X-Rays, How Much Is Too Much.

Everyday in my office I'm asked the same question, Are you going to X-ray me? I don't want any X-rays' Then I give a 5 minute speel on why we need them and if I still haven't convinced them, I have them sign a part of their chart saying that my examination was not complete because I couldn't X-ray their mouth Not saying that I X-ray every patient routinely, but these are cases where I feel it is necessary for a good diagnostic examination.

Sometimes I feel my encouragement is not backed up by enough fact so that's what made this research come about.

Lets start way back about 1895 with a little history of X-rays.

The ~~most~~ MAN responsible for the X-ray was Wilhelm Conrad Röntgen. To most of us Rontgen is a celebrated German Scientist and only a few know him as a European, who almost missed the boat of science. He was born to Friedrick Conrad Rontgen, a merchant and his wife Charlotte Constange from Amsterdam , On March 27th, 1845 in Lennep, a small town at the Ruhr district in Germany. His parents moved to the Netherlands and he became a Dutch citizen in 1846 Romtgen spent his youth and adolesence in Appledorn. He Attended Technical School in Utrecht, Holland until 1863. He had to leave school because of a joke played on one of his teachers and without the "Abitur"(final exam) of a secondary education school in Central Europe, he could not enter a University. He had to take private lessons before he could enroll at the Utrecht University. He then studied in Zurich and received a diploma of a machine engineer in 1868. A year later he was given the doctor title for his thesis "Studies on Gases".

In 1872 Rontgen married Bertha Ludwig and in 1874 became a professor at the University of Strassburg He then became the head of the Institute

of Physics of the University of ~~Giefeen~~ Giessen/ Germany and in 1888 took the same position at Wurzburg

He devoted his time to the study of cathode rays which lead to the discovery of X-rays on November 8th, 1895. On December 28th of the same year Rontgen submitted a manuscript "About a new kind of Rays". It was published in the proceedings of the societety at the end of 1895. Rontgen enclosed two exposures: The left hand of his wife and a strip of zinc sheet. Both radiograms indicated very well the two ways in which x-rays should gain a paramount importance: Medicine and industry.

In less than 40 days the news about Rontgen's x-rays was spread thru scientific publications. Verbally Rontgen presented his discovery on January 13th 1896 before the German Emperor WilhelmII, which was a great honor, and on January 23rd before the Physical-Medical Society of Wurzburg. He recalled that he had noticed luminescence of a bariumplatinum cyanide paper with every emission from a Crookes bulb. By chance, he said, "I noticed that the rays penetrated black paper". Rontgen had tried various materials (books, wood, metal, a door and his hand) and finally documented his experiments on photographic plates. At the end of his presentation he asked the famous anatomist VanKoelliker to have his hand photographed with the new rays. When this radiogram was shown to the audience Rontgen was given a roaring applause and VanKoelliker, quite moved, made a short speech about the importanceof the session and asked the audience for three cheers for Prof. Rontgen. and also suggested that the x-rays should furtheron be called Rontgen -Rays. His proposal was well accepted by the society.

In 1900 Rontgen was elected Professor and Head of the Physical Institute of the University of Munich. One year later he was the first scientist to be honored with the Nobel Prize in physics. His academic work terminated with his last publication in 1920. Three years later he died in Munich.

People were quick to look for cures in new innovations, an editorial in the Journal of the American Medical Association in February 1896 expressed the opinion that the new x-rays might have a beneficial theraputic function. Unfortunately the ray's were put into use before any of the adverse effects could be recognized and the many necessary precautions were not observed. Interestingly to note that Rontgen, on the other hand, made all his exposures with a lead shield interposed between himself and the tube.

Many of the early investigators of X-ray observed various strange effects with their experimentation For example Thomas Edison noted that after several hours work with x-rays, he suffered severe pain in his head and eyes. Similar occurances were reported by W.J Morton, M.D. who is credited with having taken the first dental x-ray in America. Dr Edmund Kells, a dentist began to use x-ray in his dental practice soon after the discovery, but as a result of the frequent exposure to the rays, died, a victim of radiation necrosis.

