Author's response to reviews

Title: Thyroid Shields and Neck Exposures in Cephalometric Radiography.

Authors:

Philippe P Hujoel (hujoel@u.washington.edu)
Lars Hollender (larsholl@u.washington.edu)
Anne-Marie Bollen (mine@u.washington.edu)
John Young (ydy2@u.washington.edu)
Joana Cunha-Cruz (silvajcc@u.washington.edu)
Molly McGee (mkmcgee@u.washington.edu)
Alex Grosso (grosso@u.washington.edu)

Version: 2 Date: 17 May 2006

Author's response to reviews: see over
Response to issues and comments raised by first Reviewer: Keith Horner

We would like to thank the reviewer for his excellent comments and suggestions. The manuscript has been modified substantially as a result of his comments.

**Comment 1:** This work has a number of weaknesses. First, as acknowledged by the authors, it is limited in its value by reflecting practice in a single educational dental institution.

**Response:** As the reviewer correctly indicates, this is a weakness of the study that was pointed out in the report. We also provided evidence that this practice was not limited to the University of Washington.

- **a.** We surveyed 24 issues of the American Journal of Orthodontics (2003-2004) shows that less than 10% of the evaluable cephalometric X-rays had thyroid collars visible.
- **b.** We contacted the manager of the X-ray control section of the Washington State Department of Health Radiation Protection. He observed during surveys in the 1990s that thyroid shields are rarely used for intra-oral films (2%), and occasionally used for extra-oral x-rays (5%) [12].
- **c.** A report of a survey on thyroid cartilage calcification at another major research institution suggests that at least one other institution did not use thyroid shields.
- **d.** The recent trend for orthodontist to look at C3 to determine skeletal age further suggests that non-utilization of thyroid shields may be more common than is asserted.

To emphasize that the study findings do not seem to be isolated to just one major research institution, we have modified the conclusions in the abstract as follows: "In agreement with other reports, thyroid shield utilization in this study was low, particularly in children.”

In addition, there is one aspect of the study which does not suffer from this potential problem of generalizability - the extent of neck structure exposed as a function of age and gender. Anatomist have reported that the soft tissues of the neck will drop with increasing age and that the thyroid descends through puberty {Crelin, 1973 #125}. However, there is currently no data quantifying this phenomenon. This is the first study suggesting that the hyoid bone descends with age, and that more neck structure is exposed in children than in adults. The abstract was re-written to emphasize the 2 distinct aims of this study. (1) to evaluate anatomical age-related changes in radiation exposures in the neck, and (2) to assess thyroid shield presence in cephalometric X-rays. Changes were made throughout the manuscript to reflect these two separate goals.

**Comment 2:** The results for frequency of use of thyroid shields are, therefore not of great interest to those outside this institution.

To our knowledge there are no reports on the actual utilization (as opposed to self-report) of thyroid shields in cephalometrics. If thyroid collar utilization is not common at a major research institution, and if there is evidence from various sources that it may not be common at other institutions/private practices, it is relevant information for determining cancer risk. It is important to have information on the extent to which the thyroid is exposed to diagnostic radiation in real-life (as opposed to doses received in phantom studies where optimal radiation protection methods are
There is a 10-fold difference in the dose to the thyroid depending on whether shielding is or is not employed. This study is – as far we know – the first to provide information to what extent shielding is employed in real-life. As more data becomes available on the real-life shielding of thyroids, a more accurate estimate of dose to the thyroid can be calculated.

**Comment:** Second, the ‘neck height’ above the edge of the lead (when present) is only a reflection of probable health risk. Thyroid position, and that of other relevant organs in the field, is not considered directly because they, of course, cannot be seen on the cephalograms.

Response: We agree with the reviewer. Quantifying the amount of exposed neck vertebrae is, unfortunately, the best one can do when calculating doses received to the neck. This comment applies to all organs which are non-visible on radiographs (e.g., prostate, esophagus, stomach). All cohort studies that have calculated thyroid cancer risks associated with radiation are based on assumptions of where the thyroid is located.

By using a retrospective study, the authors had to ‘best guess’ whether they were looking at a thyroid shield or full lead apron. I suppose the value of the study, at best, is that it might be answering the question, ‘how much coverage of the neck does lead protection truly give in practice?’. That would be OK, as I could be persuaded that hanging a lead apron around necks of patients would be much the same everywhere and the results could be generalised to other institutions. Instead, the message seems to get lost. What are the implications of this study?

Response: There is one major implication of this study; thyroid shields may not be used as commonly as is it is claimed. Since doses to the thyroid depend substantially on the presence/absence of a thyroid shield, we consider this finding to be of significance. If a T2 vertebra is visible on the cephalometric X-ray, we know there was a likely full exposure of the thyroid. On the other hand, if all we see on the cephalographic X-ray is a C2 vertebra, then the thyroid was in all likelihood not in the direct beam. The implications of this study are that thyroid doses may be underestimated or overestimated by a factor 10 when making the wrong assumption as to whether the thyroid was or was not in the direct radiation beam.

