InterACTIONS

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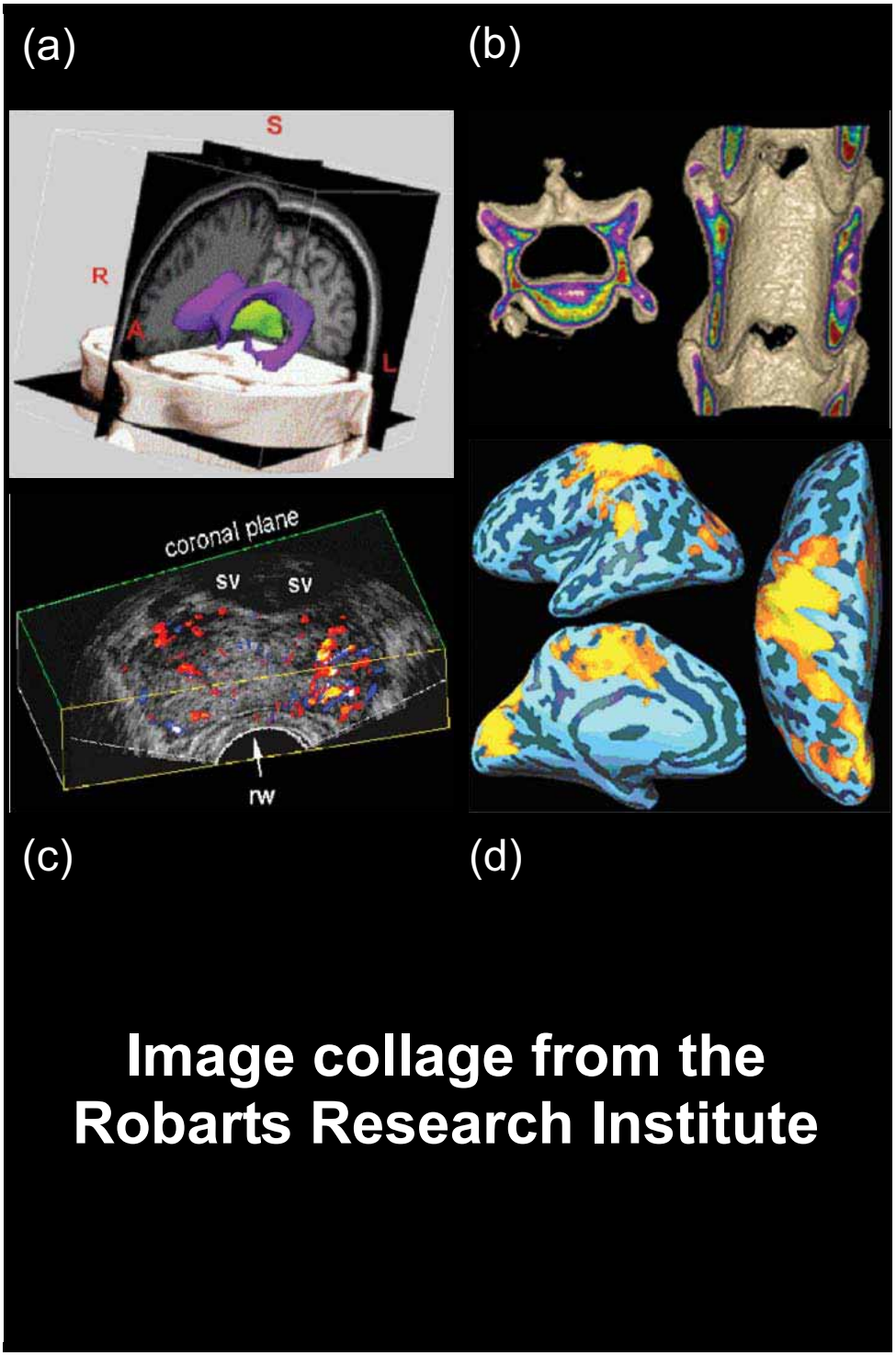

Image collage from the Robarts Research Institute

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LE COLLÈGE CANADIEN DES PHYSICIENS EN MÉDECINE

51 (3) juillet/July 2005

About our Cover

Our cover for this issue consists of a collage of images from current research projects being carried out at the Robarts Research Institute.

(a) 3D image showing deep brain structures used in surgical planning and procedures (courtesy of Dr. Terry Peters).
(b) 3DMicro-CT image of rat vertebrae used in bone mineral density studies (courtesy of Dr. David Holdsworth).
(c) 3D power Doppler ultrasound image of prostate cancer showing hypervascular regions (courtesy of Dr. Aaron Fenster).
(d) fMRI scan showing regions of the brain activated by self-motion (courtesy of Dr. Ravi Menon).

Images provided by Aaron Fenster, Terry Peters, David Holdsworth, and Ravi Menon of the Robarts Research Institute, London, Ontario.

The Canadian Medical Physics Newsletter, which is a publication of the Canadian Organization of Medical Physicists (COMP) and the Canadian College of Physicists in Medicine (CCPM) is published four times per year on 1 Jan., 1 April, 1 July, and 1 Oct. The deadline for submissions is one month before the publication date. Enquiries, story ideas, images, and article submissions can be made to:

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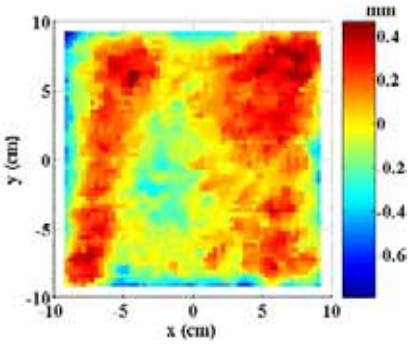

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Message from the COMP Chair:

I was reminded by **Stephen Pistorius** – the COMP chair-elect, that this year is the fiftieth anniversary of nationally organized medical physics in Canada. The Canadian Association of Medical Physicists (CAMP) was formed in 1955 and almost immediately morphed into the Division of Medical and Biological Physics (DMBP) of the Canadian Association of Physicists. COMP is a relative newcomer, being formed in 1989. (This information is taken from "A New Kind of Ray", **John Aldrich** and Brian Lentle, 1995). CAMP, the DMBP and now COMP have had common objectives – "to promote and encourage the development of scientific knowledge towards the applications of physics to medicine" and "to further the exchange and publication of scientific and technical information relating to the science and practice of medical physics." The main strategy for meeting the second objective has been the annual scientific meeting and these have grown and improved over the decades. We have taken only tentative steps towards meeting the first objective – promotion and encouragement for the development of scientific knowledge. Examples include the Sylvia Fedoruk and Young Investigator's awards, and the annual poster awards. The time now seems ripe for more steps towards meeting our society's objectives. We have introduced the COMP Gold medal, a recognition of lifetime achievement, to be awarded for the first time in 2006. There are other changes and additions that we should consider. Our annual meetings are of excellent quality but focus almost exclusively on proffered papers. The exception of course is the annual CCPM topical symposium which acts as a review of an important area with invited expert speakers. I propose that COMP introduce annual lectureships (2 at each annual meeting). These will be invited talks by working Canadian medical physicists who have recently made significant contributions to the field. A challenge for COMP would be to change our annual meeting with these additions while not losing the attraction of a small and relatively short, high quality meeting.

The time now seems ripe for more steps towards meeting our society's objectives.

An area where COMP, as an organization, can do more, is in the support of our colleagues in the third world. There are many individual Canadian medical physicists making contributions in this area by their own efforts and through work with the International Atomic Energy Agency (IAEA) and the International Organization of Medical Physicists (IOMP). However COMP does not have a direct role in the efforts of those groups. COMP has recently been approached to send a participant to the World Conference on Physics and Sustainable Development taking place in Durban, South Africa later this year. Our response was to turn down the invitation and to indicate that COMP will investigate the creation of a traineeship in Canada and an associated travel scholarship program for medical physicists from developing countries.

Mr. Peter O'Brien, COMP Chair

As we move into the next stage in the evolution of COMP the executive will consider these as well as other ideas to help us meet our objectives. I hope this will be the start of a dialogue that you will consider joining. To solicit your ideas in a more direct manner, our executive director, **Nancy Barrett,** has proposed a survey of the membership. This tool will help the COMP executive to understand where we can improve and where you want your organization to go in the future.

Message from the CCPM President:

As I write this, I have just returned from participating in the second CCPM oral examination, held in Toronto on Saturday, 28 May. The experience of sitting in a room all day interviewing 15 or so candidates brings certain things into focus. Some candidates breeze through the experience with little outward sign of either stress or discomfort whereas others appear to have great difficulty. I will devote this column to some observations and recommendations for future candidates.

Firstly, it was apparent to us, the examiners, that most of the candidates are anxious, some extremely so. Clearly an oral examination is a nerve-wracking experience and almost all of us would suffer a certain level of discomfort under these circumstances. This is to be expected, despite the fact that the examiners make some effort to put the candidates at ease and have never been known even to snarl, let alone bite! Most of the candidates handle this stress well and the ability to do this is clearly as asset in our work. However, for a small number of candidates, this examination appears to be such a high stress situation that their performance is significantly impaired. My recommendation is that if you think you are going to be nervous to the extent of being unable to give it your best effort, there are several things you could do help prepare yourself for the examination. Probably the most obvious is to ask a colleague, preferably the most ferocious within your vicinity, to put you through a "test" interview(s), asking similar questions with appropriate follow-up as a "rehearsal". (Remember the questions are the type that we might be asked during a routine day in the clinic). This would have the combined effect of drilling you on the material and also helping to raise your comfort level with oral questioning. Other options are to take every opportunity to present your work either within your department or at meetings such as the COMP annual meeting. All these experiences help to prepare us to express ourselves under pressure and "think on our feet". As a last resort, if you believe that you will be severely affected by nervousness during an oral exam, it should be postponed a year or two until you have sufficient experience of this kind of event to be more comfortable.

Dr. Brenda Clark, CCPM President

Another observation is that many of the candidates are not comfortable in the "teaching" mode. When asked to draw on the board and explain some relatively simple concept or aspect of clinical work, the mechanics appear to be difficult. From experience, I know very well that drawing on a vertical plane in a size appropriate for an audience several feet away is something that needs practice. For example, those of us who have done some teaching will know that the easier way to draw a graph is to label the axes *after* drawing the curve. Attempting to draw the curve onto pre-labeled axes is challenging on a piece of paper and disastrous on a vertical board! One of the best ways to prepare for this examination is to teach basic clinical physics in a formal setting but clearly not every candidate will have that opportunity. An alternative would be to give a few seminars or "in-services" to any of your colleagues who will participate. You will be amazed how much this will help with situations such as this examination.

Finally, the question of image and self projection. The MCCPM is a professional examination and as such, attempts to ensure that the successful candidates contribute to the success of the Medical Physics profession. We are fortunate in working in a clinical environment rather than, say a court of law where the dress code is completely inflexible. On the other hand however, there is a level of accountability in the clinical environment that is absent in, for example, an academic one. While we don't expect a navy three piece suit, neither do we endorse scruffy.

(Continued on page 103)

...if you think you are going to be nervous to the extent of being unable to give it your best effort, there are several things you could do help prepare yourself for the [MCCPM oral] examination.

Message from the Executive Director of COMP/CCPM:

...I am in the process of working on the publicity for COMP's first ever public lecture: Medical Imaging: The Vision for New Medical Advances.

I am pleased to be making my second submission to Interactions. Time certainly flies! In the last few months, I have had an opportunity to connect either in person or via teleconference with many of COMP/CCPM's committed volunteers. I am most appreciative of how welcoming and open everyone has been.

In Peter O'Brien's column for the April issue of Interactions, he indicated that the role of the Executive Director is to serve as the "face of COMP" and be the main point of contact for members, corporate members and other communities of interest.

It has been a pleasure connecting with some COMP/CCPM members over the past few months. The Hamilton Conference is an opportunity to further understand how I can work with the volunteers to serve our members and meet the objectives of COMP/CCPM.

As you are aware, our corporate members provide important funding or "non-dues revenues" for the programs we provide. In the month of April I conducted a review of COMP's non-dues revenue generation activities and developed an action plan to ensure that we continue to build relationships with our corporate colleagues in order to maximize this funding opportunity. Part of this review included a telephone survey of corporate members as well as lapsed corporate members to learn more about how we are perceived, why members choose to support COMP and what are the areas for improvement.