One of the most often reported ill effects observed to be related to the use of x-ray in the days of its infancy was that of loss of hair or epilation. Several people than postulated that the x-rays might indeed be used for the removal of unwanted hair. It was believed that exposure of a man's chin, for example, to the rays would remove a beard and therefore eleminate the necessity of shaving.

Other work was done with x-rays , and a fellow named Thompson determined the effect of x-rays on the skin. He exposed his hand to a tube for 1½ hours For several days little effect was noted, but then his fingers became swollen and began to blister and peel. Thompson then recognized the absolute necessity for a shorted exposure time.

One of the earliest reports of the dangerous effects of x-rays in dentistry was cited in a 1897 journal Two dentists had a certain Miss McDonald undergo a series of x-rays of her face in order that they might better diagnosis her dental problems . The radiographs were taken by Mr. J. O'Connor, who claimed to have taken 1000 x-ray photographs, many of them similar to the ones he planned to take of Miss McDonald. In Only one other instance was anything like a burn resulting, and that indeed was a very minor one. However as a result of the exposure to "the strange mysterous light" Miss McDonald suffered severe burns A few days after the radiographs were taken, the skin on the young lady's face, neck, shoulders,arms, and breasts became blistered and finally peeled off The ear on the affected side swelled to three times its normal size and she complained of total loss of hearing on that side In addition to the burns, large patches of Miss McDonalds hair had fallen out Upon further questioning Mr. O'Connors admitted that the first radiograph taken was unsatisfactory and he made a second attempt, this time with the exposure time from 8-13 minutes.

By 1905 evidence had been accumulated that x-ray exposure had several undesirable effects upon the tissues within the body, as well as upon the skin and other superficial structure. The health profession had by this time recognized the great value of x-rays in diagnosis as well as its considerable therapeutic value. Thus the medical profession was earnestly desiring that the character of the disturbance providing then occasional toxic reaction be delayed in order that they may thereby attempt to devise a well-found method of preventing the reactions.

Many results of problems following x-ray exposure were recorded, but, by this time, the cause of such problems and methods of preventing them were beginning to be recognized. ~~Thus~~ in addition ~~to the many and~~ there were many and

various devices which were being developed and employed to protect both operator and patient It's interesting to note that the concept of sensitivity was also being recognized, some persons are more susceptable of x-ray damage than others

It was the results of reports such as I have stated that led a fellow named Thompson in about 1910 to compile his list of facts concerning x-rays which are valid today. Among these were that x-rays were undisputably responsible for tissue damage and that the amount of damage was directly related to the amount of exposure time, which exposure time could not be allowed to go beyond a critical point without causing severe trouble Futhermore, he concluded that x-rays have a cummlative effect and that several short exposures , if occuring within a short time span would have the same effect as one long exposure equivilent to the same amount of time and further, that the biological effects so indirect would not be immediately apparent. He also developed the inverse square law as a means for detecting proper exposure time. This law states that the intensity of rays decreased as the square of the distance from the source increases.

Now that we have discussed history and the early pioneers of x-ray, let's define some terms related to X-ray to give us a clear understanding of what happens to us in either a medical or dental X-ray:

Exposure and Dose

1 Exposure: is the amount of radiation produced (in our case by the X-ray machine)

2 Unit of Exposure is the Roentgen (R)

A measure of ionization (caused by energy transfer to molecules) produced in one cubic centimeter of air in the X-ray beam. (This unit of measure does not refer to either the area or volume of tissue exposed.

Exposure is expressed as a rate, i e. 1R/second ~~a~~ an X-ray machine set at 10ma and 65 KVP produces at 8 inches from the tube about 1R/second. Exposure does not indicate how much of the radiation is absorbed by the tissues or how much is trnasmitted without effect.

3. Dose: Pertains to the amount of energy actually absorbed by the tissue.

4. Energy: is defined as the ability to do work and the most devastating work done by radiation is the ionization of atoms or molecules in the cell. This process of ionization can also separate molecules into atoms which make ~~the rays~~ them up. The most important molcules altered are the RNA and DNA molecules which are the genetic blueprints of the cell. Unfortunetly, if the cell is not killed by ionization, it is reproduced in its altered or mutated form with concommited ~~cellution~~ alteration in its form.

