European ALARA Network

The Use of Thyroid Shields in Dental Radiography

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Introduction

In the UK, the current Guidance Notes for Dental Practitioners on the Safe Use of X-rays state that "Thyroid collars should be used in those few cases where the thyroid may be in the primary beam, based on advice from an MPE [Medical Physics Expert]" (NRPB, 2001).

The question of whether thyroid shields are beneficial has come to the fore recently due to a number of factors, including:

- the introduction of new imaging technologies such as cone beam CT (CBCT), which have been generally associated with higher patient doses
- high profile publications linking dental radiography to increased cancer risks
- national organisations promoting the use of thyroid shields

This has left many dental practitioners unsure as to whether they should, or indeed are required, to provide thyroid shields for their patients. This paper reports a review of the available evidence for the use of thyroid shields in dental radiography.

For most patients the thyroid will not be within the X-ray beam (see Figure 1) and therefore current UK advice indicates that thyroid shields are not normally required.

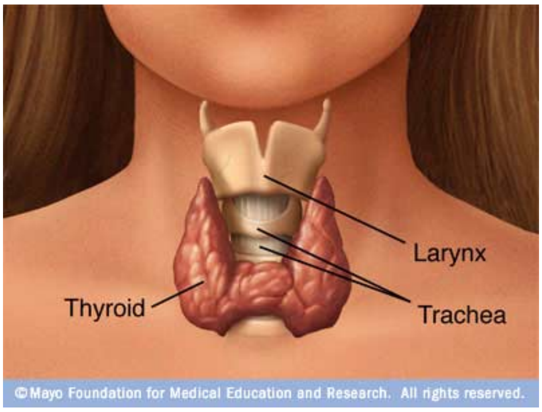

Figure 1. - The location of the thyroid

There are some dental radiographic exams where the thyroid will be within the primary beam (eg. maxillary anterior occlusal radiograph), however these are not common examinations for a general dental practice. There may also be circumstances where difficulties with certain patient groups may require the use of unusual positioning techniques, which could place the thyroid within the primary X-ray beam.

Figure 2. - A typical thyroid shield

Figure 2 shows a typical thyroid shield. The shield is wrapped around the patient's neck and contains a sheet of lead or lead equivalent material (typically 0.5 mm of lead) to reduce the radiation exposure of the thyroid.

Literature review

A search of the literature was carried out to determine the current evidence base related to dental radiography and thyroid exposure. This search focused on measured doses to the thyroid and the efficacy of thyroid shields. The resultant documents were reviewed to ensure that they were appropriate to the topic of interest. A brief summary is provided of the relevant documents, in chronological order.

Sikorski and Taylor (1984) showed a reduction in thyroid exposure of 5-56% for a full mouth series of radiographs, 2-18% for bitewing radiographs and 10-79% for panoramic radiographs when using a thyroid shield. The choice of collimation and technique were not detailed for intra-oral radiography, however, given the date of this publication it is likely that circular collimators and the bisecting angle technique were use.

Schmidt, Velders and van Ginkel (1998) showed that a thyroid collar reduced the equivalent dose to the thyroid for intra-oral periapical radiographs but not for bitewing radiographs. The choice of collimation and technique was not discussed.

Rush and Thompson (2007) considered the entrance dose to the thyroid from intra-oral radiography. The authors looked at the choice of collimation, technique and provision of a thyroid shield over a range of anatomical views. The maximum thyroid entrance doses over the range of anatomical views is summarised in Table 1 below.

Collimator, Technique, Thyroid shield	Entrance Dose (µGy)
Rectangular, Bisecting angle, no shield	9.5
Rectangular, Paralleling, no shield	1.5
Circular, Bisecting angle, no shield	13.5
Circular, Paralleling, no shield	4
Rectangular, Paralleling, shield	0.4

Table 1. - Summary of results from Rush and Thompson (2007)

Hujoel, Hollender and Bollen (2008) showed that the equivalent dose to the thyroid was 32-92 µGy for intra-oral radiographs, 330 µGy for posterior anterior (PA) cephalometric radiographs and 90 µGy for panoramic radiographs. For intra-oral radiographs, circular collimation was used and the choice of technique was not described.

Sheikh (2010) showed the entrance dose to the thyroid was 109 µGy for a full mouth series and 15 µGy for a single maxillary occlusal radiograph. A circular collimator and bisecting angle technique were use.

Koivisto et al. (2012) estimated the equivalent dose to the thyroid of 800 µSv for a CBCT radiograph (exposure factors used were 8 cm x 8 cm field of view, 84 kV and 145 mAs giving a dose area product of 574 mGy cm^2).

Grünheid et al. (2012) determined equivalent doses to the thyroid to be 167-367 µSv for CBCT, 67 µSv for a panoramic radiograph and 30 µSv for a lateral cephalometric radiograph.

Toossi, Akrabi and Roodi (2012) measured the entrance dose to the thyroid to be on average 38 µGy from panoramic radiographs.

Qu (2012) looked at equivalent doses to the thyroid for different CBCT radiographs with and without thyroid shields. The results are shown in table 2 below.

