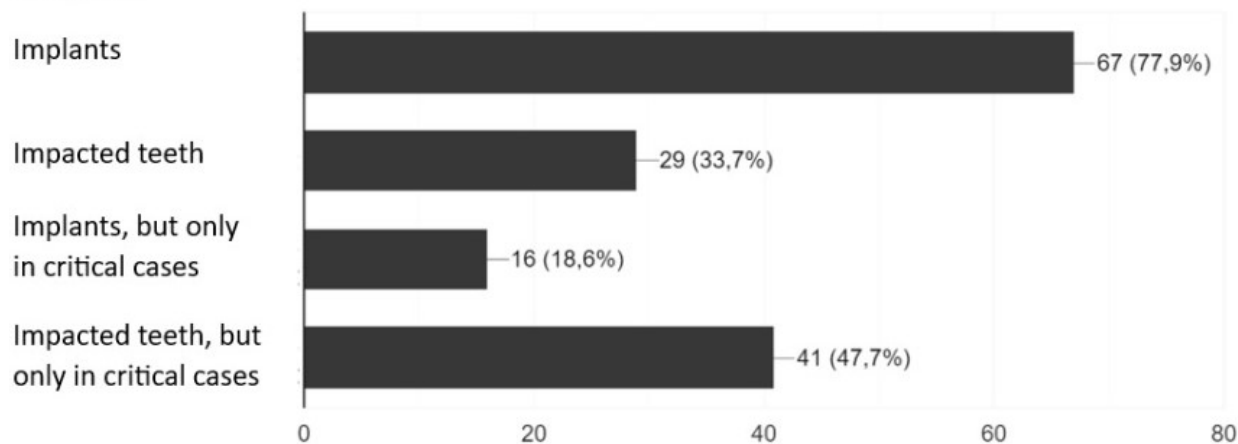


Figure 19. Participants' perception regarding the reasons why CBCTs are mostly required.

The final question of the questionnaire deals specifically with the indications of CBCT. This specific question was the only one that allowed participants to choose more than one of the available answers. The answers suggest that dental implants and impacted teeth are the most common reasons for a CBCT, according to the opinion of dentists in Thessaloniki (Figure 19).

## Discussion

All researchers agree that the sample can be considered sufficient, in order to extract crucial conclusions related to dentists' perception on dental radiology and several of its sectors, such as radiographic techniques and radiation protection. Concurrently, survey's observations represent the two genders equally, as the proportion male: female is 1:1. It is worth noticing that more than half of the dentists who participated in our research have successfully acquired a master of degree (MSc) or finished their PhD dissertation. Nevertheless, the results of the survey indicate a lack of fundamental knowledge of the principles and methods of radiation protection for the great majority of the sample.

In the past, digital radiology was still under development, which explains the reduced proportion of dentists making good use of this technology<sup>15</sup>. However, nowadays, dentists working in Thessaloniki seem to prefer digital radiography (69.8%). Digital radiological technology contributes to the more effective protection of patients and dentists from radiation exposure. Indeed, the superiority of digital radiography can be attributed to the better control of the X-rays direction, the higher imaging quality, the more effective maintenance of radiographic records as well as the limited required time and radiation dose, which justify why it is preferred by most dental professionals<sup>16, 17</sup>.

Since 2015, an abrupt progress related to accumulation, distribution and process of digital dental data has been more than obvious<sup>18</sup>. The modern technological development and the use of upgraded radiological equipment have significantly assisted in the digitalization of radiographic data. This allows not only for a more detailed recording, thus enhancing diagnostic accuracy, but also for a more effective management of radiographs. In order to allow the easier search and evaluation of older radiographs by the same or a colleague dentist, it is suggested to keep radiographs in a digitalized form<sup>19</sup>. Remarkably, the National Health System of Greece has deployed the use of the Personal Electronic Health Record of each patient since 2019. It serves as a priceless achievement, aiming to ease hygienists' access to the personal health record and health modifications of Greek patients. According to the findings of our research, most dentists are used to keeping digitalized radiographic record for their patients, but they do not call on their colleagues for prior health records in case of a new patient. This could possibly be related to the lack of digital familiarization, to concerns correlated to the distribution of patients' personal data, or to occupational competition. Consequently, the existing digital data tend to remain unused, thus making it harder for colleagues to cooperate effectively.

Furthermore, the literature suggests that digital radiography, including CBCT, is more preferable by dentists working for less than 10 years, which is also indicated by our research<sup>20</sup>. On the other hand, dental professionals working for slightly more than a decade seem to be used to conventional radiography. This may be attributed to the fact that the available technological equipment of the last decade is far more upgraded than earlier, so older dentists used to utilize second-hand radiological equipment, which was mainly non-digital, due to financial difficulties of their era. Certainly, constant

education is directly related to dentist's financial potential. When one decides to apply digital techniques, the cost to upgrade their radiological equipment is significantly high. But, it is widely accepted that training on a modern methodology and the acquisition of technologically advanced equipment is considered a major and anticipated investment. The financial crisis that Greece has faced since the beginning of 21<sup>st</sup> century, the expense of newly introduced digital radiographic technology, as well as its demanding handling, may be factors preventing older dentists from upgrading their radiographic methods<sup>11,21</sup>.

