Methods for determining radiation exposure from dental x-ray examinations

For decades, numerous dosimetry studies have been conducted to determine the “magical” number that best defines radiation exposure dose for dental x-ray examinations. Dose values have been determined, but seem to change with time. Part of the reason is, as science, dosimetry is an evolutionary process. Since the mid 1980’s, dosimetry methods and data interpretation have become more standardized and changes less dramatic due to the influence of the International Commission on Radiation Protection (ICRP)\(^1\). They classified tissues/organs using a numerical radiation sensitivity rating and recommended the concept of the effective dose (\(E\)) to reflect exposure as a detriment to the whole-body. This approach essentially ignores only nominal sensitive tissues or lumps them into a low-risk remainder category. Although this reference is used for dosimetry data analysis, it is not without critics. Having indicated some of the issues associated with dosimetry studies, I would like to briefly describe the methods for obtaining and interpreting exposure data using my panoramic dose article\(^2\) as a reference model.

The preferred measurement is the absorbed dose to the internal critical organs. Since obvious limitations with living subjects exist, a standardized head and neck dosimetry phantom is used to simulate the patient exposure. The typical model (Fig. 1 A) contains a human skull embedded in a tissue-equivalent rubber type material. It is divided into several horizontal layers, which can be separated for access to simulated internal organs regions.

continued on page 14
President's Message

Craig Dial

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AADMRT Web Report

The www.aadmrt.com web site in its latest report shows that it has been visited by more than 1350 times in a given 30-day period. The 30-day scale was tracked from January 20th to February 18th. This report tells us that our web site is getting consecutively more hits every month, and the site is being visited by many more countries from around the world.

Other reports (not shown) inform us that 287 people have visited the site for the very first time. The most downloaded files were the newsletters with the fall 2001 Currents downloaded 129 times.

Photo Contest Membership Directory Winner!

The winner of the photo contest for the cover of the AADMRT 2002-2003 membership directory is Lyn Spencer of Clayray Radiographic in Melbourne, Australia. I asked Lyn to describe her photo, and she said:

“The photo was taken on a Minolta Dimage 7 digital camera, at the Lavender Harvest festival in country Victoria, Australia. It is a close up of Italian lavender, with fields of lavender in the background. The harvest is carried out in traditional style at a commercial lavender farm known as “Lavendula”. The day was celebrated with English country dancing including maypole dancing, gourmet foods, demonstrations of country crafts.”
News and Trends

Diagnostics Leads Dental Services

This graph provides information of what specific type of dental service Americans receive for 1987 and 1996. The percentage of all dental procedures means that at least one procedure type was performed per visit. Please note that diagnostic services have increased about 10% over this nine year study.

Dates To Remember

AADMRT Convention 2002
September 19-21
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U.S. Web Site for NewTom

The NewTom volumetric x-ray machine now has an official U.S. web site. The U.S. Distributor Web site of the Newtom QR-DVT-9000 is:
www.aperioservices.com
As a dental student and while working as a General practitioner, I developed a special interest for the disease of the maxillo-facial complex and their radiologic presentation. In pursuing this interest, I graduated from the university of Toronto in 1987 as a specialist in Oral and maxillofacial Radiology. At the time of my training, a special interest and emphasis was placed on the principles and practice of radiologic interpretation, and the correlation between different disease mechanisms and their radiologic presentation. I am very proud of being the graduate of the Toronto program.

I also completed the Fellowship Examinations of the Royal College Dentists of Canada in the specialty of Oral Radiology soon after graduation, then in 1998 I moved to Calgary with my husband, and son Peter.

In Calgary I have associated with the Wilson Radiographic Centre as part owner and partner. Historically, Dr.’s B. Hoffman and R. Wolk opened the Wilson Radiographic Centre in 1983; Dr.’s Hoffman and Wolk are recognized orthodontists in Calgary for more than two decades. At the time of opening the Wilson Lab, their goal was to produce American Board Quality Orthodontic records. These high quality services have been offered to the Calgary Dental Community as well.

With myself coming on board as an Oral Maxillofacial Radiologist in 1997, the operation extended into the field of Diagnostic Radiology. The name then changed to Wilson Radiographic and Diagnostic Centres Ltd. We have expanded our facility and incorporated new imaging equipment. The Comm-Cat complex motion tomographic unit was the most important part of this expansion.

Presently our services include the following large categories:
* Implant imaging
* Temporomandibular joint imaging
* Radiologic lesion investigation  Patients are often referred to our clinic for investigation of a certain condition. This is a very challenging and interesting part of our everyday practice. Imaging is also provided for oral and maxillofacial surgeons prior to patient surgery.
* Radiology Interpretation  As the dental consultant for a medical radiology group, I also provide interpretation on MRI examinations of the temporomandibular joints from other individual dental practices and once again this is very challenging. In many cases, further referral is suggested for other imaging procedures, such as a CT or MRI.
* American Board Quality Orthodontic Imaging  This includes digital photography and computerized cephalometric analyses. Our highly motivated and trained staff take special pride in correctly tracing the cephalometric views.
We are striving for excellency in all aspects of our everyday work. Special emphasis is placed on patient management. We spend lots of individualized time with each and every patient. Prior to the imaging procedure, details and particularities of the process are discussed in detail with every patient. Therefore, there is excellent patient collaboration. Images are shown to the patient after completion of the imaging procedure and I also take the time to discuss briefly the findings after TMJ surveys, implants or radiologic lesion investigation.