I learned that the number one reason that respondents became aware of COMP was because of the reputation of the organization within the medical physics community in Canada. 87% of the respondents considered the networking opportunities available at the annual conference to be the most valuable part of their relationship with COMP. The fact that at the Hamilton conference we have 24 companies exhibiting with some providing further support as sponsors speaks to this finding. **Thank you to Varian Medical Systems, our gold sponsor; Elekta, Nucletron, Phillips and Siemens, our silver sponsors; and Donaldson Marphil Medical and Tomotherapy, our bronze sponsors.**

It has also been a pleasure to represent COMP to communities of interest outside the organization. The World Conference on Physics & Sustainable Development is interested in involving us in their mission in some way and options are being explored. We are also looking at ways of supporting the Physics co-op programs that are offered at some Canadian universities. As I write this article I am in the process of working on the publicity for COMP's first ever public lecture: Medical Imaging: The Vision for New Medical Advances. This initiative will illustrate how this medical imaging "vision"

Ms. Nancy Barrett,
COMP/CCPM Executive Director

is stimulating new advances in cardiology, tumour detection and biopsy, cancer treatment, and assessment and treatment of diseases of the brain and is another opportunity for COMP/CCPM to reach out to new audiences.

One of the projects I will be working on with Doug Cormack, one of our Emeritus members, is to create a COMP/CCPM Archives. I learned recently from both Doug and Stephen Pistorius, COMP's Chair-Elect, that the inaugural meeting of the Canadian Association of Medical Physicists, which a year later became the Medical & Biological Physics Division of the Canadian Association of Physicists, took place in 1955. This means that the organization has been in operation for 50 years – something worth celebrating indeed! Stay tuned for more information.

(Continued on page 103)

Harold Johns Travel Award Report—RSNA 2004

November 27 to December 2, 2004

Submitted by Karl Otto
Vancouver Cancer Centre, BC Cancer Agency,
Vancouver, BC

Every major imaging modality is used in the diagnosis and treatment of cancer. This is true today more than ever before. At least one of the primary 3D imaging modalities CT, MRI PET and Ultrasound is used in conjunction with a radiation therapy patient treatment. As a radiation therapy physicist I used the H.E. Johns award to further my knowledge of diagnostic imaging techniques as applied to the treatment of cancer with radiation. The 90th Annual meeting of the Radiological Society of North America (RSNA) was an ideal venue for me to do so. Scientific sessions, symposiums and refresher courses were provided with themes ranging from diagnostic imaging to radiation therapy.

For those who have never attended the RSNA (like myself) it can be a bit overwhelming. It is truly the Behemoth of conferences, having approximately 60 thousand attendees and 2.2 million square feet of exhibit space. To give you an idea of the size, in Canada we would have to hold COMP meetings for about 200 years to accumulate the same number of attendees as one RSNA meeting.

Scientific sessions were held on automatic registration and segmentation, a popular topic for people in radiation therapy where the large quantities of 3D imaging data require more efficient methods of processing and manipulating patient images. Cone beam CT was also a popular topic for the radiation therapy community. Online commercial systems are now offered by all of the major linac vendors and should improve target localization, although it is not clear how this will be implemented in the clinical setting.

The RSNA annual oration was given by Princess Margaret Hospital physician Dr. Brian O'Sullivan. He provided a stimulating presentation on "Redefining Therapeutic Targets in the Treatment of Soft-Tissue Sarcoma. The annual RSNA/ AAPM symposium was a debate titled "Routine Clinical Proton Spectroscopy: Are we there yet?". Dick Drost from London, Ontario and Brian Ross from Pasadena, California presented their views. My overall impression is that although there is useful clinical information being produced today it is expected that the amount of clinically useful data provided by spectroscopy will increase exponentially over the next few years.

Molecular imaging in Radiation Therapy is a growing area of interest among clinicians and there were several interesting presentations on this topic. The idea of replacing the standard dose volume histogram with a "Dose Function Histogram" was of particular interest to me. Basically, by using information derived through molecular imaging it may be possible to estimate the maximum dose levels required to preserve organ function. A significant amount of clinical testing will be required before we can make clear relationships between the functional imaging data and dose response.

In the novel treatments category there were several presentations of which stereotactic ultrasound ablation was particularly interesting. Techniques are under investigation where highly focused ultrasound is capable of destroying tissue at precise locations within the brain. The main technical hurdle for this technique is the perturbation of sound waves as they pass through skull bone. Methods of compensating for this effect were presented.

An afternoon symposium on the state of the art of IMRT provided an excellent review of current IMRT practices and technology from a wide range of speakers. IMRT from a physicians perspective, medical imaging in IMRT, plan optimization, delivery and quality assurance techniques were presented and discussed.

One session that I was surprised to see in the program was a 4 hour presentation with the title "Effective Real Estate Investment Strategies". I wondered for half a second whether I had come to the wrong conference. There was an additional charge for this session and I didn't think it would have been very "appropriate" to use my travel grant for improving my investment portfolio.

Another session I didn't have the time to attend but seemed to be a popular topic was "Protecting Assets from Creditor Claims, Including Malpractice Claims". I did manage to see at least one presentation along the same lines, "Medical Simulators" similar to flight simulators are being developed so that physicians can practice evaluating images and performing procedures before working with actual patients. This technology may become popular in the more litigious United States where insurance companies have agreed to reduce premiums for those doctors who have passed medical simulation tests.

The most important and obvious idea I took away from the conference was how radiation therapy physicists like myself must keep up to date with new imaging technologies. The growth in this sector of medicine is exceptional. If we want to understand and use the latest imaging developments effectively in the clinic it will be necessary to update our knowledge on a regular basis. I am grateful to the CCPM for the opportunity that the H.E. Johns award has afforded me and encourage other new members of the CCPM to apply.

Compensator Thickness Measurement Using an aS500 EPID

By Geetha Menon[1] and Ron Sloboda[2],
[1]Tom Baker Cancer Centre, Calgary, Alberta,
[2]Cross Cancer Institute, Edmonton, Alberta

1. INTRODUCTION

The quality of radiotherapy treatments has been significantly improved in the last couple of decades through the use of portal imaging devices for verification of the patient position relative to the treatment beam. Portal imaging was conceived with the idea of being able to image the patient immediately prior to or during treatment, by placing a detector (such as film) beyond the patient to capture the exit radiation. Today, port films are rapidly being replaced by electronic portal imaging devices (EPIDs) because of their ability to produce digital images immediately for online review and approval of patient position, thereby reducing setup time and systematic errors. This in turn speeds up treatment delivery time and improves the accuracy of both conventional and sophisticated treatments, including intensity modulated radiation therapy (IMRT). Advancement in EPID technology has resulted in the emergence of several imaging systems[1] based on different radiation detectors, the newest being the amorphous silicon (a-Si) flat panel.

Although EPIDs are primarily used to verify radiotherapy setup geometry, there has been growing interest in extending their application to verification of delivered dose, verification of photon beam flatness/symmetry, and compensator design and quality assurance[2-4]. Of considerable current interest is their potential for verification of IMRT protocols[5]. Here we describe the use of an a-Si EPID to perform quality control (QC) of custom-made compensators that are used in radiotherapy to compensate for missing tissue, modify the dose distribution in the patient, and as a means for delivering IMRT[6]. As performed conventionally using an ion chamber in a water equivalent phantom, the compensator QC procedure is time consuming when measurements are made at several beam locations. Our objective, therefore, was to develop a faster method of making multiple transmission measurements from which compensator thicknesses could be inferred.

2. aS500 EPID

A Varian PortalVision aS500 EPID mounted on a dual energy Varian 21EX linac (Varian Medical systems, Palo Alto, CA) was used for the measurements. The image detector of the aS500 is in the form of a stack having three distinct layers: a 1 mm copper buildup plate, a Kodak Lanex Fast B scintillating screen, and an a-Si photodiode image receptor. The distance from the megavoltage x-ray source to the top of the detector stack is the position displayed by the EPID remote control (source-to-EPID distance, SED). The 512 x 384 pixel matrix (pixel pitch = 0.784 mm) that constitutes the image receptor is located 1.3 cm beyond the SED (at the source-to-detector distance, SDD). All measurements were done using 6 MV photons delivered at 300 MU/min, with the EPID positioned at the standard clinical imaging distance of SED = 140 cm. Single images were acquired repetitively (n = 3) at the temporal midpoint of beam delivery ([0-50%-0] acquisition mode) and averaged. As the copper converter and fluorescent screen in the detector provide an inherent buildup equivalent to only ~1 cm of water, a 0.5 cm slab of solid water was placed on top of the detector cassette to position the image receptor at the depth of dose maximum.

Any radiation measuring device must exhibit a consistent and reproducible response over time. In the case of an EPID, such behavior can be verified by examining the variation in pixel values under similar irradiation conditions over an extended period. For the aS500 used in this research, such variation was observed to be < 0.4% over a period of several months (Fig. 1).

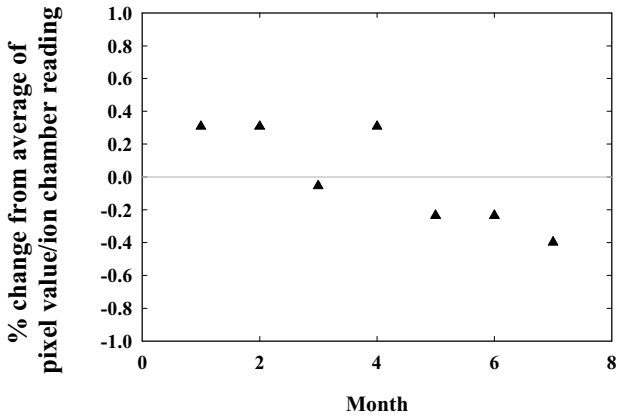

Figure 1: Percent change from the average of the central axis pixel value divided by a reference ion chamber reading, monitored over seven months.

Image lag was also of potential concern at the outset of our work, as consecutive images are averaged to obtain transmission data. Image lag is manifested when there is latent charge trapped in the detector photodiodes after they have been reset, which contributes to increased pixel readings in subsequent image frames. When multiple images are acquired in quick succession at the beginning of beam delivery, this effect can be significant, and has been found to change an a-Si EPID response by ~3% if no corrections are applied[7]. The effect of lag was verified using the [0-50%-0] acquisition mode by taking images of 6 x 6 cm^2 and 20 x 20 cm^2 open fields in immediate succession (35 sec interval), and then acquiring another image of the larger field 15 min later. Fig. 2 shows two such images and corresponding profiles across them.

Differences in pixel values between the surrounding background region and the interior ghost image region in Fig. 2

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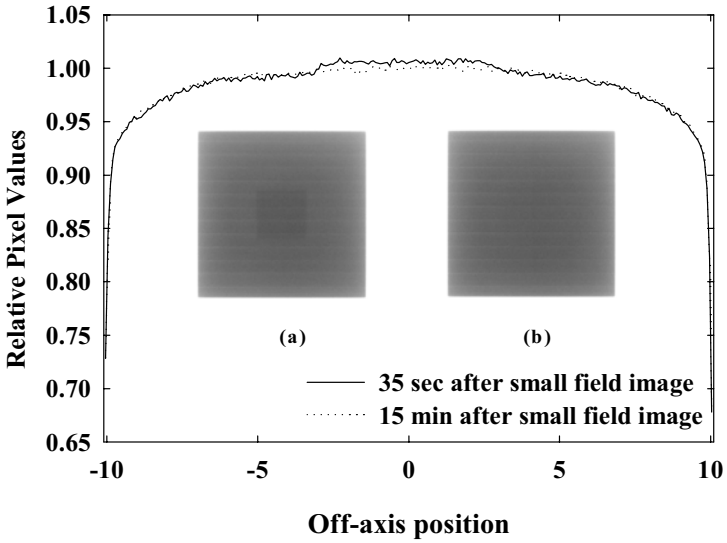

Figure 2: Profiles across the 20 x 20 cm^2 field images inset, normalized to the mean value in the interval (-5,5) cm of image (b). The inset images were taken (a) 35 sec and (b) 15 min after imaging a 6 x 6 cm^2 open field.