5 The unit of dose ~~is~~ the Rad and is 100 ergs of energy absorbed by one gram of tissue

6. The rem is similar to the Rad, however the rem contains a factor for the special biological effects of different types of radiation. In the case of diagonostic x-rays, rems can be considered equal to rads.

Energy from X-Radiation is absorbed as a function of the atomic number, or Z number of the absorber. Since air and mixed body tissue have the same average atomic number, for diagnostic x-radiation 1 R is considered to result in the absorbed dose of approximately 1 Rad. Therefore Roentgens are interchangeable ~~^~~ c rads or rems for diagnostic radiation.

The other way we can compare different situations is to speak of total absorbed dose. This is done by integrating the absorbed dose, rads, with the volume of tissue expressed in grams. Unit of measure of dose is gram/rads

As you can see from this, it is not possible to give a simple but but accurate answer to questions regarding the amount of radiation received

by a patient during radiographic procedures.

The average background radiation dose/person in the U.S. is about 130 m/rem/year.

50 m rem of cosmic radiation originates outside the earth's atmosphere.

50 m rem emenating from radiation substances such as uranium, ~~thoriuss,~~ thorium and octinium within the earth itself.

25 m rem from ingestion of such things as radioactive strontium 90, potassium 40 and carbon 14

Other sources such as tritium and radon contribute about 5 m rem.

Yearly dose ÷ 365 days equals 0.35 m rem as average daily dose.

1 Full mouth set of dental x-rays is the same total dose to the bone marrow as 45 days of background radiation. ≅ 3 mR / Day

One complete full mouth x-ray equals one and a half chest x-rays.

A flight from NewYork to Los Anglesyou receive 2.5 millirems.

If you were ½ mile from Three Mile Island incident you received an extra 83 millirems.

X-ray of the brain 1000 millirems

Radiation for cancer is 100,000 millirems, or this is a complete cell death

How much then is too much?

Scientists know that x-rays pass through some cells harmlessly, ionize others or, at high enough dose kill them outright. And they know that at large enough doses cancer becomes inevitable. But whether the small doses we get at the doctor and dental offices can ultimately lead to cancer is a more difficult question, about which there is considerable disagreement at the moment. After all many cells die or are damaged everyday from natural causes. Could a few more here or there make a difference? No one

has really pinned a single case of cancer on the low doees we normally receive. Because cancers from x-ray may take from 5-40 years to develope it's hard to say whether the original culprit was x-ray or some other factor.

Since 1974 the Federal Government has mandated, and X-ray machine manufacturers have seen to it, that x-ray machines possess proper filtration with aluminum shields to remove low energy x-rays from the beam which would be absorbed in the tissues with no chance of reaching the film and would be of no value to the patient. Proper collination or shape of the x-ray beam so that it is only slightly larger than the film. The most importantant factor in reducing the amount of radiation to the patient is the use of the fastest film for the examination being done.

Also the use of lead apron and colars to minimize any unnecessary radiation

No one should fear necessary radiation "If the exposures are low, the risks are low."

Future developements include reducing the current dose in fluoroscopy by means of a pulse x-ray. The use of hard radiaton ~~with~~ using a more penetrating beam, thereby less is needed, digitizing using ~~electrodes~~ electrons to amplify the image rather than more x-ray. An expecially promising new development is necular magnetic resonance scanning N M R S, a type of non-ionzing radiation. The NMR scanner will be more astounding than the cat scanner. Not only will there be a cross section of the body using absolutely no x-rays, it also allows the study of body functions as well as anatomy, but as usual the practioners are cautious since NMR scanning does magnitize the body.

Although a general concern about the potential hazards of radiation is healthy, both in the medical profession and in the general public, the one sided reports of the lay press and the restrictions of the federal regulators tend to instill only fear about radiation. Such an approach is

not beneficial to anyone.

Radiation is potentially hazardous. It should be used with care and only as indicated in both clinical and industrial environments. But even more hazardous to the health of the community is the fear of radiation that is developing in the minds of the public today. Physicians and dentist must make sure that the best job possible is being done in obtaining x-ray examinations. That is, that radiographs are made with minimal exposure to the patient while producing maximum diagnostic information and that the public in general is educated by having the benefits and risks of diagnostic imagery put into the proper prospective for them.