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# Development of a thyroid shield with recycled material for use in dental radiology

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**Abstract:** Due to the great importance of radiation protection in dental services, in this work we aim to develop a thyroid shield from reusing lead foils contained in dental periapical radiographic films. To manufacture the thyroid shield, 300 lead foils contained in intraoral film packets were collected in dental offices in the city of Marabá, in Para State, Brazil, and reused for made the shield. It was observed that this shield made from recycled material is as effective in radiation shielding as those already on the market. The methodology presented here for the manufacture of thyroid shield is simple, effective, and inexpensive. This personal protective equipment constructed from recycled material is as effective as those already on the market, although it is still necessary to evaluate the new thyroid shield with more comprehensive testing

**Keywords:** X-Rays, Radiation Protection, Thyroid Shield, PPE

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## 1. Introduction

The thyroid shield is one of the types of personal protective equipment (PPE) required for those who make use of ionizing radiation. This protection, as well as other PPE, serves as a barrier to these radiations if properly used and when does not interfere with diagnostic [1]. Thyroid shield is also named as thyroid collar or thyroid guard.

Thyroid gland is one of the most radiosensitive organs in head and neck region. This factor makes it necessary to use thyroid collar by patients in radiological examinations, since this use enables reduce up to 10 times the amount of radiation absorbed [1,2].

Despite the thyroid gland cancer is a rare disease if compared with other existing cancers, the incidence of tumors in this organ has increased annually [3, 4, 5]. Studies relate this augment to various factors such as increasing rates of cancer diagnosis, the heavy use of cell type, B ultraviolet radiation, and well as the association of malignant tumors in the thyroid glands and dental radiology [3, 6, 7]. Although it is not entirely clear how much radiation is

contributing to the increasing incidence of thyroid cancer, it makes sense to reduce radiation exposure, especially of children [8]. It is probable that the natural radiation has little influential for this disease, since it is estimated that annual effective dose due to this radiation is in the range between 1 and 10 mSv.

In radiology, radiation exposure of the thyroid gland varies with the type of technique and equipment used. In dental radiology, in a complete-mouth survey, the effective radiation doses in thyroid gland can vary from 0.01 to 1.75 mSv. This amount of radiation is much higher than that thyroid received due natural radiation from the sun and space. Under the current radiographic recommendations, this amount of radiation in the thyroid is considered large enough to produce damaging effects on this tissue. Since then, a shield is required to prevent radiation reaches the thyroid gland [3, 8, 9]. Thyroid collar and rectangular collimation for intraoral radiography are the shields more effective for this radioprotection.

Radiology requires that special attention be given to the radiological protection of patients and practitioners alike, as

well as to image quality for correct diagnosis [10].

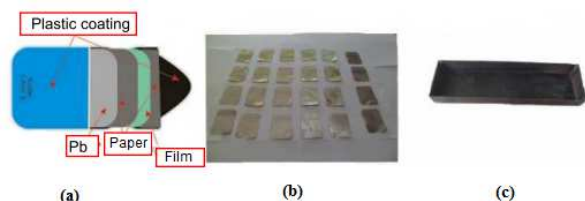
Although thyroid shields are available commercially, in this paper we develop a methodology to manufacture these shields using lead contained in intraoral dental film packets.

Intraoral film packets contain a paper liner around the film and a lead foil on one side. Normally, vinyl is used as the packet material. The lead foil helps protect the film from secondary radiation during exposure. After the use of the film, the vinyl wrap and the sheet paper that coating the film should be discarded in regular trash, but the lead must have other disposal, because it is a toxic material. So, to avoid incorrect disposal, it has been recycled for new uses. The possibility of reusing such lead foils in another application to radiation protection is the main motivation of this work.

## 2. Materials and Methods

The raw material used was lead shield contained in film packets utilized in intraoral dental radiographic. To this, we collected 300 lead foils from dental offices in the city of Marabá, Pará, Brazil.

Figure 1(a) shows the contents of a film packet of periapical radiology. The film, paper and lead have dimensions of  $4 \times 3 \text{ cm}^2$ . Figure 1b shows some lead foils after have been removed from the film packets. The canister used to melt the lead foils is showed in figure 1(c).



**Figure 1.** (a) Representation of periapical dental X-ray film; (b) lead foils to be melted; and (c) the container where the foil were melted.

The evaluations of the thyroid shield were held in dental x-ray equipment, Dabi Atlante, type mobile column, comprising a control panel, an arm extender tube and X-ray. To the analyses we used periapical films (DFL-EV-58) with size  $3 \times 4 \text{ cm}^2$ .

The tests for evaluating of thyroid shield were conducted in two ways, in the first way periapical films were placed under the shield and exposed to X-rays; in the second, only half of the film was exposed to the radiation beam, and the other half shielded by the lead plate of the thyroid collar. After developing the films, it was observed with the aid of a light box whether or not the radiation had been block by the lead foils and lead plate.

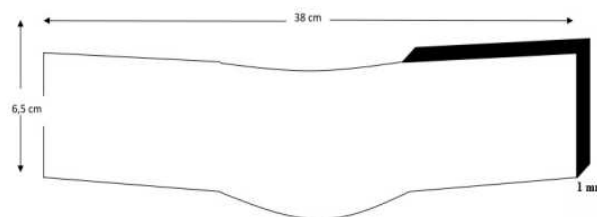
Time exposure was 0.5 s for all tests. According to the film manufacturer recommendations, this exposure time is considered ideal for the radiographs.

Protectors lead in dental sold, has a thickness of 0.2 mm Pb, and allow spending 0.32% of the radiation to a range of 70 kVp and 3.2% for 100 kV [11]. The protector made in this work is 2.5 mm thick in order to have better results on the screen at the time of dental X-ray examinations.