(a) are typically ~1%, and vanish in Fig. 2(b), indicating that the phenomenon of incomplete readout is negligible for single images obtained sequentially using the [0-50%-0] acquisition mode.

3. CHARACTERIZATION OF THE EPID FOR DOSIMETRY

For use in radiation dosimetry, the pixel values recorded by the EPID have to be translated to an equivalent fluence reading and corrected for in-detector scattering effects. This necessitates the generation of a calibration curve to relate the EPID pixel response to the energy fluence measured by an ion chamber in air at the same position, and the measurement of EPID scatter factors for a range of field sizes of interest.

(i) EPID calibration curve

Due to the EPID's differing radiation response for open and attenuated fields, calibration curves for these fields were measured separately. Fluence variation at the EPID for open fields was achieved by varying the SDD (from 105 – 160 cm), while for attenuated fields it was accomplished by changing the thickness of steel shot attenuators (from 0.5 – 4.5 cm in increments of 0.5 cm) placed in the beam path for a fixed SED of 140 cm. The EPID pixel values used to create the calibration curve were obtained as the average from a 10 x 10 pixel region of interest along the central axis (ROI_{CAX}). Subsequent to each EPID image acquisition, corresponding energy fluence measurements were made at the same SDD with a Wellhöfer CC-13 ion chamber (IC) (Scanditronix Wellhöfer, Bartlett, TN) in a buildup cap to provide electronic equilibrium. Variability arising from linac output fluctuations was minimized by normalizing the IC readings to a reading for a 10 x 10 cm^2 field at SAD (source-to-axis distance = 100 cm) obtained at the time of calibration. All measurements were made for a field size (FS) of 20 x 20 cm^2 at the detector.

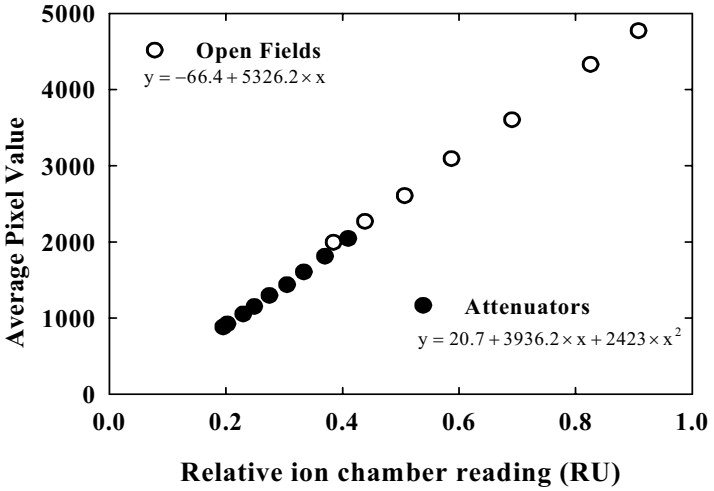

Figure 3: Calibration curves for the aS500 EPID relating average pixel value to relative ion chamber reading for open and attenuated fields. Error bars are not shown, being smaller than the plotted symbols.

Figure 3 shows the average pixel value from the ROI_{CAX} as a function of relative ion chamber reading for both open and steel shot attenuated fields. As the phosphor in the EPID exhibits an enhanced response to lower energy photons present in relatively greater numbers in open fields, the open field calibration curve is seen to be distinct from the attenuated field curve. The open field curve follows a linear form, whereas the attenuated field curve is fairly well described by a second-order polynomial. It was also observed that the EPID showed a slightly different response for different attenuating materials, suggesting that dose calibration should be done with the same attenuating material that is used in subsequent measurements.

(ii) EPID scatter factors

The change in response of the EPID in the presence of an attenuator prompted the measurement of scatter factors for each thickness of steel shot used to create the calibration curve. To calculate the EPID scatter factors, central axis (CAX) pixel values for a set of field sizes from 6 x 6 cm^2 to 28 x 28 cm^2 and all attenuator thicknesses used for calibration (i.e. 0.5 - 4.5 cm) were measured. The EPID scatter factors were determined using an iterative algorithm, in which the factors are represented as a ratio of the EPID energy fluence (R_{EPID}) for an arbitrary radiation field size of interest to that for a 10 x 10 cm^2 reference field at SDD, divided by a ratio of collimator scatter factors (S_c) for the same collimator settings and SDD[8].

$$S_{EPID}(FS) = \frac{R_{EPID}(FS)/S_c(FS)}{R_{EPID}(10x10)/S_c(10x10)}. \qquad (1)$$

The inputs for the iterative process are the open and attenuated field calibration curves and central axis pixel values for the operational range of field sizes and attenuator thicknesses. The outputs are the two calibration curves for a 10 x 10 cm^2 field, and EPID scatter factors as a function of field size

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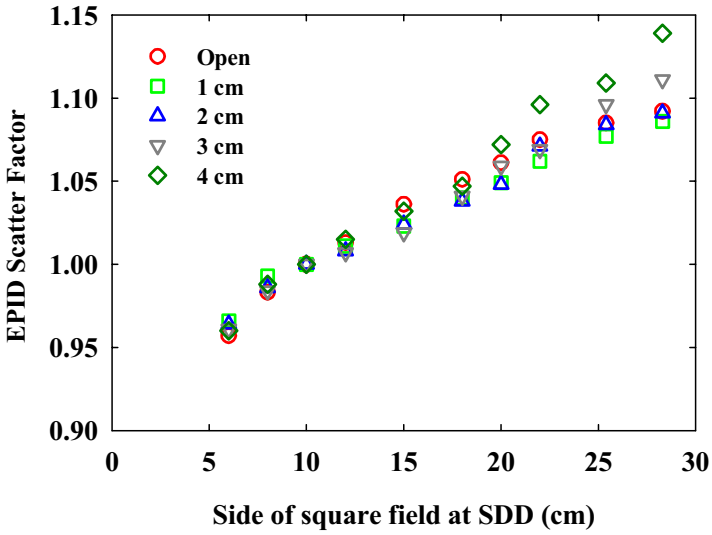

Figure 4: EPID scatter factors for square fields of size 6 x 6 cm^2 to 28 x 28 cm^2 measured with the detector at an SDD of 140 cm, for open and steel shot attenuated beams.

and compensator thickness along the CAX. To obtain scatter factor values away from the central axis, Day's method[9] was employed. Data analysis and modeling was performed using Matlab 6.5 software (The Mathworks Inc., Natick, MA).

It was observed that the scatter factors exhibited a small dependence on attenuator thickness and field size. There was a 5% spread in the scatter factors for the largest field size of 28 x 28 cm^2 (Fig. 4). The scatter factors for each attenuator thickness were fit with a straight line, and values for arbitrary field sizes and attenuator thicknesses were calculated from the fits by interpolation.

(iii) Corrected EPID reading

The inferred EPID energy fluence reading at any position, corrected for non-linearity in EPID response and associated field size effects, was obtained as,

$$R_{EPID}(FS,x,y) = f(P(x,y)) \times S_{EPID}(FS,x,y), \qquad (2)$$

where $f(P(x,y))$ is the appropriate calibration curve relating the mean pixel value P from a region of interest at (x,y) to the ion chamber reading in air at the same SDD for a fixed calibration field size, and $S_{EPID}(FS,x,y)$ is the EPID scatter factor at the depth of maximum dose, d_{max}, that takes into account how detector scatter varies with field size and detector location. This expression was used to convert all compensator transmission measurements to equivalent fluence readings.

4. COMPENSATORS

Compensators used in the study were constructed from 5.0 ± 0.1 cm thick Styrofoam slabs[10] according to specifications generated by compensator design software developed in-house. Each slab was milled with a Huestis Compuformer, sandwiched between 0.6 cm thick Lucite sheets, and filled through a channel cut in the Styrofoam with granulate of cast steel shot (density = 4.69 ± 0.05 g/cc). Variations in the steel shot diameter (ranging from 0.5 to 0.9 mm) were responsible for the observed variability in packing density. In this study, we examined 3 sets of compensators: (i) flat attenuators of thickness ranging from 0.5 - 4.5 cm in increments of 0.5 cm, (ii) test compensators shaped in the form of a wedge, hemisphere and frustum of pyramid[4], and (iii) clinical compensators used mainly for treatment of head and neck, larynx, tongue, hypopharynx, brain and sinus, designed using data obtained either by digitizing the patient contour or from the Helax treatment planning system (Nucletron, Kanata, ON).

5. COMPENSATOR THICKNESS MEASUREMENT

Thickness measurement is a practical means of verifying the accuracy of compensator fabrication and mounting. A 2D thickness distribution can be obtained from EPID transmission measurements by determining the primary transmission (T_P), which can in turn be estimated by subtracting the scatter component of transmission (T_S) from the total transmission (T_T) data. The thickness is related to primary transmission via an attenuation coefficient using a simple exponential relation,

$$T_P = T_T - T_S = \exp\{-\mu t\} \qquad (3)$$

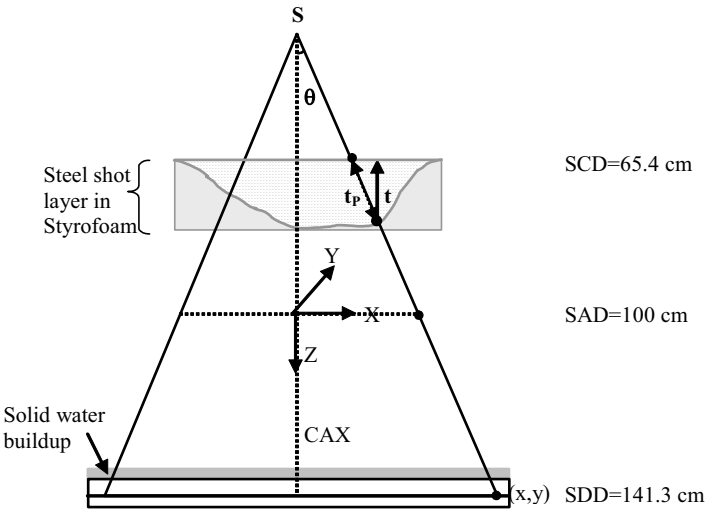

Figure 5: Schematic representation of the geometry used for describing compensator thickness measurements. The primary ray path thickness, t_p, and the normal thickness, t, are calculated from EPID measurements at position (x,y) in the imaging plane.

(i) Total transmission

The total transmission is determined from images of an open and compensated field acquired using clinical jaw settings, as shown in Fig. 6 for a patient with neck node melanoma. The position of the CAX is ascertained with respect to the field edges and the image area is divided into 4 x 4 pixel regions of interest around the CAX. To reduce noise, the image is smoothed using

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Compensator Thickness Measurement... (Continued from page 90)

a 9-point median filter. The total transmission can then be expressed as a ratio of inferred EPID energy fluence readings in compensated R_{EPID}^{comp} and open fields R_{EPID}^{open},

$$T_T(FS,x,y) = \frac{R_{EPID}^{comp}(FS,x,y)}{R_{EPID}^{open}(FS,x,y)}, \quad (4)$$

where,

$$R_{EPID}^{comp/open}(FS,x,y) = \frac{R_{EPID}^{comp/open}(10x10)}{S_{EPID}^{comp/open}(FS,x,y)} \times OAX(x,y). \quad (5)$$

The ratio $R_{EPID}^{comp/open}(10x10)/S_{EPID}^{comp/open}(FS,x,y)$ represents the reading obtained from the normalized calibration curve for a 10 x 10 cm^2 field corresponding to the measured pixel value, corrected by the EPID scatter factor to account for the field size used in imaging. The second factor is the off-axis fluence ratio, introduced to overcome the suppression of the energy fluence profile during EPID flood field calibration, and calculated as a quotient of fluence measurements obtained from in- and cross-plane scans of the beam,

$$OAX(FS,x,y) = \frac{R^{open}(FS,x,y)}{R^{open}(FS,CAX)} \quad (6)$$

This technique was verified by comparing the difference in transmission as measured by the EPID and an ion chamber for different thicknesses of flat attenuators at several beam locations. The average percentage difference between these measurements was found to be $0.13 \pm 0.66\%$.