I am happy to work with a dedicated staff. Linda and Rhonda are RDA level II, working very competently as radiology technologists in all our fields. Linda has recently completed a course with the Canadian Association of Medical Radiology Technologists in Quality Control, with excellent results. Linda and Rhonda are currently enrolled in a computer course at the University of Calgary. Anne (not pictured) brings the knowledge and experience of a medical radiology technologist to our clinic, and Lynn is our skilled receptionist who handles the bookings and manages the patients in a very professional way, with ease and accuracy.

I am very proud of our imaging clinic, unique in Calgary and one of the few private oral and maxillo-facial radiology practices in Canada. My family and I love living in Calgary and that is a wonderful bonus for me.

Recent Tomographic Study submitted by Dr. Anna Csillag

This radiologic presentation was most consistent with the presence of a Complex Odontome developing in the left posterior maxilla. This patient is presently scheduled for the oral surgical consultation. This tomographic survey is intended to help in landmarking at the time of surgery.
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Generally, the personnel radiation monitoring type lithium fluoride thermoluminescent (TLD) chips are used for dose detection. Multiple chips are placed in the holes for each internal anatomical site. This obtains the average site dose and compensates for any variations in x-ray energy (Fig. 1B). Our model requires about 100 chips to fill all sites. After all TLDs are positioned, the phantom is reassembled and exposed. Making a phantom radiograph helps to verify that a representative human exposure was used (Fig. 2). Exposure sample size should be large enough to ensure the detected radiation by the TLDs is adequate for analysis. In my studies, a representative sample size is 25 survey examinations. This is achieved by performing 5 sets of 5 simulated radiographic surveys. The phantom was disassembled after each set, and all TLDs removed for analysis.

TLDs store absorbed radiation in an excited electron state until it is “read”. This involves heat activating each TLD and using a photomultiplier tube to read the visible light intensity emitted when the excited electrons return to their normal state. Variations in the emitted light correspond to the amount of detected radiation. The result is the initial raw data radiation dose. This is best accomplished by a dosimetry monitoring service.

The absorbed dose is calculated from the raw data. Dividing the raw data dose for each TLD by the number of x-ray examinations results in the average absorbed dose per TLD for a single examination expressed in microgray (μGy) units. The absorbed dose to a specific anatomical site is the calculated average of all TLD doses for that site. For our model, this was 41 TLDs for the head and neck bone marrow and 24 for the thyroid.

Table 1, modified from our reference, exhibits how the data are organized and calculations made using the ICRP recommendations. The critical organs and remainder category for dental radiography are in the first column.
Although controversial, any organ not listed was not calculated. The $W_T$, 1990 column is the ICRP numerical radiation sensitivity rating. Higher numbers indicate increased radiation sensitivity. The $H_T$ column is the tissue/organ equivalent TLD internal absorbed dose.

<table>
<thead>
<tr>
<th>Tissue/Organ</th>
<th>$W_T$, 1990*</th>
<th>$H_T$</th>
<th>$E$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone marrow (red)</td>
<td>0.12</td>
<td>11</td>
<td>1.3</td>
</tr>
<tr>
<td>Bone surface</td>
<td>0.01</td>
<td>50a</td>
<td>0.5</td>
</tr>
<tr>
<td>Thyroid</td>
<td>0.05</td>
<td>41</td>
<td>2.0</td>
</tr>
<tr>
<td>Remainder</td>
<td>0.05</td>
<td>0.9b</td>
<td>0.045</td>
</tr>
</tbody>
</table>

**Total** $E = 3.85$

*ICRP 60, 1990*

a Bone marrow dose 11 x bone surface unit, 4.64
b Average, 10 remainder tissue/organisms, + Sella, 9 mSv.

Bone surface dose and the remainder category, including the brain, required some additional calculations described in the legend under Table I. Column $E$ is calculated by multiplying the numbers for $W_T$, 1990 by those for $H_T$. Total $E$, expressed in microsievert ($\mu$Sv), is the sum of all dose effects upon the whole-body. $E$ for the panoramic example is 3.85 $\mu$Sv.

With $E$, we can do comparisons for different dental x-ray survey exposures. If $E$ for examination exposure A is 3.85 and for examination B is 7.7, then B produces twice the patient exposure as A. Dividing the $E$ ($84 \ \mu$Sv) for a 20 film round collimated full-mouth (FMX) series, as reported by White\(^3\), by the panoramic 3.85 shows the FMX to contribute 21.8 times more dose to the patient than the panoramic survey or that 21 panoramic x-rays could be made before exceeding the FMX absorbed dose. Another comparison is to the whole-body background radiation. Annual background dose ranges from 3000 to 4400 $\mu$Sv\(^3\) or 10 to 12 $\mu$Sv per day.

