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"Gheorghe Asachi" Technical University of Iasi, Romania

DENTAL RADIOLOGY FROM AN ECOLOGICAL PERSPECTIVE. THE ATTITUDE OF DENTISTS REGARDING THE MANAGEMENT OF THE MATERIALS USED IN DENTAL RADIOLOGY

Mariana Constantiniuc[1], Daniela Popa[1*], Ana Ispas[1*], Cecilia Bacali[1], Alexandru Burde[1], Valeria Laza[1], Graziella Turdean[2]

[1] "Iuliu Haţieganu" University of Medicine and Pharmacy, 8 Victor Babeș Street, 400000, Cluj-Napoca, Romania
[2] Babes-Bolyai University Cluj-Napoca, Romania, Faculty of Chemistry and Chemical Engineering, Department of Chemical Engineering, 1 Mihail Kogălniceanu Street, 400084, Cluj-Napoca, Romania

Abstract

The films and the developing solutions used with radiological films contain a number of harmful substances that are very toxic to the environment, as well as to the living organisms, particularly aquatic organisms. Therefore, this type of toxic waste requires simple, but adequate collection and treatment measures, in order to be transformed into environmentally friendly products. This paper reviews the existent knowledge and the methods for the management of this special waste in dentistry-related units of dental radiology in Cluj-Napoca and Cluj County. An analysis of the answers reveals that many dentists do not know enough or do not use appropriate methods in radiological waste management, which can result in environmental pollution.

Key words: dentistry, ecology, radiology, waste

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1. Introduction

Technological development in medicine has increased the accuracy and efficiency of exploration; it ensures truth in higher rating on medical statistics, allows public control over their development provides scientific progress (Antoniac et al., 2016; Şenel et al., 2015; Ursu et al., 2017; Zaharia, 2016). To this date, in dental medicine, radiology has proven to be the most widely used paraclinical investigation method. In the ecological concept in dentistry, dental radiology is of utmost interest due to its potential of environmental pollution, and to the measures required to limit this risk. The benefits medical radiology brings to the diagnosis and therapeutic plan, grant it an important role in the laboratory investigations in almost all specialties, especially in dentistry, where it plays a central part. In this situation, the issue of safe use of the materials and substances used in radiology and of the appropriate disposal of the resulting waste products is crucial (Alcaraz et al., 2009).

Silver and lead are among the toxic compounds which enter into the composition of the substances used in radiology. Both are dangerous metals that can contaminate the soil and groundwater if collected together with the household waste as unsorted municipal waste (ADA Council, 2003; Deliens and De Deyn., 1984; Grigoletto et al., 2011; Hiltz, 2007; Nordberg et al., 2007). Silver is found in various chemical combinations in many of the materials used in radiology: the radiographic film, the developer and fixing solutions. Like most other environmental chemicals, silver has a dichotomous effect: it is harmless in small doses, but toxic in excessive doses.

* Author to whom all correspondence should be addressed: e-mail: Popa.Daniela@umfcluj.ro; Phone: 0744349278; ana24ispas@yahoo.com

It has been used as an antibiotic (antibacterial, antiviral, antifungal) since the time of Hippocrates, without there being any description of harmful side effects. In excessive amounts, however, it deposits into the dermis and sweat glands and can cause argyria (or argyrosis), which is not only an aesthetic nuisance, but may also associate with cardiac, liver and kidney disorders. Being a rare metal that exists in limited amounts, it is vital to be recovered from the materials it can be found in (Orenstein, 2012). In dental radiology practices silver is found on radiographic films as gelatino-silver bromide or silver iodobromide, forming the photosensitive layer on both sides of the transparent substrate. New unused films containing unreacted silver are toxic if disposed of in the environment as such. This is also partly true for exposed films, as these contain areas where the amount of radiation was insufficient to make an impression. For this reason, the films should not be collected together with the household waste, but must be disposed of safely.

Currently, due to the latest technological developments in radiology, which has allowed for the elimination of the image chemical processing phase, the amount of waste generated by this activity has been greatly reduced (ADA Council, 2003; Anderson, 1999; Grigoletto et al., 2011; Hiltz, 2007). Silver also enters into the composition of the fixer and developer, which are the solutions classically used in radiology in the processing of dental X-rays. For example, in the fixer it can be found in an amount of 8-12 g/L. The high levels of silver found in dental film processing solutions (developers and fixers) prohibit the disposal of these solutions into the sewer or together with septic or domestic waste (Goshima et al., 1994; Sundell-Bergman et al., 2008).