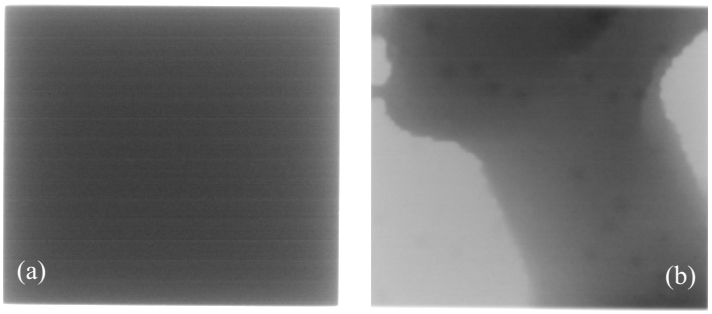

Figure 6: Portal images of an open (a) and compensated (b) field taken at an SED of 140 cm using a 6 MV beam.

(ii) Scatter transmission

Analogous to the representation of the total transmission in Eq. (4), the scatter transmission can be written,

$$T_s(FS,x,y) = \frac{R_S^{comp}(FS,x,y)}{R^{open}(FS,x,y)}, \quad (7)$$

where R_S^{comp} is the reading due to scatter generated in the attenuator. The fraction of the incident energy fluence scattered from a steel-shot compensator positioned at 65 cm from the x-ray source and striking the EPID at 140 cm is roughly 5%[11]. This fraction is mainly constituted of Compton scattered photons, as the associated secondary electrons are lost by absorption and deflection before reaching the EPID. It has been shown that the single Compton scatter model of Spies *et al.*[12], which incorporates analytical expressions for the three operative interaction processes: (i) Compton scattering, (ii) photoelectric absorption, and (iii) pair production, and for the photon beam energy spectrum, can provide a fairly good description of the scatter component of transmission. Considering the aS500 EPID to be a Compton detector, we modified this model to suit our linac photon beam, steel-shot compensator material, and measurement geometry[13]. The adapted model calculates a modified scatter-to-primary ratio (SPR*) at the detector as,

$$SPR^*(FS,x,y) = \frac{\phi_s^{comp}(FS,x,y)}{\phi^{open}(FS,CAX)}, \quad (8)$$

where $\phi^{open}(FS,CAX)$ is the energy fluence for an open field along the CAX and $\phi^{comp}(FS,CAX)$ is the energy fluence of singly scattered photons at a point (x,y) calculated using a 4D integral which takes into consideration the compensator thickness, field size, energy spectra of incident and scattered photons, photon attenuation and scattering, off-axis photon fluence variation, and energy response of the detector. Values of SPR* were calculated over the EPID image plane for a generic Varian 6 MV photon spectrum[13].

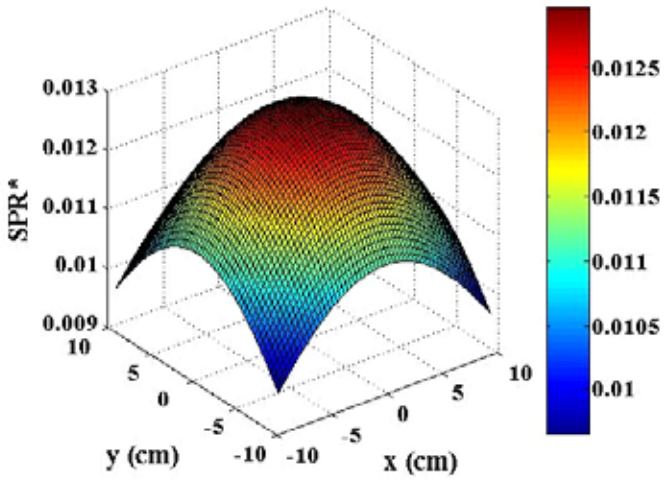

Figure 7: Characteristic shape of the modeled modified scatter-to-primary ratio (SPR*), shown here for a 4 cm thick attenuator irradiated by a 20 x 20 cm^2 field at SDD.

The CAX value of SPR^* was found to increase by a factor of ~ 2.5 as the attenuator thickness was increased from 1.0 cm to 4.5 cm. The scatter transmission can be expressed in terms of SPR* using Eqs. 6 and 8 as,

$$T_s(FS,x,y) = \frac{SPR^*(FS,x,y)}{OAX(FS,x,y)}. \quad (9)$$

The model predicts that for a 4 cm flat attenuator and

(Continued on page 92)

20 x 20 cm^2 field size, the scatter component of transmission (Fig. 7) is only 3.2%. The scatter component increases with increasing compensator thickness and field size.

(iii) Thickness estimation

The primary transmission, determined as the difference between the measured total transmission and the analytic scatter estimate, was used to estimate compensator thickness using the exponential attenuation model of Eq. (3),

$$T_P(FS,x,y) = T_T(FS,x,y) - T_S(FS,x,y) = \alpha \times \exp\{-\mu_{ss}(FS,x,y)\cdot t_P(x,y)\}, \quad (10)$$

where α is the primary transmission amplitude and $t_P(x,y)$ is the compensator thickness traversed by a primary ray intersecting the EPID imaging plane at (x,y). $\mu_{ss}(FS,x,y)$ is the effective linear attenuation coefficient for steel shot as a function of field size and position, and was represented by the empirical form[14],

$$\mu_{ss}(FS,x,y) = \frac{\mu_0(FS,x,y)}{1+\kappa\cdot t_P(x,y)}, \quad (11)$$

where $\mu_0(FS,x,y)$ is the initial attenuation of the incident beam as a function of field size and off-axis distance, and κ is a hardening coefficient that accounts for spectral changes in the beam with depth. The normal thickness (t) corresponding to detector position (x,y) was calculated as (see Fig. 5),

$$t = \cos(\theta)\cdot t_P, \quad (12)$$

where θ is the angle between the primary ray and the CAX.

The corresponding intended thickness was obtained for comparison purposes from the compensator fabrication specifications, using an iterative algorithm to determine the point where the primary ray passing through the EPID imaging plane at (x,y) exited the bottom of the compensator[13].

(iv) Steel shot attenuation

Required values of α, μ_0 and κ were determined using the images of the flat attenuators (thicknesses 0.5 – 4.5 cm) acquired for estimating EPID scatter factors. First, total transmission data as a function of radial position were obtained for a range of field sizes (FS = 6 x 6 - 28 x 28 cm^2 at SDD) by sampling in the cross- and in-plane directions. Then the primary component of transmission was extracted from the total transmission data by subtracting the modeled scatter, plotted against attenuator thickness, and fit to the exponential form of Eq. (10).

Figure 8(a) shows that the variations in α and κ with off-axis distance and field size are quite minimal; all of the fits yielded values very similar to those given in the figure. Hence the primary transmission was remodeled with the exponential form using average values α = 0.909 ± 0.005 and κ = 0.029 ± 0.005 cm^{-1} (Fig. 8(b)). Since thickness calculations are affected significantly by small changes in the attenuation coefficient, μ_0,

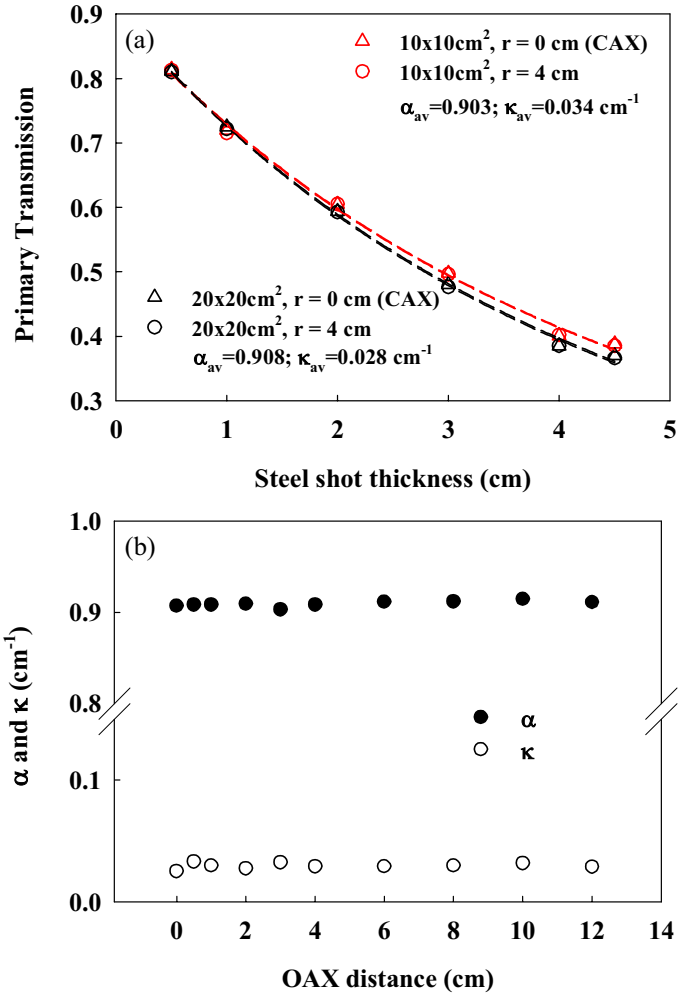

Figure 8: (a) Primary transmission vs attenuator thickness data along the CAX and 4 cm off-axis for field sizes of 10 x 10 cm^2 (red) and 20 x 20 cm^2 (black) at SDD = 141.3 cm. The curves represent exponential fits to the data using Eq. (10). Average values of the fitted parameters i.e. amplitude, α, and hardening coefficient, κ, for the measured off-axis distances are shown for each field size. (b) Plots of α_{av} and κ_{av} with respect to off-axis distance for all measured field sizes.

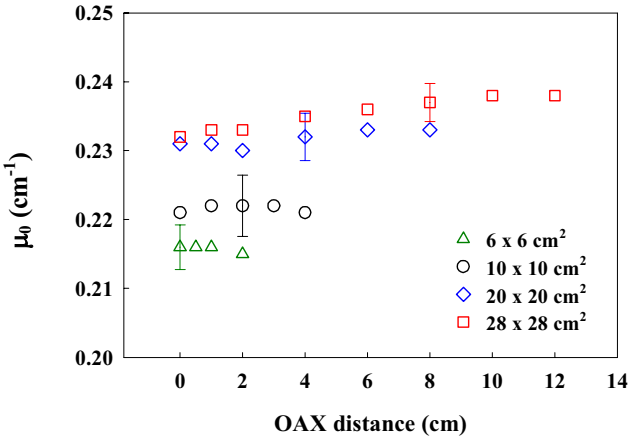

Figure 9: Steel shot linear attenuation coefficients determined as a function of off-axis distance for four different field sizes. The error bars on the single data points represent typical uncertainties in μ_0 for each field size.

(Continued on page 93)

these values were determined individually for each of four field sizes.

Figure 9 shows that the attenuation coefficients for the two smaller fields remain almost constant, and hence average values were used. But for the larger 20 x 20 cm^2 and 28 x 28 cm^2 fields, there is a definite increasing trend with off-axis distance because of beam softening at the field edges, and so μ_0 values were obtained from linear fits to the data.

(v) Thickness Measurement

We measured thickness distributions for several compensators using the described method and compared the results with intended thicknesses. The ability of the method to extract thicknesses was tested initially using the simple scenario of flat attenuators. Differences between measured and intended thicknesses for a 3 cm flat attenuator are shown topographically in Fig. 10(a) and as a histogram in Fig. 10(b), and have a mean value of -0.03 ± 0.19 mm (1 SD).

The fluctuations seen in the measured profiles in Fig. 10(c) are likely due to a combination of variation in steel-shot density and the presence of grooves on the Styrofoam shell bed caused by the mill bit (diameter ≈ 3 mm). The fall off evident at the field edges was seen for most of our thicker compensators and is believed to be caused by non-uniform packing near the edges of the Styrofoam cavity. Across the full range of flat attenuators investigated (0.5 – 4.5 cm), we found a mean difference between measured and intended thicknesses of -0.22 ± 0.25 mm (1 SD).

Two of the three test compensators incorporate severe gradients, and the efficacy of our EPID-based thickness measurement method is discussed here using the example of the frustum of pyramid compensator. The intended thickness at the frustum is 4.5 cm, whereas that at the base is 0.3 cm.

