

SHORT COMMUNICATION

Early victims of X-rays: a tribute and current perception

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X-rays were discovered in 1895 and since then much has been written about Wilhelm Roentgen and the events surrounding the discovery. However, there have been only scattered references in the literature about the early workers who dedicated their life, and death, to X-rays.

Radiology has come of age since then. Large exposure times have been reduced to milliseconds and there has been a change from analogue to digital. The advent of new and rapidly developing modalities and the ubiquitous presence of cone beam CT (CBCT) highlight the need to remember the early victims of X-rays, especially with the lack of universal guidelines for taking a CBCT scan. The aim of this article is to alert the oral radiologist to exposing patients irrespective of need, and to pay respect to the victims on the 116th anniversary of the discovery of X-rays. *Dentomaxillofacial Radiology* (2011) 40, 123–125. doi: 10.1259/dmfr/73488299

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Introduction

In the early days, while American workers were busily exploring and reporting the beneficial use of X-rays, less welcome news was beginning to trickle in from many parts of the USA. The rays, it was discovered, produced undesirable changes in exposed tissues. In the 116th anniversary year of the discovery of X-rays, when Roentgen and others were glorified for their discovery and use of X-rays, this article throws light on some of the early victims and martyrs. Given the ambiguity of universal guidelines in obtaining a cone beam CT (CBCT) scan and the undue use of panoramic and full-mouth periapicals at tertiary care centres, oral radiologists may end up making unnecessary examinations, which can result in undue radiation exposure. This highlights the need to look back through history.

Historical perspective

It was barely 14 days after the announcement of the discovery of Roentgen rays that Friedrich Otto Walkhoff took the first dental radiograph. He took an ordinary photographic glass plate, wrapped it in a rubber dam, held it in his mouth between his teeth and tongue and then lay on the floor for a 25 min exposure. Walkhoff said that those 25 min of exposure were a torture to him.¹ However, the exact nature of this torture has not been described. Later, in 1896, Walkhoff

succeeded in making extra-oral pictures with an exposure time of 30 min. He noticed a loss of hair on the side of the head of some of the patients he irradiated,² but as there was no mention of blisters on the skin it is assumed that the absorbed dose was less than 300 rads.

In 1896, Otto Walkhoff and Fritz Giesel established the first dental roentgenological laboratory in the world. For many years the laboratory provided practitioners with images of the jaw and head. Fritz Giesel later died in 1927 of metastatic carcinoma caused by heavy radiation exposure to his hands.³

In February 1896 a child who had been accidentally shot in the head was brought to the laboratory at Vanderbilt University (Tennessee, USA). Before attempting to locate the bullet in the child, Professor Daniel and Dr Dudley decided to undertake an experiment. Dr Dudley, with his characteristic devotion to science, lent himself to this experiment. A plate holder containing the sensitive plate was tied to one side of Dudley's head and the tube attached to the opposite side of the head. The tube was placed 0.5 inches away from Dudley's hair and activated for 1 h. After 21 days all the hair fell out from the space under discharge, which was approximately 2 inches in diameter.⁴

On 12 August 1896, *Electrical Review* reported that Dr HD Hawks, a graduate of the 1896 class of Columbia College, gave a demonstration with a powerful X-ray unit in the vicinity of New York.⁵ After 4 days, he was compelled to stop work. He noticed a drying of the skin, which he ignored. The hand began to swell and gave the appearance of a deep skin burn. After 2 weeks the skin

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came off the hand, the knuckles become very sore, fingernail growth stopped and the hair on the skin exposed to X-rays fell out. His eyes were bloodshot and his vision became considerably impaired. His chest was also burnt. Mr Hawks' physician treated this as a case of dermatitis. Hawks tried protecting his hands with petroleum jelly, then gloves and finally by covering it with tin foil. Within 6 weeks Hawks was partially recovered and was making light of his injuries. *Electrical Review* concluded by asking to hear from any of its readers who had had similar experiences.