Field of view	Equivalent dose to thyroid (µSv)			
	No shield (µSv)	Shield front (µSv)	Shield front and back (µSv)	% Reduction in thyroid dose (front shield)
20x19	1895	625	728	67%
16x10	2700	768	740	72%
16x7	2360	695	695	71%

Table 2. - Summary of results from Qu (2012)

Han et al. (2013) considered the use of thyroid shields in panoramic radiography. The results for the equivalent dose received by the thyroid are summarised in Table 3. They concluded that the thyroid shield reduces the equivalent dose to the thyroid for digital radiography but not for film imaging. The authors also considered the use of a second thyroid collar positioned around the back of the patient and found that this offered no significant additional dose saving.

Machine	Dose without thyroid shied (µSv)	Dose with thyroid shield (µSv)	% Reduction in thyroid dose
GE OP200 (film)	27.89	25.20	10%
Sirona Orthophos CD (film)	67.87	58.87	13%
Sirona Orthophos XG plus (digital CCD)	54.60	43.95	20%
Planmeca Promax (digital CCD)	54.95	42.60	22%

Table 3. - Summary of results from Han et al. (2013)

Effect of intra-oral radiographic technique

One letter to the editor in a dental journal (Hamilton, 2012) called for a review of the use of thyroid collars, citing policy statements in the UK, EC and USA. The letter presented an the image on the left below (Figure 3a) as an example of the thyroid being in the primary X-ray beam for an upper anterior periapical radiograph.

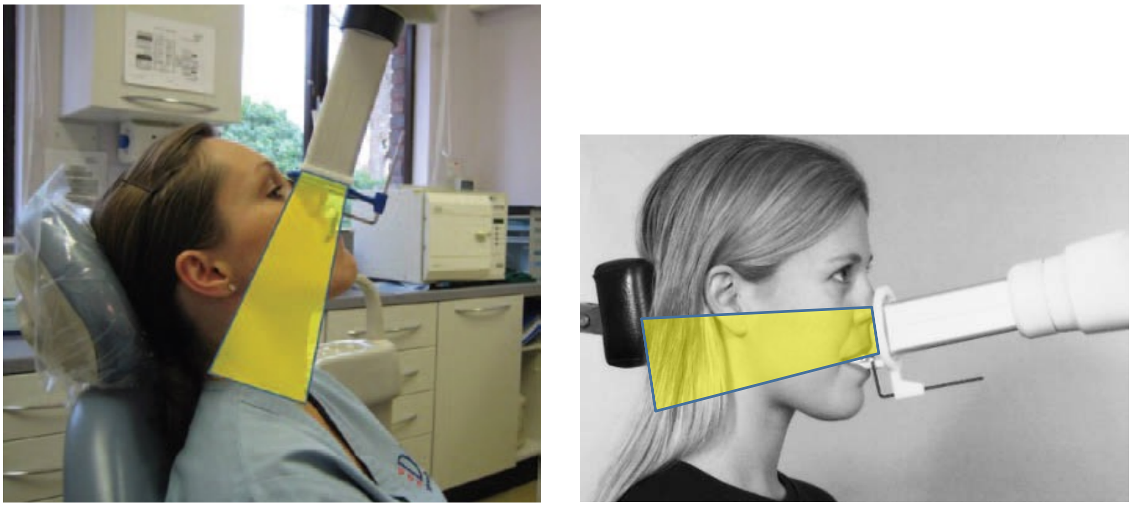

Figure 3. - Intra-oral cone positioning for a maxillary incisor shown in (a) Hamilton (2012) and (b) Whaites (2002)

Figure 3a shows the X-ray tube directing the X-ray beam towards the thyroid; however, this image shows unusual operator technique. Figure 3b, on the right, shows the standard positioning for this radiograph using the paralleling technique (Whaites, 2002). For a long time, the paralleling technique, which should not cause the thyroid to be directly exposed, has been the recommended intra-oral imaging technique in the UK. However, there may be exceptional cases where this positioning cannot be used and the operator should then consider using a thyroid shield, if the thyroid would be directly exposed, in line with current UK advice.

Organisational policy statements on the use of thyroid shields

The UK position on the use of thyroid collars is similar to that of some other countries; including New Zealand where thyroid shields are recommended for projections such as the vertex occlusal exam (National Radiation Laboratory, n.d.) and Ireland where the Radiological Protection Institute of Ireland (RPII) states that "Where the thyroid will be exposed, special consideration should be given to the shielding of the thyroid. A thyroid collar may be required where intraoral radiographs with circular collimation are taken on persons under the age of 30 years" (RPII, 2011).