Figure 11(a) shows that the maximum difference of ~-1.5

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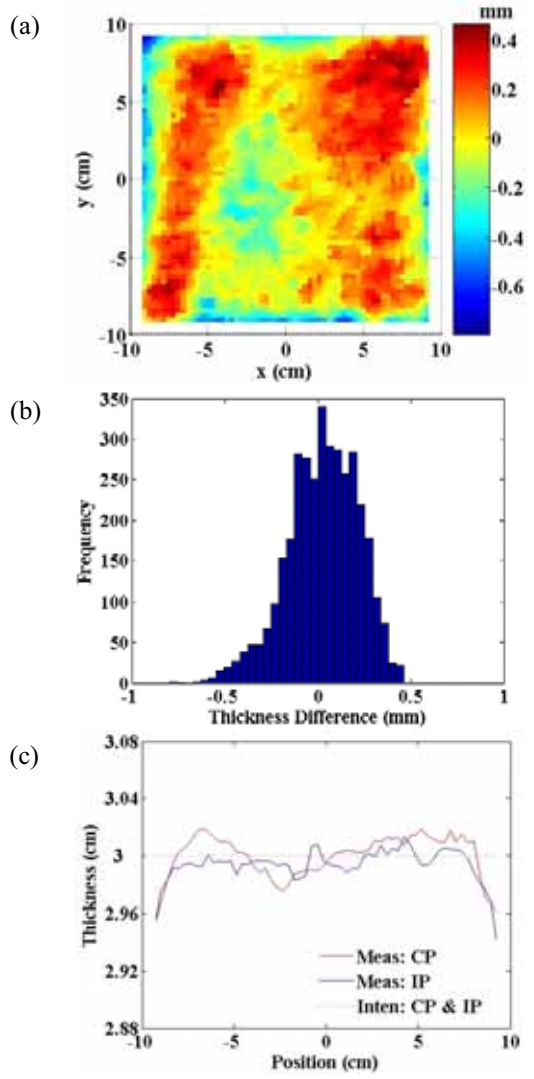

Figure 10: Differences between measured and intended thickness for a 3 cm flat attenuator imaged in a 20 x 20 cm^2 field at SDD are represented as a (a) surface plot and (b) frequency distribution. (c) Cross- and in-plane profiles of intended and measured thicknesses along x = 0 and y = 0.

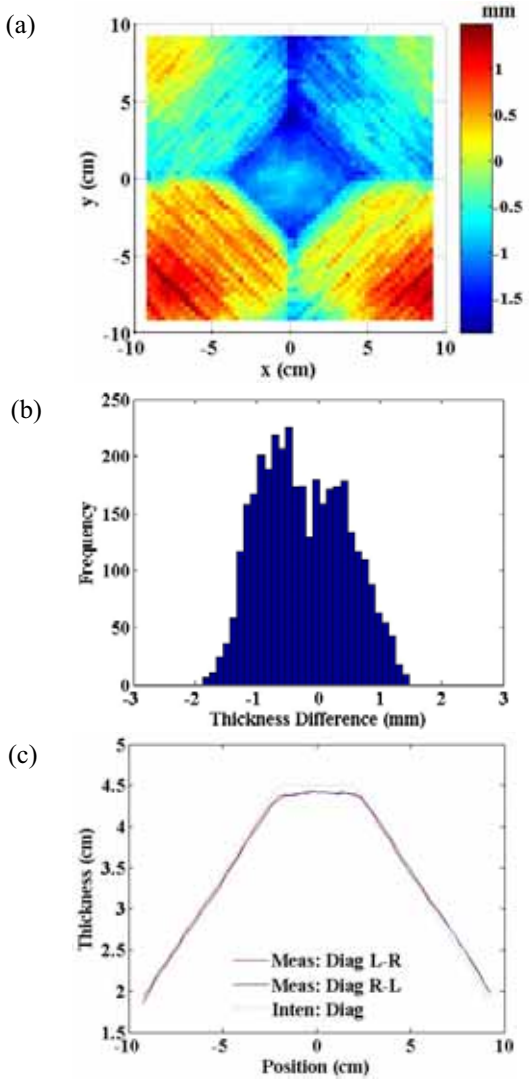

Figure 11: Differences between measured and intended thickness for a frustum of pyramid compensator imaged in a 20 x 20 cm^2 field at SDD are represented as a (a) surface plot and (b) frequency distribution. (c) Cross- and in-plane profiles of intended and measured thicknesses along x = 0 and y = 0.

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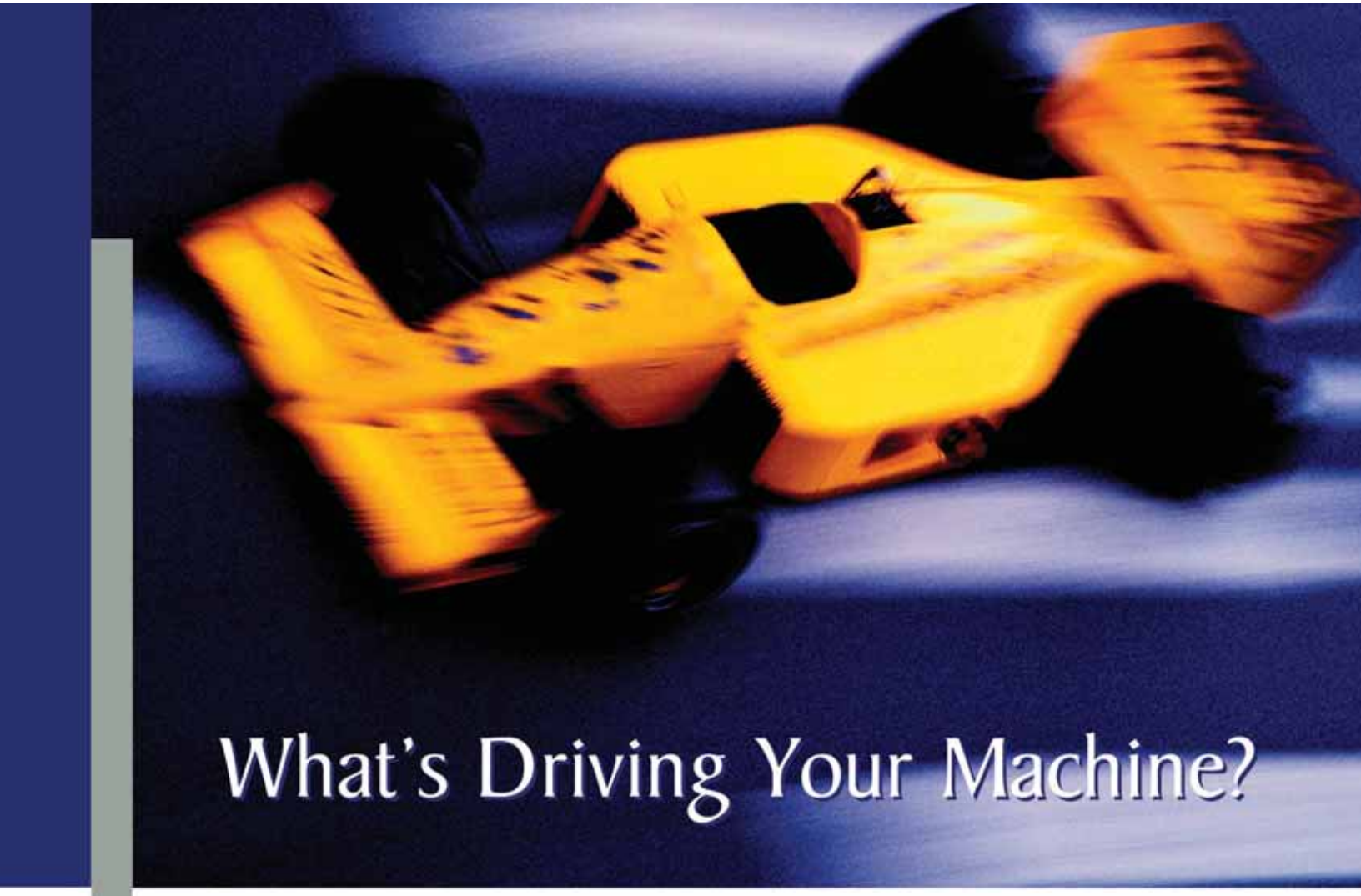

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mm between measured and intended thickness for this compensator occurs at the frustum. The Styrofoam slab used for this compensator had a thickness of only 4.9 cm and this is manifested in the difference map as a reduction in thickness at the frustum. There is a discernible difference in thickness between the top and bottom halves of the topographical map in Fig. 11(a), which is thought to arise primarily from sub-millimeter uncertainties associated with lateral positioning of the Styrofoam slab in the mill and during mounting. Figure 11 (c) shows diagonal profiles across the truncated pyramid. The average thickness difference for this compensator was -0.24 ± 0.69 mm (1 SD).

We limit our discussion of clinical compensators to two that exhibited most of the characteristics observed for the entire set examined. Figures 12 and 13 display results for a digitized compensator used to treat the base of tongue and a Helax designed compensator used to treat melanoma of neck nodes, respectively.

There are two regions within these compensators that showed large thickness differences owing to inevitable manufacturing limitations. First was the significant disagreement in thickness near the channel that was used to fill the Styrofoam slab with steel shot (lower left corner in Fig 12 (a)). Thickness differences near these fill channels for the whole set of compensators ranged from -1.5 to -4 mm. The holes used to mount shielding blocks on the top Lucite plate are visible as circular regions of disagreement on the thickness difference surface plots (Figs. 12(a), 13(a)) and as dips in the profiles (Fig. 12(b)).

For the neck node compensator, thickness differences were mostly < 1 mm, except within regions at the edges of the neck contour. Differences of up to 8 mm in these regions stem

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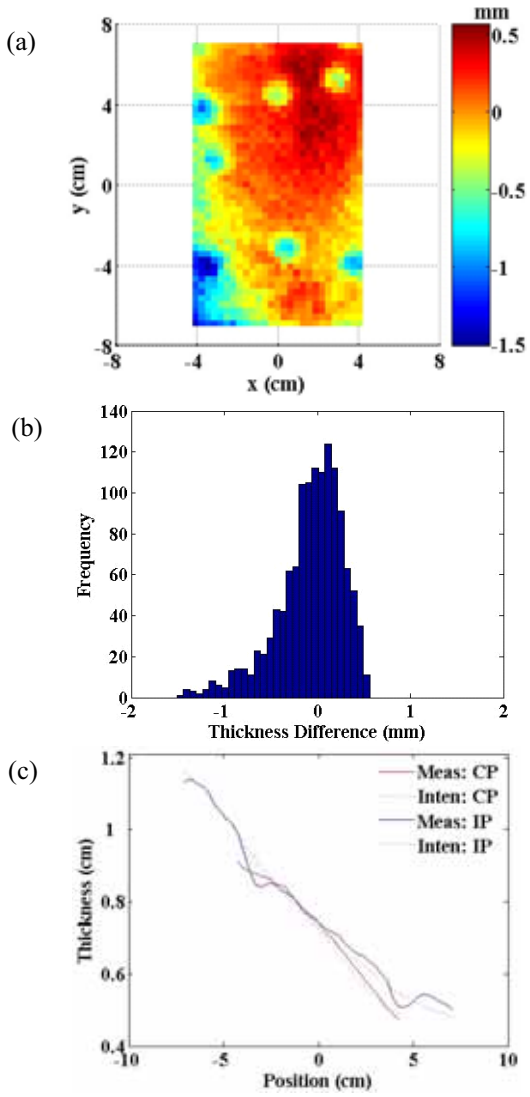

Figure 12: Digitized compensator used to treat base of tongue imaged in a 9.9 x 15.5 cm^2 field at SDD. (a) Surface plot and (b) frequency distribution of differences between measured and intended thickness. The mean thickness difference was -0.07 ± 0.35 mm (1 SD). (c) Cross- and in-plane profiles of intended and measured thicknesses along x = 0 and y = 0.