The outer covering of the thyroid shield was made with Napa leather.

## 3. Results and Discussion

The lead plate used to make the thyroid shield has the dimensions of a commercial thyroid collar, with  $65 \text{ mm} \times 380 \text{ mm} \times 1 \text{ mm}^3$  in its largest dimensions (Figure 2). A plaque prepared with the lead foils served as a base material for the design of the shield thyroid (Figure 3).

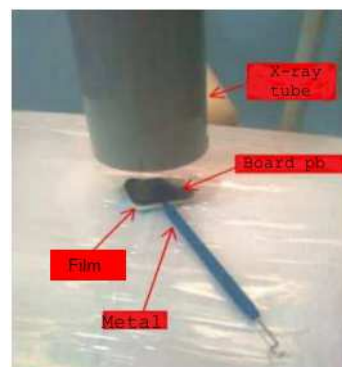


**Figure 2.** Industrial design of the thyroid protector length, width and thickness.



**Figure 3.** (a) Representation of lead plate without form of thyroid shield, and (b) in the final format.

In initial tests, it was verified how much the lead foils absorb X-ray beam (Figure 4). For this test, an object of steel was placed between one lead foil and the periapical film. As can see in Figure 5, the steel artifact appears in the image when such artifact was covered with just one foil, because the radiation emitted by dental X-ray equipment is poorly absorbed in this thickness of lead. In other words, a shield made with the approximate thickness of only one lead foil does not absorb the radiation efficiently. The following steps are described below.



**Figure 4.** Test conducted to determine which would be the thickness of the lead plate.



**Figure 5.** Image obtained with the artifact steel between lead foil and the film.

The test performed with three lead sheets superimposed on the artifact steel also showed an unsatisfactory result in absorption of radiation (Figure 6).



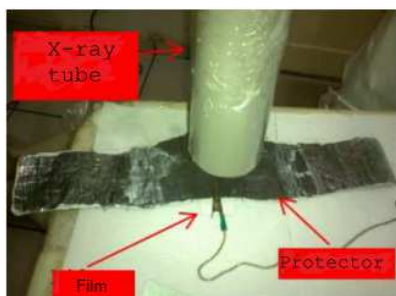
**Figure 6.** Test performed with 3 lead foils overlap.

The desired result was reached in the experiment in which five lead foils were superimposed on the artifact, because after the film exposition to X-ray, the obtained image from this film showed no sensitization by ionizing radiation neither the image of artifact, as it can be observed in Figure 7. These overlapping of five lead foils have a similar thickness to the commercial model, 1 mm, approximately.



**Figure 7.** Image obtained with overlapping of five lead foils.

Once adequate lead thickness has been known, the thyroid shield was made with a lead plate in the same thickness. Figure 8 shows the lead plate of the thyroid shield when it was irradiated.



**Figure 8.** Test performed with the lead plaque of the thyroid shield.

Figure 9 shows one of the results obtained in the tests with the lead plate. To obtain this image, half of the film was positioned under the plate and the other half was exposed to direct X-ray beam.



**Figure 9.** Film with a half exposed to radiation and the other shielded.

After the lead plate has been prepared with a proper format of shield thyroid, it was covered with plastic (Figure 10). It is noteworthy that this plastic used in this primer coating was also obtained from the intraoral film packets. This first coat has the intended to prevent contact with the outer lead shield thyroid.



**Figure 10.** Shield with plastic coating.

From the steps followed above, the outer coating was made of fabric with Velcro so that the thyroid collar can be adjusted on the neck of the user. The shield in its final form is shown in figure 11.



**Figure 11.** Thyroid shield in its final form.

According to the dentists from Maraba city, PA, Brazil, on average, from 1 to 4 dental X-rays are performed per day, and about 24 to 96 per month.

The making of thyroid shield from the reuse of lead foils contained in intraoral film packets showed satisfactory results. The possibility of this type of reuse of lead contained in these packets can prevent such material be discarded as medical waste or to be dispersed in the environment, contaminating soil, water, food and animals.

As we can see, the lead plates of the film can be melted down and reused to made thyroid shield, as well as other shields for radiological protection as plumbiferous aprons, gloves, skirts, for example.

In Brazil, the cost of a thyroid collar in a store that sells hospital supplies ranging from R\$ 80.00 to R\$ 160.00, which is equivalent to US\$ 35.00 and US\$ 45.00, approximately. Nowadays, this protection may already be sold along with the lead apron, making it even more expensive. The methodology presented here for the manufacture of thyroid shield is simple, effective, and inexpensive, with an approximate price of US\$ 7.00 per unit.

This personal protective equipment constructed from recycled material is as effective as those already on the market, although it is still necessary to evaluate the new thyroid shield with more comprehensive testing. This thyroid shield made from recycled material can be used in any dental office while performing radiological exams, both by staff, patients and individuals from the public at all times when they are exposed to ionizing radiation.

#### 4. Conclusion

The results obtained in this study were satisfactory, the reuse of lead foils contained in dental periapical radiographic films can contribute significantly to the conservation of the environment, avoiding contamination by this metal.

The thyroid shield made with lead foils have high efficiency for shielding radiation beam of X-rays used for periapical images. In its confection for use by people, the lead plate was coated with plastic obtained of also reused intraoral film packets. This plastic protection prevents contamination user by lead shielding and protects the lead of the climatic conditions of the Amazon region. Besides the plastic coating, another external coat provides user comfort.

The thyroid collar, besides its low cost and for represents an opportunity to reuse the lead foil, is also extremely important personal protective equipment for individuals exposed to radiation in X-ray dental examinations.

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