Comment: To me, despite the long discussion, the authors fail to get to the meat of the problem. Assuming that thyroid shielding is of any value, the authors should discuss how to improve neck coverage, perhaps by design of the shields. A far more important issue is whether use of shielding should be our great concern. The key radiation protection question is surely whether there is a need for cephalograms for much orthodontic work and, if there is, whether we should be improving beam collimation rather than relying on bits of lead hanging on the patient.

Response: We agree with the reviewer. A key point is indeed whether a cephalographic X-ray is needed at all. The best dose reduction is not to take a radiograph at all. The “European Guidelines on radiation protection in dental radiology” provide a useful guideline in this respect. Guidelines for taking cephalometrics were first published by Atchison in 1992, but without surveys or chart audits we do not know to what extent these guidelines are followed.
We found that orthodontic therapy is typically associated with 3 panoramic radiographs, 3 cephalographic films, and 1 full-mouth series of intra-oral films. These data at our institution are similar to the results obtained from self-report by orthodontists in California who reported that for each patient typically 3-4 pans and 3-4 cephs are ordered [17]. This is the number of cephalogric X-rays that are being taken.

In addition, the current US guidelines do not provide suggestions when not to use cephalographic X-rays. The FDA guidelines for radiographic examinations suggest that for monitoring growth and development for children and adolescents the following: “clinical judgment should be used in determining the need for, and type of radiographic images necessary for, evaluation and/or monitoring of dentofacial growth and development” [14]. Furthermore, the FDA provides no guidelines for diagnostic radiation during orthodontic therapy.

Similarly, there are currently no clear US guidelines whether thyroid shields should be used with cephalometrics.

We agree with the reviewer that the best protection is not to take a radiograph. However, the goal of this study was not to determine what should be done, the goal was to determine what is done. The goal of this study was to provide a survey of what is actually happening, not what we would like to see happen.

Comment: In Europe, where ‘individual justification of exposures’ is enshrined in national laws, cephalograms are not routinely used in orthodontics, but selected on the basis of individual need (e.g. no ceph in simple orthodontics with no skeletal discrepancy) and PA cephs are almost never used. Furthermore, appropriate beam collimation to the areas used for cephalometric tracing seems the obvious answer.

Response: We agree with the reviewer. Our study reinforces the need to follow available guidelines. To our knowledge this is the first study to provide verifiable data on thyroid shield utilization on real-life situations. If the reviewer is aware of studies that have looked at the prevalence of thyroid shield utilization, or an audit on the number of films typically taken by orthodontists we would be very interested in knowing about them. Unfortunately, there are many guidelines in health matters that are not followed. A recent report from Denmark suggests that 22% of the requested dental radiographic images were not opened within 3 months after they were taken, with orthodontists being the heaviest users of extra-oral films. Enshrining ‘individual justification of exposures’ in national laws was insufficient to avoid these unnecessary exposures in patients.

Major Compulsory Revisions (that the author must respond to before a decision on publication can be reached)

1. The authors should address the points raised above. In particular, they should consider whether the use of the thyroid shield matters in comparison with the issue of whether cephalograms are necessary at all and that of using better collimation.

Response: We agree with the reviewer that a major concern is the appropriate indication for cephalograms as a diagnostic tool in orthodontics. However, this study’s aim was not to determine how thyroid doses are best reduced, but rather
to survey the extent to which thyroid shields are used. This survey suggested that thyroid doses were not reduced by either (1) limiting the number of radiographs, (2) collimation, or (3) thyroid shield utilization.

2. P 13: last paragraph, beginning ‘Oversight is important’. This whole paragraph is semi-intelligible waffle and should be deleted.

Response: This paragraph was deleted.

3. P 15, paragraph beginning 'In the absence…'. I got lost here. Why should the orientation of the film influence the amount of tissue exposed? The amount of tissue exposed depends on the beam collimation; turning the film round through 90 degrees doesn’t change anything. Similarly later, the authors argue that the reason children and females have more exposed neck structure is because ‘film sizes are constant’. The film size is irrelevant.

Response: Film sizes are irrelevant if collimation or thyroid shielding are used. When no radiation protection mechanism is used film size is critical. The larger the film (and consequently the collimation used to permit the “print” of the image in the whole film), the larger the exposed body area. When taking ceps in portrait format, T2 is typically exposed. When taking ceps in landscape format, C7 is rarely exposed.

Minor Essential Revisions (such as missing labels on figures, or the wrong use of a term, which the author can be trusted to correct)

P 2: abstract. I have the typical basic stats knowledge of a dental radiologist, but I do not understand the term ‘secular variability’.

Response: The term “secular” was deleted.

P 3: lines 2-6: the sentence ends abruptly – something is missing.

Response: This was corrected.

P 5: line 4: can the authors clarify what they mean by a ‘systematic sample’?

Response: The term systematic was now explained in a separate sentence.

I was also a little confused by the dates ‘July and November 2005’, as later it is clear that the data were obtained from radiographs taken between 1973 and 2003. It does not say in the Methods section that the sample was an historical one taken over a twenty year period, unless I’m missing something.

Response: This was clarified. The dates July and November 2005 refers to the time the systematic sampling of the charts was performed. The charts are from patients in the orthodontic department that could have been seen as long ago as 1973.