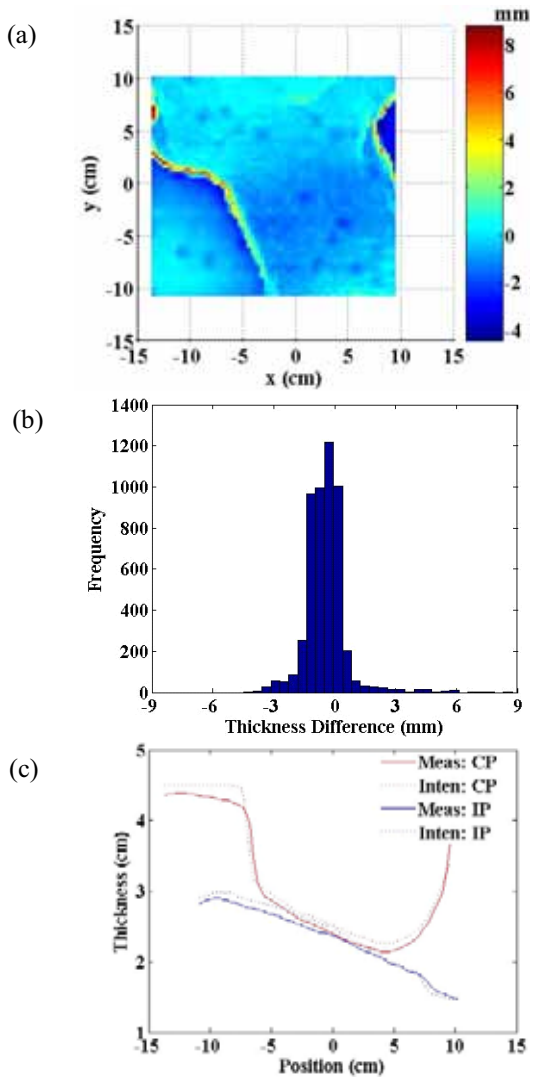

Figure 13: Helax designed compensator used to treat melanoma of neck nodes imaged in an asymmetric field of size 26 x 24 cm^2 at SDD. (a) Surface plot and (b) frequency distribution of differences between measured and intended thickness. The mean thickness difference for this compensator was -0.44 ± 1.03 mm (1 SD). (c) Cross- and in-plane profiles of intended and measured thicknesses along x = 0 and y = 0.

Compensator Thickness Measurement… (Continued from page 96)
from the inability of the finite-sized mill bit (~3 mm diameter) to accurately reproduce contours having a sharp fall-off. As seen in Fig 13(c), regions outside the neck contour were intended to be milled to the largest thickness of 4.5 cm but due to the Styrofoam slab being thinner (4.9 cm instead of the standard 5.0 cm), were not cut to the required depth.

Figure 14 shows a box plot of the average differences between measured and intended thicknesses for all three categories of compensator. The mean ± 1 SD of differences for the flat, test, and clinical compensators were -0.22 ± 0.25 mm, -0.06 ± 0.94 mm, and -0.63 ± 0.74 mm, respectively. On the whole, it was observed that the greatest thickness discrepancies occurred in the vicinity of steep gradients, field edges, and fill holes. For compensators cut to depths of 4.5 cm (the outlier in Fig. 14), larger thickness differences were observed because of the flattening of the primary transmission curve at this thickness (see Fig. 8). In addition, uncertainties due to Styrofoam slab positioning in the mill, mounting between the Lucite plates, and steel shot filling were estimated to contribute to a combined uncertainty in thickness estimation of ~ 0.8 mm (1 SD).

6. SUMMARY AND CONCLUSION

The work presented here builds on previous investigations that validated the use of an aS500 EPID for dosimetric measurement. In particular, we have made use of procedures for dose calibration and scatter factor determination that enable energy fluence measurement with the EPID. a-Si EPIDs are generally considered to have a linear dose response, but it was observed that calibration curves relating aS500 pixel values to ion chamber readings for attenuated beams had a mildly quadratic shape because of the detector's sensitivity to the photon spectrum, necessitating the measurement of separate calibration curves for open and attenuated reference fields. To apply the calibration curves to other field sizes, EPID scatter factors for both open and attenuated beams were determined using an iterative algorithm. These were found to be dependent on attenuator thickness and source-to-detector distance as well as field size. The requirement to calculate off-axis EPID scatter factors was met by relying on Day's method.

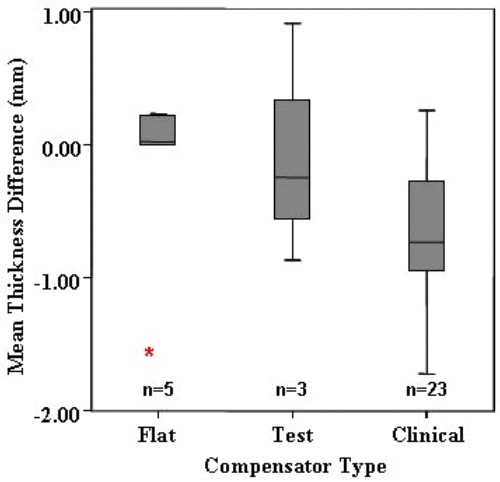

Figure 14: Mean thickness difference distribution for flat, test, and clinical compensators. The line in the box represents the median value and the upper and bottom hinges, the 75th and 25th percentile, respectively. The ends of the whiskers indicate the minimum and maximum data values. 'n' represents the number of compensators in each group. The red asterisk is an outlier that has a value more than 1.5 times the box length from the lower edge of the flat compensator box (corresponds to the 4.5 cm thick slab with an average thickness difference = -1.58 ± 0.34 mm).

Using the formalism described, we were able to verify the accuracy of compensator fabrication by measuring compensator thickness radiographically on a 2D grid. Our approach involved making total transmission measurements with the EPID, subtracting a calculated estimate of the scatter contribution, and inferring compensator thickness from the resultant primary transmission using a primary transmission model. The average difference between measured and intended thicknesses for all the compensators examined was -0.51 ± 0.68 mm (1 SD).

There are some features of the aS500 EPID that merit particular attention for dosimetry applications. For the most part, the EPID demonstrated good pixel response stability during the period of study, although we occasionally observed slight changes. One reason for this was that the dose calibration was prone to drift over an extended period of time. To overcome this problem, we suggest that it is desirable to update the pixel-to-dose response relation at least quarterly. Another reason was that the image acquisition timing was intermittently premature, whereby aS500 images were occasionally acquired ahead of the specified time (particularly for the [0-50%-0] acquisition mode), resulting in a reduction in the recorded pixel value of up to 4% for consecutive images taken with identical setup parameters. Our workaround here was to look at the acquisition time of all images and eliminate those found to be premature. As regards the steel shot compensators examined, we observed measurable variations in their physical properties arising from fabrication and mounting uncertainties associated with positioning in the milling device and linac, the finite size of the milling tool, non-uniform packing of the steel shot and variability in the thickness of the Styrofoam slabs. Such uncertainties complicate the assessment of accuracy of EPID-based thickness estimates, and have to be accounted for in interpreting results, especially for those compensators having steep contour gradients such as the pyramid and neck node compensators.

After accounting for uncertainties associated with compensator manufacturing, we conclude that transmission measurements made with an aS500 EPID can be used to determine the 2D thickness distribution of a steel-shot compensator to within ~ 0.5 mm in regions where steep gradients are absent and the fill material is < 4 cm thick.

Acknowledgement

This article describes a portion of the work presented in the Ph.D. thesis of G. Menon and carried out at the Cross Cancer Institute, Edmonton, AB.

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In Brief

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Imaging Research Laboratories, Robarts Research Institute
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Submitted by Aaron Fenster

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To realize the lab's mission, we crafted a highly collaborative and multi-disciplinary environment where students and scientists interact on a daily basis, sharing ideas and equipment, pooling intellectual and institutional resources. This dynamic environment has accelerated the lab's success and expansion; IRL was initiated in 1987 with 8 faculty and staff and has grown to 230 today! This includes 15 scientists, 28 Associate Scientists, 82 graduate students, 36 summer students, and many post-doctoral fellows, research associates, technicians, and support staff. Since the IRL was started in 1987, many of our scientists and students have obtained awards from prestigious agencies, e.g. 2 Canada Research Chairs (Tier 1), the Barnett Ivey Stroke Chair, 2 salary awards from the HSFO and 3 PRIA PREA awards. In total, our scientists have received 110 awards and our students have won about 50 paper/poster awards! Scientists at the IRL hold or participate in 33 CIHR grants and numerous others totaling $17M in annual research funding

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The IRL offers a unique learning environment for graduate students. Our students are enrolled in 10 different graduate programs at the University of Western Ontario, but work together as teams on multi-disciplinary research projects. Nearly half of these high achieving students come to the IRL with their own funding from various personnel awards and scholarships from national or provincial funding agencies. The interdisciplinary approach creates a dynamic research experience, which allows the students access to resources, funding and expertise as needed to advance their research. We also train a large number of undergraduate students (about 40 every year) who join our lab as part-time or summer students as they begin to develop ideas for future graduate thesis topics.

In addition to mentoring graduate students from many Departments, the IRL has initiated and led two major interdisciplinary training programs at UWO:

> The IRL was the driving force behind the implementation of a new CIHR funded trans-disciplinary training program for students focusing on vascular and cerebrovascular disease. There is a crucial need \ for individuals who can bridge different disciplines, and for scientists who are able to function as leading members of multi-disciplinary teams and be at the forefront of health research. Our training program teaches graduate students to think in terms of multidisciplinary approaches, including teaching them the "language", tools and expertise of other disciplines. http://www.robarts.ca/CIHR_VTP/index.html
>
> The IRL has also led the formation of a new UWO Graduate Program in Biomedical Engineering, for which Dr. Fenster was the original Program Director. In its 4th year of existence, this new program has already attracted 44 Masters and PhD candidates who have an entrance average of 84%. About half of the students have national and provincial scholarships. http://www.engga.uwo.ca/research/biomed/

RESEARCH THEMES

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CARDIOVASCULAR IMAGING: the mission of this theme is to develop, refine, and apply new vascular imaging methods to solve the major vascular disease problems facing our society. The major areas of research are: studies of vessel wall/plaque hemodynamics with a particular focus on carotid artery plaque rupture leading to stroke, studies of the microvasculature and tissue ischemia in the brain and heart, and development of vascular image guidance and interventional techniques.

BRAIN & MIND IMAGING AND SPECTROSCOPY: This theme concentrates on the interactions between the electrical, vascular and metabolic activity in the brain. The major areas of research are: the study of the relationship between fMRI and human behaviour; the development of techniques to extend the spatial and temporal information in fMRI; the development and application of metabolic imaging and spectroscopy in disease; and the development of perfusion imaging techniques.

IMAGE-GUIDED SURGERY AND THERAPY: The focus of this theme is on the development of minimally invasive surgery and therapy techniques based on image guidance using 3D MRI, CT and ultrasound, with applications in: neurosurgery, prostate

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ACROSS CANADA… (Continued from page 99)
cancer therapy, breast cancer biopsy, MR-guided cardiac intervention, robotic cardiac surgery and robotic-aided prostate therapy.

MUSCULOSKELETAL IMAGING: This theme is working closely with orthopedic surgeons on the development of techniques to improve the initial placement and alignment of prosthetic devices by providing real-time image guidance during surgery; the development of advanced 3d ct techniques to monitor the joint after surgery, and the quantification of prosthetic wear and bone resorption during clinical trials, and the development of high-resolution MRI techniques for cartilage imaging using 4 T.

MOLECULAR, CELLULAR AND MICRO-IMAGING: This is a new and expanding area of research involving close collaboration between the imaging scientists and scientists working in neuroscience, stem cell biology, immunology, virology and genetics to study disease processes in experimental animal models using magnetic resonance microscopy (MRM), micro 3D CT, PET, and micro 3D ultrasound.

BASIC IMAGING SCIENCE & ENGINEERING: The focus of this theme is to develop fundamental aspects of the science and engineering of medical imaging systems. With research topics covering many imaging modalities, theour objective is a better understanding of the physical processes important in both conventional and unconventional imaging systems. Applications of this work include the development of new MRI coil designs, studies of ultrasound wave propagation, x-ray diffraction imaging methods, and theoretical models predicting image quality and system performance.

ONCOLOGICAL IMAGING: This theme is primarily focused on brain, prostate and breast cancer; however, other organ sites of cancer are also being investigated. The research program deals with diagnosis and therapy applications in humans as well as basic research in animal models using micro-imaging systems. The program is making use of all imaging modalities, including, MRI, MRS, CT, Ultrasound, PET and SPECT.