Naturally, the water used for the intermediate flushing and the water used for the final flushing contains traces of silver and other chemicals from the developer and fixer remaining in the gelatine on the film. Flushing is a diffusion process through which water extracts the salts from gelatin, thereby becoming itself a pollutant, given that this water is discharged into the sewage system, as it happens at present. Once in the waste waters which are subject to specific treatments, silver thiosulfate from the used solutions and the water used for radiographic film flushing are transformed into silver sulphide which accumulates in the sludge. This compound is 17,500 times more toxic than silver thiosulfate, as the toxicity of the free silver ions (Ag^+) is 15,000 times higher (Goshima et al., 1994). Proper management of the waste products containing silver consists in recovery and recycling. To this end, the waste must be collected by a company authorized for the transport and management of such waste products (Hiltz, 2007; Muhamedagic et al., 2009; Nordberg et al., 2007).

Another hazardous metal encountered in the dental practices equipped with a radiology lab is lead. This covers the protective foils inside each packet of traditional X-ray film. The cumulative amount of protective film foils resulted from the current radiological examinations can be significant, i.e. the lead content of the film foils, given that a full-mouth series of radiographs for an adult patient generates 11.2 g of waste lead (Eker and Bilgili, 2011; Farmer et al., 1997; Guedes et al., 2009; Tsuji et al., 2005). This heavy metal is found in the earth's crust, but human activities have increased the spread of lead in the environment. Lead has been used in the preparation of all indoor and outdoor paints, in particular before 1950 (Gilbert and Weiss, 2006). As of 1978, its use in indoor paints has been banned in some countries, such as the USA (Henretig, 2006). In addition, for a period of many years it was also used as a fuel additive. Many cosmetics (liner), children's toys, batteries, ceramic or tiles, welds in the water supply network (Payne, 2008) or canned food, crystal objects, etc., still contain lead as their main component, which can increase the level and sources of toxic exposure. Lead has no physiological roles in the biological systems, but its adverse effects range from subtle subclinical forms (cognitive impairment in children) to peripheral neuropathy in adults (Berg, 2009; Murata et al., 2009).

The toxicity of lead is due to the fact that once it has entered the body it blocks the enzymatic thiol-SH groups (Ferrochelatase, delta-aminolevulunic acid dehydratase) resulting in: failure of heme synthesis in the haemoglobin composition, peripheral nerve demyelination with peripheral motor neuropathy, neurological, mental and behavioural disorders, convulsions, coma, Saturnin encephalopathy (headache, insomnia, agitation, delirium, hallucinations, temporospatial isorientation, visual disorders, paralysis of the cranial nerves) (Comăniță et al., 2016). Oral cavity examination reveals a specific clinical manifestation, namely: the characteristic Burton gingival line (Bellinger, 2011; Nordberg et al., 2007).

The objective of this study is to investigate the way in which the specific dental radiology activity is carried out in a dental practice/radiology clinic, as well as the equipment and materials used and radiographic waste management. The ultimate objective of this paper is to highlight the sensitive issues detected in dental radiology management of the dental radiology waste products in order to help prevent further degradation of the environment and human health (living matter).

2. Materials and method

The study addresses the medical units that carry out dental radiology activities and private practices of dentistry and specialty departments from other medical units or higher education establishments in the city of Cluj-Napoca, and Cluj County. These were distributed a questionnaire prepared by a team of dentists, a radiologist and a physician specializing in environmental hygiene, and the physicians/dentists with a private radiology lab were invited to answer the questions. The list was obtained from the Department of Radiation Hygiene of the Public Health Department of Cluj County and the Department of Dental

Radiology of the University of Medicine and Pharmacy of Cluj-Napoca, where these doctors have attended training courses to this end. The questionnaires were distributed to the doctors by e-mail, directly by the authors of this study or by the College of Dentists. The questionnaire included questions regarding: the type of radiographs performed, the type of radiological film used, the devices used in film developing, and a list of the radiological hazardous waste resulted in the radiology lab.