Dividing the FMX 84 $\mu$Sv by the daily background dose shows the FMX equivalent to 7-10 days of background radiation. In contrast, the panoramic examination 3.85 is approximately 1/3 the daily background. Such accepted life-risk comparisons help patients determine the value of accepting the associated radiation risk for the perceived benefits of the impending radiographic survey.

In conclusion, dosimetry is a series of progressive improvements involving methods, assumptions, and interpretation of data. As such, the “magical” number is a current best guesstimate of dose and risk. Despite this, dosimetry data does help us to make evidence-based risk/benefit decisions about how to best use radiation in dentistry and better serve our patients.

References:

The Olympic Winter Games of 2002 with the theme of “Light the Fire Within” are over; and even though Salt Lake City is somewhat back to normal I thought you might be interested in some of the human-interest stories associated with the “BIG EVENT”.

I should be used to the sounds made by the Mormon Tabernacle Choir and the effect they have on people. But I was surprised and impressed by the sweet, peaceful, beautiful sound that filled the stadium as they sang the U.S. national anthem. Even though I was watching from my living room, I almost stood with the 55,000 people sitting in the Olympic Stadium, amazed at how voices could sound so powerful yet so serene, so majestic yet so personal.

Many emotions came to the surface from exuberance to solemnity. How can you put into words the overwhelming silence enveloping the stadium as eight American athletes, accompanied by representative New York police officers and firefighters, bore the battered U.S. flag that flew at the World Trade Center September 11th? A choir member said it best for me: “I was surprised at how silent it was. But after I thought about it for a moment, I wasn’t that surprised because that was the only response we could give. It was very emotional. It was all I could do to keep from weeping.”

Then there was the athletics streaming into the stadium, the Olympians. I guess I wasn’t prepared for the burst of pride I felt as each country was announced and athletes filed in. Some countries sent dozens; others had only one Olympian. In my mind’s eye I could see mothers and fathers, siblings, aunts, uncles, grandparents across the world sitting in front of television screens exclaiming, “Look! There she is!” or “He looks great!”

The entire opening ceremonies was a moment in history, a time I will likely never forget. If choir member Sally Brinton hadn’t already said it, I’d say, “It was spectacular. It was uplifting. I felt for that moment in time that the world was unified.”

Then there are the lessons we learned from long-track speed skating. It really is a simple sport, even tedious at times. If I got it right it’s like this: go around and around in a big circle, and the fastest person wins.

It’s like life in many ways. The little, sometimes-tedious things are the ones that count. The Winter Olympics probably should leave us with the lessons of life. A thing like the ways to deal with goals, dreams and shattered hopes. That’s because, despite the many winners that we watched every day and night, the overwhelming majority of athletes at the Games did not win. Perhaps a better wording might be they did not win, but they didn’t necessarily lose.
The great lesson from Olympic athletes is that they practice and practice, train and train for the love of competing. They have no dreams of wealth like Shaquille O’Neal. They do it for the love of doing it. But the drudgery of training holds huge lessons for those of us willing to take the time to see. We may not have to skate fast and turn left, again and again, but we do have to wake up, go to work, come home, tend the kids, put everyone to bed and start it all over again the next day. We do it with little fanfare.

There may not be any Olympic Games where our everyday type of drudgery pays off, but it does pay off if done well. Just look at the rewards in developing a satisfying career, in raising children who become caring, responsible adults and in oh, so many other ways.

Those athletes who didn’t win the medal (and many that did) have shown us there is grace, dignity and even ultimate victory in getting the routine things down to perfection.

And how about America’s Chris Witty who set a world record in the 1,000 meter Olympic speed skating and won a gold medal. And if gold medals were awarded for courage, she’d surely have won one for that event as well. For a little over a month, her strength had been sapped to the point that she even doubted whether she could compete. That’s because a month before the Games started she was diagnosed with mononucleosis. Great athletes have the ability to rise up when others would call in sick. Witty’s heart, more than her skates, is responsible for one of the great moments in Olympic skating history.

Yes, the Olympic flame was extinguished Feb. 24, but for all who watched or participated the hope is that the “fire within” will never dim. So it should be with all of us. In closing ceremonies, Jacques Rogge, president of the International Olympic Committee, told the “people of America, Utah and Salt Lake City, you have given the world superb Games. You have reassured us that people from all countries can live peacefully together. Thank you, thank you.”

In his brief remarks, Mitt Romney, President of the Salt Lake Olympic Organizing Committee declared: “Something very magical happened here. You Olympians came here representing 78 different countries, but today you go home heroes of the entire world. You may have been here to pursue your dream, but you also brought the Olympic spirit to us. . . . Win or not, you each reached for your dream, and we dreamed with you. There’s another dream that is shared by all, a dream that one day our children will live in peace. For 17 days, we lived that dream. Olympians, we cheered all of you, but not just our own. We saw in you the universal greatness of the human family.”

So that’s it, many Olympic lessons for all of us to learn. Not only should we “Light the Fire Within”, but we should keep it lit by living each day with hope and grit that we can make a difference. Hopefully those Olympians have taught us to look beyond the moment; to be the best we can be; and to practice, practice, practice for the love of living.
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