Comment: P6: the statement ‘The most inferior vertebra….’ At the end of the ‘Anatomical neck features’ section is essentially repeated at the end of the subsequent section.

Response: Duplication was deleted.
I am not clear whether the entire ventral surface of a vertebral body needed to be present or any part of it for the vertebra to be considered ‘the most inferior’

Response: This issue was clarified.

P 6: despite the figures of radiographs, I am still not quite sure how reliable or meaningful the ‘best guess’ decision on thyroid shield versus lead apron really is.

Response: We agree with the reviewer. What we have is a best guess and we have illustrated with the figure the difficulty that may sometimes be present in determining whether a thyroid shield is present. The main point in our opinion is which is the most inferior vertebrae visible on the radiograph.

P 6: Statistical analysis. I’m sorry, I do not understand the statistics described. That may be my fault, but the editor might ask a statistical expert to have a quick look at these.

P8: what do ‘apical of the mandible’ and ‘apical of the hyoid bone’ mean?

Response: We have replaced the word “apical” with “inferior” which makes it now consistent with the explanation in the materials and methods.

P 8: penultimate line: ‘the most apical vertebrae that was…’ should say ‘vertebra was’ or ‘vertebrae were’.

Response: Correction was made.

P 14. Statement relating to increased scatter with thyroid shields (reference 26). I would hesitate to make this statement myself based on one paper in a very obscure journal. Unless all laws of physics are being altered, such a statement is bizarre. You do not get scatter in lead; you get photoelectric absorption. Thus it would not only absorb primary beam, but also absorb scatter.

P 14/15, paragraph beginning ‘Moreover…’. While I appreciate a full discussion, this seems so far removed from the subject of the manuscript.

Response: We have deleted this reference

Discretionary Revisions (which the author can choose to ignore)

What next?: Unable to decide on acceptance or rejection until the authors have responded to the major compulsory revisions

Level of interest: An article of limited interest

Quality of written English: Needs some language corrections before being published

Statistical review: Yes

Declaration of competing interests:
'I declare that I have no competing interests'
Reviewer's report

Title: Thyroid Shields and Neck Exposures in Cephalometric Radiography.

Version: 1 Date: 3 May 2006

Reviewer: david manson

We would like to thank the reviewer for his excellent comments and suggestions. We have substantially modified the manuscript following his suggestions.

Reviewer's report:

General
This article raises significant concerns regarding the appropriate use of radiation protection in the practice of dental radiography. Current guidelines as outlined by the ALARA (as low as reasonably achievable) principle mandate that any area of the body that is not of clinical interest must be excluded from the examination or must be appropriately shielded. While there are those who continue to question this principle, there is little doubt that this is widely accepted as standard of care in any radiographic examination. This study brings to light the relatively widespread neglect of this principle practised by many in the dental profession. Various explanations are entertained by the authors, most of which are thinly coated excuses for lack of attention to appropriate care. The theory of hormesis has not gained general acceptance and does not justify inappropriate shielding. Establishing a skeletal age has limited applicability in this population, and can be performed using the left hand/wrist examination when needed, without exposing radiosensitive organs. The authors have performed an excellent piece of work, with clear, unambiguous and critical conclusions based on solid data regarding the current state of radiation protection in dental radiography in a major US urban setting. The data collection and statistical methodology is sound.

My suggestions below are given to make the article more concise and readable. I leave them to the authors’ and editor’s discretion.

Major compulsory revisions
The discussion is too long, and can easily be shortened to keep the focus on the major points of the paper. The following portions can easily be excluded or shortened to a one sentence summary

We thank the reviewer for this useful suggestions. We have drastically shortened the discussion.

a. pg 12 paragraph starting with 'Self-reported statistics.....direct observations can be replaced with 'this survey is a self-reporting survey, open to overt selection and reporting biases’.

Response: paragraph was deleted and replaced by the reviewer’s suggested sentence.

b. Pg 13 “ paragraph limitation...that it dose can be deleted” this is obvious

Response: paragraph was deleted
c. Pg 13 paragraph 'oversight....in print can be deleted" it is not the role of the authors to present potential excuses for not using shielding, especially oversight

Response: paragraph was deleted
d. Pg 14 paragraph 'Moreover, the potential...determine’can be shortened to a short comment that even those who understand hormesis do not support the exclusion of radiation shielding.

Response: paragraph was deleted
e. Pg 17 'in conclusion ‘the reasons for such practises ....extra-oral radiography’ can be excluded not pertinent to the authors findings.

Discretionary/minor revisions

Response: sentences were deleted.

Abstract “ please define ‘secularar variability’

Response: “secular” was deleted”

Background

Line 6 ..to which thyroid shields are used.

Response: This sentence was modified.

2nd paragraph line 1 “ to determine prior to any...

Response: This sentence was deleted;

Major Compulsory Revisions (that the author must respond to before a decision on publication can be reached)

Minor Essential Revisions (such as missing labels on figures, or the wrong use of a term, which the author can be trusted to correct)

Discretionary Revisions (which the author can choose to ignore)