As far as the rules for the handling and management of toxic substances used in radiology were concerned, the questions aimed the discarding of the waste substances (developing solutions), the exposed and unexposed old films, their plastic packaging and lead foils, the radiological film printer. The questions also relate to the number of radiographs performed within a certain period of time and the amount of chemicals used for developing them, the data obtained being an indicator of the volume of the activity and implicitly of the degree of possible environmental pollution when poorly managed.

3. Results

For a proper interpretation of the results of this study one should consider two aspects that can influence the answers to these questions to some extent, namely:

- the target group consisted of physicians that carry out their professional activity in a university town or who have at least attended courses organized in this centre;
- currently, the wide spread of the digital radiology, which tends to replace conventional classical radiology, can greatly reduce the amount of waste generated by this activity.

The first finding of the study reveals a somewhat unexpected issue, namely that only 33 people responded of a total of 90 people who were distributed the questionnaire.

Given that the number of private practices has increased from year to year, we find that dentists tend to perform dental X-rays in their own practices. Therefore, a percentage of 81.8% of those polled operate in a private practice equipped with radiological equipment, in which the main dentist performs X-rays according to the diagnosis and purpose set. Of all the physicians surveyed, a significant percentage are using more and more digital radiology, performing an average of 46.68 digital X-rays/week and 2063.75 digital X-rays/year, which significantly influences the study results, in terms of the use and production of waste in smaller amounts than in the past (Aps, 2010; Deliens and De Deyn, 1984). The radiological activity carried out in the medical practices included in our study generates an average of 200 mL/month developer and fixer, with an average of 20.3 conventional films/week and 710 conventional films/year.

Based on the responses obtained we found that the processing solutions used had been disposed of properly: in a proportion of 69.6% by collection into a special container to be handed over to specialized companies and 12.1% by collection in order to recover the silver from the fixer. 30.3% of the old exposed films are collected in a container for hazardous waste compared with 27.2% that are reported not to be preserved in the practice, but handed over to the patient at the end of treatment. There are also doctors who collect them in containers for non-hazardous waste or bacteriological risk waste in an equal proportion (Fig. 1). The physicians involved in the study show a correct attitude in terms of the collection of the old films, past the due date exposed and unexposed radiographic film, which they store in a special container for toxic waste.

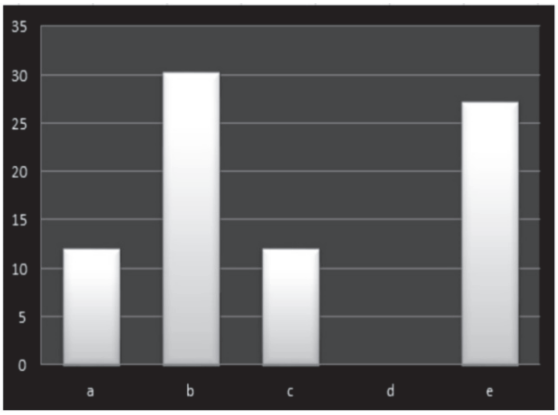

Fig. 1. Methods of collecting old exposed films (percentage)

Regarding the collection of the film lead foils, the answers are correct in proportion of 66.6% (Fig. 2); however, there are some doctors who consider them to be non-hazardous, with a non-bacteriological risk.

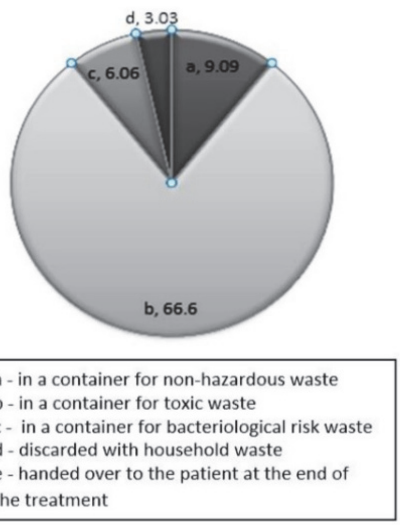

Fig. 2. The collection of the film lead foil in the dental film packaging

The opinion about recycling radiographic film was mostly favourable to the reuse of their component substances (42.4%).