GA Frei of Frei and Co., a Boston manufacturer of X-ray tubes, replied the next day: Mr K, an employee of the company, complained of peculiar itching and burning in his left hand and thought it was due to poisoning with chemicals. Mr K used to regularly attend to testing of tubes during and after the exhausting process at the rooms. The same phenomenon also appeared on Frei's hand. The letter concluded by stating that further developments would be carefully monitored.⁵

A distressing case was reported in September 1896. William Levy had been shot in the head by an escaping bank robber 10 years previously. The bullet entered his skull just above the left ear and presumably proceeded towards the back of the head. Having heard about X-rays, he decided he wanted the bullet localized and extracted. Levy approached Professor Jones of the Physical Laboratory, University of Minnesota. Professor Jones, who was familiar with Daniel and Dudley's experiments, warned Levy against the exposure, but Levy was undeterred and an exposure was made on 8 July 1896. Exposures were made with the tube over his forehead, in front of his open mouth and behind his right ear. Levy sat through the exposures from 8 o'clock in the morning until 10 o'clock at night. Within 24 h his entire head was blistered, within a few days his head was an angry sore and his lips were badly swollen, cracked and bleeding. His right ear had doubled in size and the hair on his right side had entirely fallen out. Professor Jones concluded that the one feature that was satisfactory to the patient was that a good picture of the bullet was obtained, showing it to be about an inch beneath the skull under the occipital protuberance.⁶

Dr Stickney reported a case in December 1896 of a woman who complained of abdominal pain. A radiograph of the patient, Mrs Q, was taken in the abdominal region. The focus of X-rays was over the liver. 3 exposures were made of 20 min, 30 min and 35 min. Two days later she developed burns over the region. The condition worsened until the surface sloughed.⁷

The above cases of Hawks, Dudley and Stickney all reported skin blisters and it could therefore be assumed that the absorbed dose of the victims was at least 1500 rads. Serious damage from the rays was also reported from the Edison Laboratory. Elihu Thomson of General Electric cited two Edison cases in a letter dated 1 December 1896 to Dr EA Codman of Boston. Thomson referred to these cases as serious because they took place over the hands and arms of the victims and

they had to stop working with X-rays altogether. The story goes that one of them was told by his physician that if he continued to work with X-rays it would be necessary to amputate his hands. The worker threatened with amputation was probably Clarence Dally, Thomson Edison's glassblower.

Clarence Dally was likely to have had an absorbed dose of approximately 3000 rads to necessitate amputation. It needs to be noted that not everyone had the same experience. Dr Williams reported in 1897 that in approximately 250 patients, who he examined with X-rays, he had not seen any harmful effects.⁸

Professor Stine of Armour Institute of Technology reported that a patient who was exposed for 2 h for 2 successive days with the plate a few inches from the skin developed itching and irritation. A few days later the skin swelled and became inflamed, and the area immediately surrounding the exposure was tanned and dry. In time the skin peeled off and resembled bad sunburn. Professor Stine, however, concluded that the effect was due to ultraviolet rays and not X-rays.⁹

Dr EA Codman, in 1902, conscientiously reviewed all papers on X-ray injuries. Of the 88 X-ray injuries published, 55 had occurred in 1896, 12 in 1897, 6 in 1898, 9 in 1899, 3 in 1900 and 1 in 1901. The decline could be due to the fact that X-ray injuries were no longer in the news and therefore went unreported unless they exhibited unusual features.¹⁰

Clarence Dally (1865–1904) is thought to be the first to die as result of X-ray exposure. He died of metastatic carcinoma at only 39 years old.

The next death to be reported was that of Elizabeth F Ascheim (1859–1905) of San Francisco. Deaths reported thereafter included those of Wolfram C Fuchs (1865–1907), who opened the X-ray laboratory in Chicago in 1896 and made the first X-ray film of a brain tumour in 1899, and Dr William Carl Egelhoff (1872–1907). Among the victims who suffered the most was Dr Walter James Dodd (1869–1916). He was operated on 32 times and died of metastatic carcinoma of the lung on 18 December 1916.¹¹

The deaths of tube manufacturers have included Rome Vernon Wagner (1869–1908), his brother Thurman Lester Wagner (1876–1912), Burton Eugene Baker (1871–1913), Henry Green (1860–1914), John Bawer (unknown year of birth–1908) and Robert H Machlett (1872–1926).¹²