RESPIRATORY IMAGING: This is the newest theme motivated by the increasing health concerns associated with lung disease, including obstructive pulmonary disease and asthma. Imaging approaches are based on CT and MRI, both preclinical and clinical and involve collaborators in the Departments of Radiology and Respirology of the London Health Sciences Centre. In particular, we are focusing on the use of hyperpolarized noble gas (HNG) MRI, an exciting new technique, which reveals the airways of the lung with unprecedented clarity. Robarts has the only turnkey clinical HNG production facility in Canada and one of only a handful worldwide.

TRANSLATIONAL IMAGING PROGRAM: We are focused on developing clinical imaging tools that can provide methods of non-invasively understanding disease progression and regression. Human diseases and conditions of the lung, heart and brain as well as cancer are our primary focus, but any human disease in which imaging tools can be developed to improve prediction, prevention and monitoring of disease will be supported. The mission of the Translational Imaging Program, is to promote and support: disease-related translational and clinical research in imaging sciences and technology, and integration and application of these imaging discoveries and developments to the understanding of disease biology and to the clinical management of disease and disease risk.

RESEARCH FACILITIES

The IRL houses approximately $20 million in imaging and engineering equipment required to perform leading edge medical imaging research. The facilities include well-equipped machine, electronic rf and gradient coil shops used by technical staff and students to build or prototype their equipment. All laboratory equipment is utilized and operated in a collaborative manner so that all faculty and students have access to multi-modality research pathways in their research programs. Our equipment includes: 4T and 3T whole body MRI systems, access to a1.5T cardiac-optimized MR whole body imager, 5 diagnostic ultrasound machines, 6 3D ultrasound imaging systems, a rotational digital angiographic system capable of 4s 3D CT, 4 High-resolution 3D micro-CT scanners for small animal and specimen imaging, 2 micro-ultrasound imaging and Doppler blood flow, 2 Coherent scatter CT scanners. A 9.4T 31cm bore animal system will be delivered in September, as well as *in vivo* confocal and intrinsic signal optical microscopes.

TECHNOLOGY TRANSFER

The IRL is committed to identifying and exploiting new innovations developed in the lab. Working closely with the Business Development at Robarts, IRL scientists and their students have founded 5 companies and generated 57 patents and numerous disclosures.

I hope that this short report will be able to communicate to you the many reasons we have for being so excited about our lab in London and the potential for continued contributions to medical imaging and health research.

Centre universitaire de santé McGill
McGill University Health Centre
Montreal, Quebec Canada

McGill University Health Centre, Montréal, QC
Submitted by Ervin Podgorsak

The Medical Physics Unit of McGill University and the Medical Physics Department of the McGill University Health Centre are integrated departments that provide both academic and clinical support. Both programs are based in the hospital environment and currently comprise 3 academic physicists, 8 clinical physicists, 6 dosimetrists, 3 engineers and 1 machinist. The department sees about 2500 new patients per year and maintains 6 modern linacs , 2 CT-simulators, one conventional simulator and 1 HDR unit. An active stereotactic program as well as electron and total body irradiation are some of the special

(Continued on page 101)

ACROSS CANADA… (Continued from page 100)
techniques supported by the group. We are also participating in some conformal HDR brachytherapy protocols.

The academic unit currently has 27 M.Sc and 9 Ph.D. students, and during the previous year there were 9 M.Sc. graduates and 1 Ph.D. graduate. We were also happy to receive two research trainees from Brazil and one IAEA visiting fellow from India. These visitors stay from three months to a year depending upon the arrangements made with their sponsoring country, and come with the intention of improving their clinical skills.

Our M.Sc. and Ph.D. programs are CAMPEP accredited and our Residency program has recently undergone a CAMPEP re-accrediation review and we are expecting a positive decision on this. We currently have 4 residents in our two-year Resident trainee program and have had 12 graduates to date.

This being the World Year of Physics our seminar committee was able to arrange for 22 weekly talks to be given from local and invited speakers on many different aspects of physics. These talks were open to the general public and were well received.

In a fiscal environment of both clinical and academic under-funding it is a constant challenge to try to keep up with both new technology and techniques. Nonetheless we have been able to participate in some interesting research projects that include the use of ultasound for on-line tumour imaging, 4D Monte Carlo based dose calculations, electron beam water calorimetry, stereotactic-based narrow field dosimetry, modulated electron beam radiotherapy, electron portal imaging, and other clinical based projects to name a few. The close collaboration between clinical and academic based physicists is certainly a satisfying aspect of working at McGill, and closely compliments our strong emphasis on practical clinical training.

During the past year a PET-CT scanner service was introduced at the Montreal General Hospital site of the MUHC and is used for selected radiotherapy patients. In addition we have commissioned a Monte Carlo based electron treatment planning system and are performing clinical evaluations. Medical physics at the MUHC and McGill continues to serve its multiple roles of clinical service, teaching and research.

BC Cancer Agency
CARE & RESEARCH
An agency of the Provincial Health Services Authority

Vancouver and Fraser Valley Cancer Centres, Vancouver and Surrey, BC
Submitted by Cheryl Duzenli

BCCA continues to expand with a major capital equipment project underway. All in all, the project involves the acquisition of 5 new linacs (3 replacing aging units in Fraser Valley and Vancouver and 2 new additions), a new CT simulator and image guidance technology. Two of these linacs will go into vaults currently under construction in Vancouver with expected completion in early 2006. Two additional vaults are being constructed for future expansion.

Fraser Valley centre is currently celebrating it's 10th year of operation, already! The physics group is looking forward to a busy time in the coming months commissioning new equipment and implementing new technology. In addition to this work, many of our staff have been involved in the planning of the new cancer centre in Abbotsford, on track to open in early 2008.

On Friday, 27 May, the One World One Heart organization held a Fundraising Gala Dinner held in the Fairmont Hotel, Vancouver, which raised a grand total of $382,500 for Precision Radiation Therapy Research at the BC Cancer Agency. The more than 600 attendees were entertained by several high profile performers and a live auction provided additional excitement over the course of the evening. The funds raised will be put towards the purchase of an image-guidance system consisting of an orthogonal pair of X-ray/amorphous silicon imager units with associated software manufactured by BrainLAB. This system will be installed to augment the current intracranial stereotactic radiosurgery system in Vancouver which uses the BrainLAB micro-multileaf collimator.

In the later half of 2004, Robert Corns, Vicky Huang and Erin Barnett joined Vitali Moiseenko, Cathy Neath and Sherali Hussein to complete the physics team at FVC. Also, in 2004, we welcomed Susan Zhang, Rustom Dubash and welcomed back Ermias Gete to Vancouver. In 2005 Joshua Audu joined us as senior physicist to complete the Vancouver group, arriving in January from Nigeria.

All in all it has been a busy time in the B.C. lower mainland as we continue to grow!

Fraser Valley Celebrates 10th Anniversary
Left to right: Back row Glenn Anderson (electronics), Denny Yu (electronics), Vitali Moiseenko, Sherali Hussein, Eric Harvey; Front row: Cheryl Duzenli, Louise Myers (secretary), Robert Corns, Erin Barnett, Vicky Huang and Sheryl Harrop
Missing from photo: Cathy Neath

First Canadian Stereotactic Radiosurgery Society Meeting

Submitted by Brenda Clark
Vancouver Cancer Centre, BC Cancer Agency,
Vancouver, BC

The inaugural meeting of the Canadian Stereotactic Radiosurgery Society (CaRS) was held in Banff, Alberta on 4-5 March. In fact, the society didn't exist until the last session of this meeting when it was agreed that it would be a useful thing to do. The idea was conceptualized by Zelma Kiss and John Wong, neurosurgeons at the University of Calgary, and consolidated during a lunch meeting with two colleagues, Mike Schwartz and Ian Fleetwood at the Canadian Congress of Neurological Sciences in June 2004. The aim was to bring together the various stereotactic radiosurgery teams from across Canada to facilitate collaboration and optimise the impact of Canadian efforts in this field. As a result of this initial lunch, it was agreed to arrange a meeting in Banff for the following March and see whether there was general support for this idea.

The Banff meeting was primarily arranged by Zelma Kiss, Neurosurgeon at University of Calgary, with the help of a local arrangements committee consisting of two each of neurosurgeons, radiation oncologists and physicists, a multidisciplinary collaboration reflected throughout the meeting even to the approximately 60 attendees, who were divided almost equally between these three professional groups. All twelve Canadian centres currently offering this technique were represented at the meeting. Three of the twelve centres are fortunate to have dedicated units, two Gamma Knife installations in Winnipeg and Sherbrooke and one BrainLAB Novalis unit in Calgary. Although there were only two radiation therapists at the meeting, they both presented interesting papers and agreed to make every attempt to increase participation from their group for the next time.

The scientific program committee (Ian Fleetwood, MD, Halifax and Michael West, MD, Winnipeg, both Neurosurgery, Shawn Malone, MD, Radiation Oncology, Ottawa and Chris Newcomb, PhD, Physics, Calgary) scheduled the presentations according to the three topics: Where Are We Now, What We Know and What We Don't Know and Where We Want To Go with three keynote speakers, one addressing each of these topics. The first keynote speaker was Michael Schwartz, MD, the current head of neurosurgery at Sunnybrook and Womens' College Health Sciences Centre, Toronto, the site for the third Canadian Gamma Knife scheduled for installation later this year. His talk gave an excellent review of the development of radiosurgery in Canada, highlighting the work of several individuals and referring to Ervin Podgorsak as the "Father of Canadian Stereotactic Radiosurgery".

The second keynote speaker was David Larson, MD, PhD, the Clinical Director of Long Hospital Department of Radiation Oncology at UCSF, who addressed the topic "Brain Radiosurgery: Foundations, Methods, Results and Questions". The third keynote speaker was Samuel Ryu, MD, Director of the Centre for Radiosurgery at the Henry Ford Hospital in Detroit, whose talk was "Radiosurgery of the Spine and Cord: Where We Want to Go". In addition, there were 30 presentations with topics ranging from clinical or physics to the results of surveys designed to determine the answers to the themes of the meeting. Of interest to those of us in the linac field was the almost overwhelming predominance of BrainLAB equipment with one or two of the same images turning up many times.

From my perspective, this was an exciting and useful meeting with two relatively unique aspects. The first was the opportunity to attend the multidisciplinary sessions and not only hear the clinical aspects of the work but also to present some of our physics work to the clinicians. These opportunities come rarely as most of us tend to use our somewhat limited travel budgets to flock together in professional groups and rarely attend meetings or even sessions focused on a technique rather than a discipline.

The second very exciting aspect of this meeting was the potential for collaboration among the attendees. The topic of the final round table discussion session focused on the future of stereotactic radiosurgery in Canada and the development of multicentre collaborative trials. There were questions like: "If you had a small meningioma, would you treat or wait?" and "Is staged treatment for AVM appropriate?" Several site groups were formed to address issues in the treatment of the major clinical sites such as AVM and acoustic neuroma. There was also consensus that we need to establish a standardisation of reporting of dose and volume information, currently something which varies not only with technique but also across the country. For example, several presentations quoted prescription dose in terms of the *n*th % where the 100% was undefined – a pet peeve of mine!

In summary, this meeting reached the goal of the organisers with participation from all professional groups and all stereotactic radiosurgery centres in Canada, agreement to form the society and a second meeting scheduled for next year in Toronto which will provide a venue for follow-up on the various initiatives developed in Banff. It didn't hurt that Banff in March is a relatively pleasant place and several of us were able to take the time either before or after the meeting to sample the skiing facilities in the area.

In Memoriam: Dr. William Que

I am sad to report the passing of our colleague Dr. William Que, MCCPM. William was a medical physicist at the Toronto Sunnybrook Regional Cancer Centre for the last 10 years. He was also a professor at Ryerson University in Toronto where he had recently been involved in designing a new undergraduate Medical Physics program. He was appointed to the Department of Radiation Oncology at the University of Toronto and was active clinically and academically in the TSRCC brachytherapy program.