4. Discussions

The study addresses a real and still current issue; as long as there is still even one practice where conventional radiography is performed, generating toxic substances, i.e. substances and preparations which, if inhaled or if they penetrate the skin, may cause serious acute or chronic diseases, and even death (Grigoletto et al., 2011; Nordberg et al., 2007; White, 2009). The analysis of the answers to the questionnaire addressed to dental practitioners who have dental radiology equipment, lead us to some useful conclusions for improving the current activity, while protecting the environment. The questions focused on different aspects of the issue that lies at the centre of the study, namely the management of the waste resulted from radiological activity (Aps, 2010; Hiltz, 2007; Muhamedagic et al., 2009).

In terms of the type of X-rays performed, we witness a reversal of the ratio between conventional and digital X-rays, in favour of the latter (66.6% vs. 33.4%). This is due, primarily to the accelerated technological progress of recent years, as well as to the attitude of dentists who want to improve the efficiency of their activity by: concentrating more specialized services within their own private practice, the provision of modern equipment, quick performance, profit growth and reduction of the number of employees. This accounts for the fact that 72.7% of those who perform dental X-rays are dentists who give up largely or entirely the use of radiology technicians, who carry out their activity alongside radiologists in university clinics. This is also facilitated by the ease of handling digital equipment and to the elimination of certain stages and substances that are characteristic of conventional radiology.

Since there are physicians who perform both digital and conventional X-rays, using the classical method of film processing with chemical solutions either in conventional tanks (15.1%) or in a developing machine (42.4%), significant amounts of waste are still generated. The same results are found in terms of the imaging media used: traditional film (45.4%), radiologic laser film (dry laser film) (33.3%) and CDs (39.3%).

The toxicity of the substances used in dental radiology (some of which become waste subsequently) was taken into consideration both by the physicians performing conventional X-rays and by those performing digital X-rays (Fig. 3). The developer and fixer were considered to be hazardous by most respondents and the flushing solution was declared to be hazardous by only a few. The figure also shows that only 23.3% are aware of the danger exposed and unexposed conventional radiographic film poses to the environment and human beings. Instead, a surprisingly number of them considered the laser film used in digital radiology to be hazardous, which can be interpreted as a lack of awareness or attention paid to the questions (Bohay et al., 1994; Shahab et al., 2012; Svenson and Petersson, 1995).

In a close enough percentage physicians are either aware (39.3%) or have no information (36.3%) on the fact that X-ray films can be recycled in order to reuse a part of the elements in their composition. The percentage of those who say that certain elements in the composition cannot be reused is identical (12.1%) to that of those who do not know that silver can be recovered from the fixing solution (Goshima et al., 1994; Shahab et al., 2012).

In terms of environmental protection, 78.7% of them know the technical regulations on the handling and management of toxic substances used in radiology. This statement is consistent with the responses on the procedures for the disposal of waste substances used in developing X-ray films, with the majority (69.6%) of them opting for collecting them in a container and to deliver them to specialized firms, which, in fact, provide limited and insufficient information regarding the exact manner of elimination and neutralization of these toxic substances. A small number of dentists are aware that silver can be recovered from the fixing solution. (ADA Council, 2003; Goshima et al., 1994).