According to the recent literature, dentists with clinical experience of less than 5 years ask for new intraoral radiographs, whereas those working for more than 25 years make good use of the digital radiographic history<sup>22</sup>. However, our findings are contrary to the literature, as the majority of dentists (44 out of 86) ask for a new orthopantomograph, in case a radiograph is needed when examining new patients. Generally, it is recommended that new patients undergo a new orthopantomographic examination, due to its reduced radiating dose<sup>23</sup>. But, according to the principles of radiation protection, this indication should be wisely applied only when a new radiograph is absolutely required, so radiation exposure cannot be avoided<sup>4</sup>. Greek legislation is clear on facts related to radiation protection, as it strongly recommends hygienists to forward diagnostic examination results to each other, in case of patients' referrals. Although this contributes to the avoidance of unnecessary exposure to radiation, it is rarely applied by dentists, as supported by our research.

It is surprising that a great number of participants believe mistakenly that panoramic radiographs are more harmful than full mouth intraoral radiographs. At the same time, modern literature reveals that orthopantomograph is characterized by a 50–85% reduced radiation exposure<sup>6</sup>. So, dentists' unawareness on the radiating dose of each radiological examination may lead to absorption of unnecessary dose by patients' body, despite the strong advice to ask for a panoramic radiograph when other radiographs can be avoided<sup>24</sup>. As far as the paralleling film holder is concerned, its use protects both patients and dentists or dental assistants from overexposure to radiation by reducing the number of repetitions required<sup>25</sup>. The low number of dentists in Thessaloniki, who apply the paralleling technique, reveals lack of knowledge of radioprotection and the fundamental principles of dental radiography<sup>26</sup>. Under the prerequisite that periapical radiographs are taken with the use of the right X-ray tube, the radiographic image is characterized by even less distortion<sup>27</sup>. It is interesting that dental professionals seem to prefer both bisecting and paralleling technique, without any statistically significant difference. In the past, the most commonly applied method for periapical radiographs in various places around the world, such as Turkey and India, was the bisecting one<sup>26,28</sup>. Today, the

paralleling technique is said to guarantee the best feasible radiological result avoiding image distortion. Indeed, it is suggested for any dental intervention that requires periapical radiographs<sup>29</sup>.

The literature proposes 90–135 degrees as the most preferable and safe angle for dentists' or dental assistants' protection during radiating, in case of no protective radiation barrier<sup>25</sup>. The findings of our survey suggest that only 1 out of 5 dentists follow this guideline. That fact is indicative for either incorrect consideration of exposure risk, or unawareness of the basic radiation protection principles when practicing diagnostic radiology. The operator of the radiological equipment is suggested to stay at least 3 meters away from the X-ray tube. Otherwise, when it is not feasible to keep distance of more than 2 meters from the X-ray tube, a protective radiation barrier is needed, such as a thick wall<sup>9,22</sup>.

Apart from the other radiographic techniques that are most usually applied in dentistry, a priceless advancement in medical science is computed tomography. Its use in everyday dental practice has brought a major enhancement in diagnostic procedures, as it has revealed the "third dimension" of the oral and maxillofacial anatomical structures<sup>30</sup>. Cone-beam computed tomography imaging is useful for a wide range of oral and maxillofacial situations and assists in diagnosis and evaluation of disease severity, treatment planning and follow-up<sup>30</sup>. In general, CBCT imaging is used by various dental specialists, such as endodontists, periodontists and implantologists, oral and maxillofacial surgeons, prosthodontists, orthodontists, pedodontists, specialists in temporomandibular joint disorders, and even general dentists<sup>31</sup>.

Based on our findings, CBCT is mostly preferred in cases of impacted teeth and implant treatments. At the same time, one could easily notice some confusion and misinterpretation of the guidelines related to the use of CBCT. Also, dentists in Thessaloniki tend to ask for CBCT examinations more often than they should, which leads to patients' overexposure to radiation. The situation is even worse regarding younger dentists, which reveals their insecurity in diagnosing and planning treatments, because of their shorter clinical experience. In the recent literature, it is stated that specific and not all categories of impacted teeth require a better radiological evaluation provided by CBCT<sup>32,33</sup>. Also, the use of computed tomography in implant treatments is a prerequisite, in order to form an accurate treatment plan or to gain information not provided by other radiographic examinations, such as anatomical variations and bone anomalies<sup>34</sup>. In order to specify the indications and safe use of CBCT, the European Academy of Dental and Maxillofacial Radiology has published detailed guidelines<sup>35</sup>. Nevertheless, clinicians should bear in mind that computed tomography has some limitations and drawbacks, such as the high dose of radiation<sup>36,37</sup>.

Despite that fact, it is widely accepted that computed tomography is a priceless technological achievement in the sector of radiology, as it provides clinicians with information which would otherwise be impossible to gather and assess. Certainly, we should always remember one of the fundamental principles of radiation protection, called justification, so radiological examinations may be requested only when needed and their evaluation is expected to benefit the patient<sup>4</sup>. As far as any possible limitations of the present research are concerned, it should be mentioned that it was carried out with self-referential questionnaires and so, the validity of the answers was in participants' discretion.

## Conclusions

The findings of our research in conjunction with the review of the recent literature reveal a gradually increasing number of radiographs conducted in diagnostic laboratories rather than in dental office. At the same time, dentists seem to apply, even today, older radiographic methodologies and principles compared to the newly introduced ones. This is closely related to one of the most fundamental prerequisites of modern medicine, which is the constant education and participation in training programs. Dentists should attend seminars, congresses, workshops and any other form of educational session upon radiology and radiology protection. Indeed, it is positive that the majority of the participants agree on that. Apart from that, the digitalization of medical records and the upgrade of radiological equipment are more that needed, so that dentists are consistent with modern scientific progress and contribute to the reduction of unneeded exposure to radiation. Obviously, this entails great cost, but it is undoubtedly worth it, as dental professionals will be more capable to satisfy patients' modern demands.

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