The case of C. Edmund Kells is well known. Kells developed a radiogenic neoplasm in 1922 and endured increasing discomfort and excruciating pain. Kells did not listen to the warning given by William Rollins regarding radiation hazards. He had undergone 42 operations and several amputations (some have reported 100). On 7 May 1928 Kells triggered a 0.32 calibre bullet into his brain.³

Dr Perry Brown, an eminent Boston radiologist, published his collection of biological essays "American martyrs to science through Roentgen rays" in 1936. He reported the deaths of Mihran Kasabian of Philadelphia (1870–1910), Eugene Caldwell of New York (1870–1918), Herbert Robert of St Louis (1852–1922), Fredrick H Baetjer of Baltimore (1874–1933) and a

number of others whose lives deserve to be remembered. However, his own story was missing; Dr Brown died of X-ray induced cancer in 1950.¹¹

Dr Cannon began using X-rays in 1896 when he was a medical student. In 1931 he developed itching of skin and fresh red papular lesions on his back, chest, thighs, knees and elbows. Dr Cannon suggested that repeated biopsies be made so that it would provide more information on this poorly understood condition. He developed several lesions all over the body, many of which continuously recurred.

In April 1944, a recurrent basal cell carcinoma of the nostril was excised. In 1945 he passed the 14th anniversary of the onset of mycosis fungoidosis — an amazingly long survival. On 1 October 1945 he died of recurrent pulmonary infection.⁶

It would be generous to accept Dr Grubbe's account precisely as he wrote it, for he truly was an X-ray martyr. Dr Grubbe suffered at least 83 surgical operations to relieve his discomfort and to stop the progress of gangrene from his left hand to his arm, elbow and finally shoulder. Grubbe's face was grossly disfigured with cancer. He became sterile. His marriage was left childless, a misfortune he attributed to the X-rays. He lived in agony for many years, yet he continued to work with the rays.

In his autobiography he maintained "my courage is my work. I treat patients who suffer more or are encumbered more than me, and so I go on. By helping others I help myself". He went on to predict "I will die from the effects of early uncontrolled exposures to X-rays. And like many of the early pioneers, I too, will die a victim of natural science, a martyr to the X-rays."

Dr Grubbe, in the chapter "The effect of the X-rays on author's body", concluded on a noble note: "I have lived large enough to see the child that I fathered develop into a sturdy, mature and worthwhile product; and I hope as I approach the evening of my day, to see even more uses of X-ray energy in the alleviation of the ills of mankind."

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Dr. Grubbe died of metastatic cancer on 26 March 1960.¹³ It could be hypothesized that Kells and Grubbe had a consistent absorbed dose of 3000 rads.

Discussion

The misfortune of most of these workers has alerted radiologists to the harmful effects of X-rays. Although doses for CBCT and panoramic and full mouth periapicals are relatively low, patient dose remains a concern in dental diagnostic imaging. The possibility of a pituitary or thyroid link in low birth weight infants owing to maternal exposures to low levels of dental X-rays justifies the scrutiny of exposures in maxillofacial imaging.¹⁴

To provide a further perspective, a full mouth radiographical examination using rectangular collimation at E- or F-speed film would lead to patient exposure to maximum equivalent dose of 25 μ Sv. A direct digital panoramic radiograph leads to an equivalent dose of 6.2 μ Sv to the patient, using the International Commission on Radiation Protection (ICRP) 1990 tissue weights. The CBCT exposure unit ranges from an equivalent dose of 44.5 μ Sv to 134.8 μ Sv using ICRP 1990 tissue weights.¹⁵

The premise of this article is to highlight the effects of unnecessary exposures, and not to extrapolate the effects of past exposures to today's exposures. No doubt, we are now better equipped to handle unwanted radiographical exposures, but CBCT¹⁶ and other equipment sited at primary care centres without the skills of oral radiologists would add to unnecessary exposures.

A number of other names that deserve to be mentioned have probably been missed; however, an attempt has been made to pay respect to all those departed souls, both reported as well as unreported, who sacrificed their health and life for X-rays.