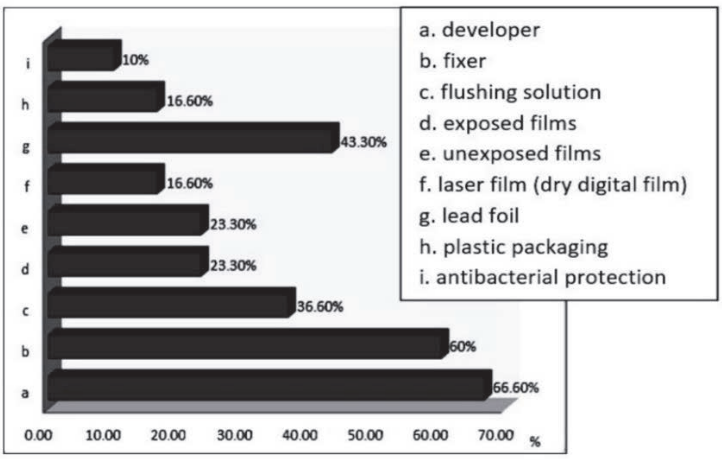

Fig. 3. Opinion on the toxicity of the substances used in dental radiology

Consistently with the statement that they know the technical standards on the management of toxic substances, many physicians say that they know about the methods for neutralizing toxic waste and more than half of them do not consider them to be a threat to the environment (Anderson, 1999; Sáez-Martínez et al., 2016; Shahab et al., 2012). It is worth noting that a large number of dentists believe that the methods of neutralization of waste from dental radiology practices are not hazardous to the environment, but only a small number of dentists consider them to be recyclable. There is also the reverse to this attitude, which appears to be somewhat surprising, namely that the largest number of dentists who consider them to be recoverable associates with a relatively high number of dentists who consider the neutralization of this waste to be an environmental hazard (Fig. 4). In fact, a large part of the answers seems to be based more on assumptions than on an informed opinion of dentists who carry out dental radiology activities.

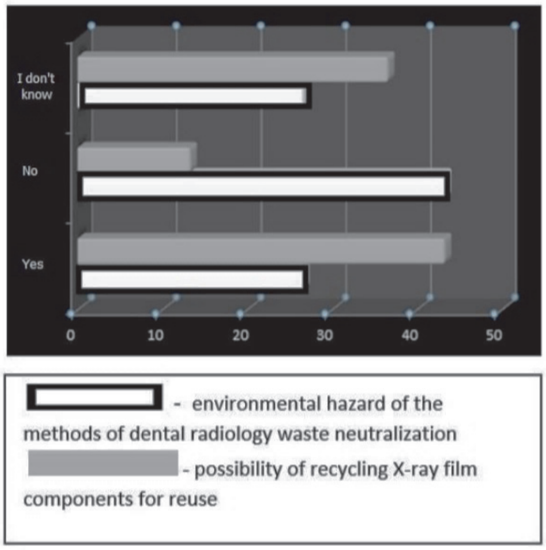

Fig. 4. Opinion on the environmental hazard of the methods of dental radiology waste neutralization and the possibility of recycling this waste

Regarding the lead foil, the number of those who recognize its toxicity is quite low (43.3%), although 70% of the respondents stated that they collect it in a container for toxic waste as an answer to the explicit question on managing this type of waste. This demonstrates that dentists are aware of the environmental hazard of uncontrolled disposal of these materials, but do not know enough about this type of waste (Guedes et al., 2009; Tsuji et al., 2005). Typically, protective foil is disposed of with paper waste, which is an environmental hazard presenting a potential risk of poisoning for beings. The proper management of this waste is identical with the one recommended for unexposed films, namely separate collection and return to the manufacturer for recycling (Anderson, 1999; Hiltz, 2007; Swanson et al., 1999).

5. Conclusions

Despite increasing competition from digital radiology, conventional radiology is still used in dentistry and is a major source of hazardous waste to the environment and to human beings. The management of the dental radiology service includes, besides the purely professional activity, the collection, storage, handing over of the waste substances, coupled with proper information on the entire cycle of elimination, neutralization, reintegration, which provides an ecological perspective to the practice of dental radiology. The X-ray technique involves radiation, but resulting wastes are not irradiated or radioactive.

The toxicity of these wastes can be high depending on many factors including the number of dental x-rays done in the practice. Digital radiology has a number of advantages over traditional film-based radiology: high speed of image acquisition, reduced exposure to radiation of patients and medical staff and elimination of the chemicals from the image processing cycle, which represents a significant contribution to environment protection. We found that many dentists do not know or do not use appropriate methods in radiological waste management, which can be incriminated in environmental pollution.

The questionnaire addressed to dentists revealed that most of them know the theoretical aspects of the handling and management of the toxic substances used in radiology and claim that they apply them properly in everyday practice. Due to the small number of respondents (2/3 of the dentists have not returned the questionnaires), the results also show the lack of interest from the respondents and that contradicts the fact they are aware of the results of malpractices. In many cases, the age of the respondents and the geographical area where they work, can be an important factor. In other situations, people do not reply because they fear the responsibility and also the need to spend money to implement treatment of their wastes or having to hire professional companies to do it.

This study is typical of a pilot research study, requiring further investigation by enlarging the group of respondents and by distributing detailed questionnaires on the management of the waste products resulted in dental radiology practices.

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