Peter O'Brien
Toronto Sunnybrook Regional Cancer Centre

CITATION AWARD 2004

Submitted by Michael S. Patterson, Juravinski Cancer Centre and McMaster University, Hamilton, ON

Avid readers of *Interactions* may recall an article I wrote about a year ago (Vol. 50, pp. 29-32) calling on COMP to change the criteria for the Sylvia Fedoruk Award, presented annually for the best paper in the field of medical physics. I argued that the 2004 award should be given to the paper published in 1994 that had been cited most often in the subsequent ten years. While my suggestion prompted some discussion, I was not able to convince the COMP executive to pursue this idea. Rather than drop the notion entirely, I realized that there was nothing (other than the editor's exasperation) to prevent me from using these pages to recognize the winner. Unfortunately, no monetary award will accompany this fame, but I pledge to buy the winners a beer if they attend the COMP meeting in Hamilton this summer. Perhaps one of our corporate members would like to pick up on this idea for future years. Now, without further ado, let me announce the winner. The following paper was cited 129 times from its publication to the end of 2004. Interestingly, and ironically, it was also the winner of the Sylvia Fedoruk Award for that year! The judges for 1994 should be congratulated on their prescience – their feat is unlikely to be duplicated in the near future.

ANISOTROPY OF NMR PROPERTIES OF TISSUES
HENKELMAN RM, **STANISZ GJ**, **KIM JK**, **BRONSKILL MJ**
MAGNETIC RESONANCE IN MEDICINE 32 (5): 592-601 NOV 1994

Abstract: Orientational anisotropy of T-2 and T-1 relaxation times, diffusion, and magnetization transfer has been investigated for six different tissues: tendon, cartilage, kidney, muscle, white matter, and optic nerve. Relaxation anisotropy was observed for tendon and cartilage, and diffusional anisotropy was measured in kidney, muscle, white matter, and optic nerve. All other NMR measurements of these tissues showed no orientational dependence. This pattern of NMR anisotropies can be interpreted from the underlying geometrical structures of the tissues.

Because it was a very close race, I feel it only right to acknowledge the runner-up. This paper was cited 124 times. As you can see, 1994 was a big year for anisotropy!

DETERMINANTS OF ANISOTROPIC WATER DIFFUSION IN NERVES
BEAULIEU C, **ALLEN PS**
MAGNETIC RESONANCE IN MEDICINE 31 (4): 394-400 APR 1994

Abstract: We report NMR diffusion measurements of water in three central nervous system models, namely the nonmyelinated olfactory, and the myelinated trigeminal and optic nerves of the spotted and long-nosed garfish. A similar degree of anisotropy of the average diffusion coefficients (D(NMR)) is observed for all three freshly excised nerve types {D(NMR)(parallel)/D(NMR)-(perpendicular) is 3.6 +/- 1.2, 3.2 +/- 0.9, and 2.6 +/- 0.4 for the olfactory, trigeminal, and optic nerves, respectively}. The anisotropy of D(NMR) for the nonmyelinated olfactory nerve argues strongly that myelin is not a necessary determinant of diffusional anisotropy in ordered axonal systems (even though it may contribute when present). Garfish nerves treated with vinblastine, in order to depolymerize microtubules and inhibit fast axonal transport, also exhibit diffusional anisotropy {D(NMR)(parallel)/D(NMR)(perpendicular) is 2.6 +/- 0.4, 2.8 +/- 0.8, and 2.2 +/- 0.7 for the olfactory, trigeminal, and optic nerves, respectively} thus excluding a significant role for microtubules and fast axonal transport in that observed anisotropy.

CCPM President's Message… (Continued from page 85)

I hope that these few hints will provide some help to future candidates as they prepare for this important event in their career. By the time you read this, we will be involved in another round of oral examinations for the Fellowship, but generally by the time they are eligible for this hurdle, most candidates have conquered their nerves and done some teaching so that hopefully these issues are moot.

As always, we are happy to hear from you on this or any other topic relevant to the CCPM.

COMP?CCPM Executive Director Message… (Continued from page 86)

In closing, I would like to encourage all members to contact me at execdir@medphys.ca or 613-599-1948 with any feedback, suggestions or concerns. I would also like to take this opportunity to thank Barb Callaghan for her dedication and support. Her help and patience are very much appreciated.

Report on Conjoint Committee on Accreditation

Submitted by Michael Evans,
McGill University Health Centre,
Montréal, QC

Over the weekend of April 3, 2005 I was in Ottawa as the CCPM General Assembly Delegate to the Canadian Medical Association's Conjoint Committee on Accreditation.

I am sure you have all committed to memory my newsletter articles concerning this meeting over the last 8 years, however, as a reminder the CCPM is a sponsoring member of the CMA – CCA. This is the body that conducts ccreditation visits for various medical technology training schools across Canada. As many medical physicists are involved with the teaching and training of technologists and therapists in both diagnostic imaging and radiation oncology, it is advantageous to have the CCPM represented at this process. During the meeting we reviewed the activities of the CCA during the last year and completed the nomination process for the executive of the CCA.

This may be one of the last years the CCA has a General Assembly meeting as the CCA is undergoing structural changes. At the end of the session I voiced some concerns that smaller sponsoring bodies such as the CCPM might be left out of the decision making process. This is because we are a professional body that provides expert reviewers for accreditation visits but we do not undergo accreditation by the CCA itself. We are not the only organization in this situation: in fact the Canadian Association of Radiation Oncologists, the Canadian Association of Radiologists and the Canadian Association of Medical Microbiologists are just a few of the many sponsoring organizations in the same peripheral situation as sponsoring groups for accreditation. The CCPM is trying to remain involved and participate in any structural changes that may affect our status in the CCA.

Over the same weekend I also attended the plenary session sponsored by the Canadian Medical Association for the General Assembly of Accreditation Sponsors entitled "Education, Certification and Accreditation in a World without Borders". This conference was attended by about 200 delegates from teaching related professions and much of the symposium dealt with challenges related the expansion of cross-border education and higher education providers in a global market place.

An opening address entitled " A world without borders" discussed the enormous demand worldwide for trained health care professionals, and the argument was made that if the non-profit educational sector is not able to meet the demand for health care providers, for-profit education can, and is, going to fill the void. This talk was followed by a panel discussion entitled "How do globalization and internationalization affect members and education programs"? Four speakers representing various universities, community colleges and training programs gave their perspectives on dealing with students and education programs from around the world, and the challenges of trying to place students from varied backgrounds at the appropriate educational levels in their system. A second panel discussion entitled "Perspectives on internationalization of health and education" featured speakers from Strategic Research and Statistics(Citizenship and Immigration Canada), and the Foreign Credential Recognition Division(Human Resources and Skills Development Canada). Here we were exposed to the problems that the government has to deal with when managing health care and other professionals from around the world. The final panel discussion entitled "How do globalization and internationalization affect your role in credential recognition and accreditation" was given by speakers representing Medical Laboratory Technologists, the Canadian Association Of Medical Radiation Technologists, the Canadian Opthalmological Society, the Canadian Council of Professional Engineers and the Canadian Association Of Schools of Nursing. It was quite clear that all professional societies are struggling with credentialing problems and they (we) continue to insist on "re-inventing the wheel" with limited resources instead of working on a combined formalism for assessing international credentialing. We, as CCPM are often asked why we do not have a common policy on professional recognition of international medical physicists and cross-certification. Coming out of this conference I realized that the task is almost overwhelming for large and well funded groups such as engineers and nurses. Expecting a group such as the CCPM that runs on a shoestring of volunteers and perhaps less than enthusiastic membership to be able to properly evaluate physicists from all over the world is probably unreasonable. The Canadian government has some initiatives through Citizenship and Immigration that are directed towards a consistent evaluation method for international health care professionals: this is likely the most practical route for small societies such as ours to take.

In addition Dr. Andrew Rainbow and myself have been nominating names of physicists to act as members of accreditation teams that conduct site visits. These names are forwarded to the CCPM executive who then pass them along to the CMA-CCA. My experience has been that the CMA is very happy to have CCPM physicists participate both at the executive level and in site visits. Last year for example I visited the University of Prince Edward Island school of Diagnostic Imaging as part of a team of 4 surveyors for an accreditation visit. The other members included a radiologist, a program co-ordinator from another school and a Senior Manager of the CMA-CCA head office. The site visit took about five days including travel. These visits take a fair amount of work prior to travel, including a review of background documentation (hundreds of pages) and several telephone conferences. On the other hand I have found the site visit to be a good learning experience, and have been teamed up with other members who have completed 10 or more site visits each and are able to lead the review. The expertise required to be a "Scientist" reviewer is not enormous, and teaching experience is probably more important. CCPM is fortunate to be able to play a role in this accreditation process as it certainly increases our visibility with "cousin professions" such as imaging and therapy technology.

I am apparently continuing on in my role as CCPM rep to the CMA. The exposure is very good for our profession, and it is a good forum to see how other societies are handling many common problems.

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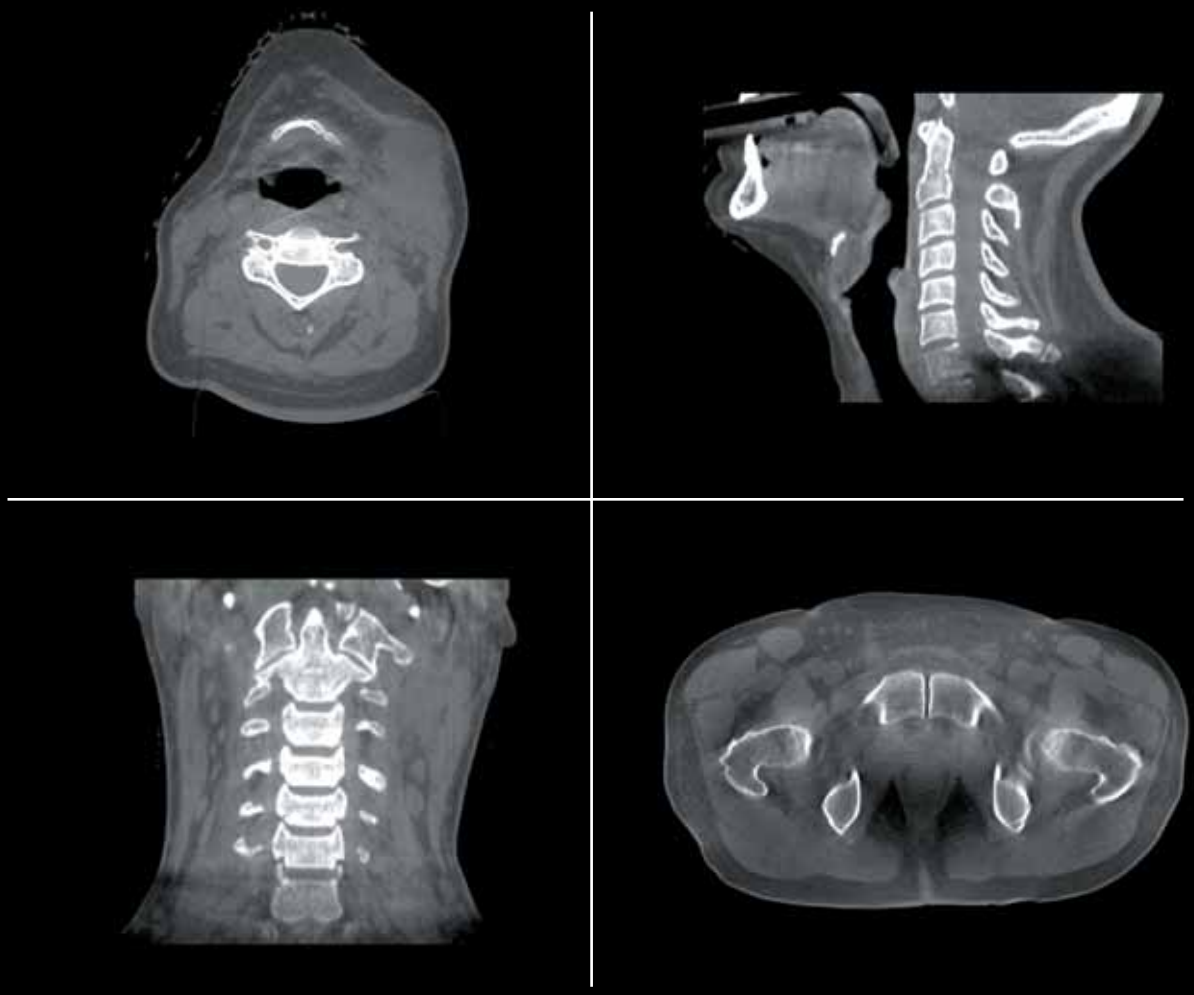

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