Guidance published by the European Commission (EC) recommends shielding where the thyroid is "very close to" the X-ray beam (EC 2004, 2012). No definition of "very close to" is provided, however it does acknowledge that "it is probable that rectangular collimation for intraoral radiography offers similar level of thyroid protection to lead shielding, in addition to its other dose reducing effects" (EC, 2004). In the USA, the NCRP (2003) requires thyroid collars for children and recommends them for adults. The Image Gently alliance has also recommended that dentists should "always use thyroid collars" when radiographing children (Image Gently, n.d.). The American Thyroid Association (ATA) goes further and recommends thyroid shields for adults as well as children, "The ATA thus endorses the recommendations of the National Council on Radiation Protection & Measurements (NCRP)

Report 145, Radiation Protection in Dentistry, 2003. However, it urges a reconsideration of the less stringent requirement put forth for thyroid shielding in adults as compared to children" (ATA, 2013). The American Dental Association (ADA) (2012) recommends thyroid shields "whenever possible".

Discussion

It is evident from all the policy statements that they do not reference any published papers that demonstrate the benefits of thyroid shields, therefore it is hard for the reader to understand the basis for the recommendations.

The use of the paralleling technique for intra-oral radiography is not explicitly recommended in any policy statement. Although the paralleling technique is the recommended intra-oral imaging technique in the UK (Whaites, 2002), the bisecting angle technique was found to be widespread in a 2003 survey. This showed that 48% of respondents in the UK used the bisecting angle technique either always or often (Tugnait, Clerehugh and Hirschmann, 2003), therefore it is probably still widely used today. A change to the paralleling technique is a relatively straightforward change in clinical practice which would significantly reduce thyroid exposure.

There is only one study where different techniques were compared (Rush and Thompson, 2007). This showed the use of rectangular collimation reduced the thyroid entrance dose from 4 μGy to 1.5 μGy and the use of paralleling technique from 9.5 μGy to 1.5 μGy. The use of a shield further reduced the entrance dose from 1.5 μGy to 0.4 μGy. This indicates that the appropriate choice of technique has the most significant influence on thyroid dose, the thyroid shield having a similar effect to using a rectangular collimator instead of a circular collimator.

The type of radiograph clearly influences the dose to the thyroid, with some evidence of no or very little benefit of a thyroid shield for bitewing radiographs but significant dose saving for other views (Sikorski and Taylor, 1984; Schmidt, Velders and van Ginkel, 1998). This is as expected, as the X-ray beam passes close to, or exposes, the thyroid for some views.

One study (see table 3) considered four different panoramic X-ray machines and showed that the thyroid shield had a significant effect on reducing the equivalent dose to the thyroid when using two of the four machines (Han et al., 2013). The two machines where the thyroid collar was beneficial used digital imaging systems. The authors' conclusion that digital imaging reduced the dose to the thyroid is difficult to confirm with such a small number of systems. The size of the X-ray beam, choice of exposure factors, geometry of the scanning system or small changes in positioning of the shield or patient could all account for the results seen and these aspects are not inherent to either film or digital imaging. The reported results appear to support this, as one of the film systems gives a significantly lower dose to the thyroid, without a shield, than the two digital machines when using a shield. This result would suggest the choice of equipment to be have significantly more influence on the reduction of thyroid doses than the use of a thyroid shield.

The ranges of thyroid doses, without the use of thyroid shields, presented in the literature are summarised in Table 4.

Type of radiograph	Equivalent Dose (µSv)
Intra-oral	1.5-13.5, 15, 32-92
Panoramic	27.9-67.9, 38, 67, 90
Lateral Ceph	30, 330
CBCT	167-367, 970, 1895-2700

Table 4. - Summary of the range of thyroid doses presented in the literature reviewed in this report

Table 4 shows the significant differences in reported doses. Most papers do not provide details of the exposure settings selected on the X-ray set, so the differences could be explained by the choice of exposure settings on the machines, the measurement method used or the positioning of the phantom.

In the case of CBCT, patient doses are generally higher than other types of dental radiography therefore as would be expected the doses to the thyroid are higher than other techniques. The equipment reported in the literature is generally large field of view scanners that will expose the thyroid to higher levels of scattered radiation than small field of view scanners.

Conclusion

Thyroid shields are capable of reducing the thyroid dose received by a patient during some dental radiography procedures and there is only a small associated cost. These two factors have probably led to the publication of policy statements recommending their use. It should be recognised, however, that the thyroid will always be exposed to some level of radiation due to internal transmission and scatter in the body.

For intra-oral, panoramic and cephalometric radiography, the use of appropriate equipment, exposure factors, technique and collimation all have equal or greater influence on the dose to the thyroid. As these factors also reduce both the effective dose to the patient and the exposure of the operator, these should be advocated ahead of the use of a thyroid shield.

For CBCT radiography, there may be a role for thyroid shields, however due to the paucity of data this must be a decision made by the practitioner in consultation with a Medical Physics Expert, taking into account the specific exam and model of CBCT.

For all extra-oral imaging the operator would need to ensure that the thyroid shield is outside the primary X-ray beam, otherwise it may render the image unusable and require a repeat radiograph without the shield.

On the balance of available information, it is considered that the existing UK guidance is appropriate and proportionate to the risks associated with exposure of the thyroid. Further research into the benefits of thyroid shields in CBCT radiography, especially for small fields of view, would be welcome.

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