

## Risk/benefit considerations in pedodontic radiology

Robert A. Goepp, DDS, PhD

**T**he use of radiation as a diagnostic instrument, and the biological effects of irradiation have received so much scrutiny during the past decade that exposure to radiation has become a public interest concern. Most lay persons, that is nonscientists, perceive radiation exposure as possibly injurious. Knowledge of possible radiation effects has become so generally disseminated that most lay persons appreciate that younger tissues, younger organisms, and growing organisms, seem to be more sensitive to, and to suffer more profound changes from, radiation exposure. The same lay persons also appreciate that there can be some sort of delayed effect of radiation exposure, and that the most serious delayed effect could be cancer.

Scientific study of ionizing radiation effects and the discovery of biologic injury is hardly new. Among notable early events are Major Borden's observation of delayed epilation following skull radiographic exposure during the Spanish American War, and dentist Rawlins' study of radiation effects on animal embryos near the turn of the century. Over the next half century, a considerable amount of information about the biologic consequences of irradiation was generated. In the early fifties, Clark, among a few other workers, was strongly critical of head and neck therapeutic irradiation for nonserious conditions in children and young adults, because of the strong possibility of causing thyroid cancer.<sup>1</sup> Paying no heed to such warnings, therapists, in this case better called the "irradiators," went on irradiating tonsils and adenoids. Twenty years later, there were thyroid cancer epidemics among the patients so treated. Certainly there was an important gap between those who studied the effects of irradiation and those who used radiation. Do such gaps still exist today? Do they exist in dental radiology? Do they exist in dental radiology for children?

The use of X rays for diagnostic purposes in dentistry has some rather obvious good results. The common dental diseases involve tissues whose internal structures are well demonstrated upon radiographic examination. A dentist can thus detect and measure

the extent of dental diseases where such diseases give little clinical or physical signs. In addition, the child dental patient undergoes a complex development of face, jaws, and teeth. It is well known that early detection and intervention of misdirected development can prevent substantial and difficult corrective treatments at a later age. Early detection and intervention most often depend upon radiographic examination. More generally, for any group of dental patients, good oral health is not possible without the use of X rays. How then, can there be a reconciliation between these good diagnostic goals and the hazards of achieving them? The answer is that we must find and characterize the hazards; we must examine the benefits and give them values.

### Risk/Benefit Ratio

The phrase "risk-benefit ratio" is increasingly used to indicate that there is a relationship between hazard and benefit. The relationship is developed for the purpose of making a decision. The process seems simple enough; merely add up the good and bad points, program in personal values and an informed, sound decision should follow. However, a more careful scrutiny of the use of risk-benefit ratio reveals layers of complexity. First, the phrase "risk-benefit ratio" gives difficulty because it presents risk as the contrapoint of benefit. More correctly, harm or hazard is the opposite of benefit. The term "risk" merely describes lack of a certain predictability in an action which could lead to loss or gain, harm or benefit.

Thus radiographic examination done on the basis of few (or no indications) is far more risky than the same radiographic examination done on the basis of well-established, indicated need, even though the dose and possible harm are the same in both cases. The degree of risk is the real difference between these two cases of equal harm potential. The degree of risk is counterbalanced by the expectation of benefit. This expectation could also be called justification. We are dealing with harm-benefit ratios and risk-justification ratios

then — two separate concepts which may lead to a better understanding of what we are doing.

Harm and benefit are tangible results. Risk and justification are intangible operating principles. Neither harm nor benefit are absolutes in themselves, and human activity cannot exclusively be classed into either; rather, human activity exists in degrees somewhere between harm and benefit. By definition, death of the organism could be the ultimate or absolute harm. However, the concept of ultimate or absolute benefit defies definition. We can only work toward some absolute benefit. Working toward absolute benefit consists of achieving specific, subtotal benefits. Whether an ultimate benefit exists, and if it is a collection of subtotal benefits, or if it is a separate superbenefit, has not been ascertained. In order to avoid the frustration produced by this lack of knowledge, we create goals and by fiat declare them to be superbenefits. To say that dental radiology, especially for children, should be safe and efficacious is the creation of such a goal.

**T**he use of the phrase “especially for children” is easily and widely accepted. This acceptance is probably based in the adult deference to the innocence of children and the desire to protect children. Yet, in dental radiology, children are not perceived as a more sensitive subgroup because no special policy or legislation has ever been promulgated to modify dental radiology practice for children. On the other hand, there may be reason to suspect that children are indeed a more susceptible subgroup. Because the size of radiographic fields are not diminished from adult sizes, the percentage volume of tissue irradiated in a child is far greater. It is known that an increase in volume of tissue irradiated is more likely to produce an unfavorable effect. Also in the head and neck area of children, critical, very sensitive tissues are much closer together and thus more likely to be included in the primary beam (or be closer to the primary beam), therefore receiving higher radiation doses than in adults. Among such tissues are thyroid, eye, lymphoid and hemopoetic marrow in the jaw bones — the latter being present in children but usually replaced by a fibrous marrow in adults.

It is also likely that the children are subjected to more dental radiographic examinations by percentage of individuals than are adults. In fact, children may be systematically radiographed. In many locales, admission to certain school levels is dependent, by legislation, upon an evaluation of childrens' dental status. While radiographic examinations are not mandated, the radiograph examination is often used in place of, or to compliment, a less than complete physical examination of the mouth. While radiograph examinations for school admission are usually not mandated, many

reporting forms ask if radiographs were taken or what the radiograph findings were. Such statements could influence a practitioner to do radiograph examinations in order to demonstrate that a complete service is being given.

Presently the use of radiology in dentistry for children does not identify children separately from adults, except for intraoral film sizes and numbers of intraoral films needed for examination.

### **Children: Susceptible Subgroup**

There are biologic and technical considerations which have been mentioned here which suggest that children may represent a more susceptible subgroup in dental radiology.

In recent years, some workers have examined specific site dosimetry utilizing phantom models. Most prior workers studied only surface doses over areas of critical organs; White has studied bone marrow dosimetry.<sup>2</sup> Danfort and Gibbs studied dosimetry in several oral area sites and applied sophisticated mathematical analysis to determine probabilities of injury.<sup>3</sup> Block and associates studied the peculiar dose distribution pattern of panoramic type dental radiographic examinations.<sup>4</sup> Block as well as Myers have pointedly demonstrated that panoramic examinations involve centers of X-ray beam rotation which are usually inside the patient, and are sites at which relatively high doses are generated.<sup>4,5</sup> Most of these studies have been done with an adult phantom format because child size phantoms are generally not available. And since there are considerable increases in facial and head size during childhood, several different sized phantoms would be necessary in order to study panoramic dosimetry in children. Myers did study exposure in child patients, but was then, of course, limited to surface dose measurement. Relatively high skin doses, especially in the thyroid area were found. Considering that panoramic doses are higher at the rotation sites, which are likely to be inside the patient, there is reason to believe that an important hazard may exist in the use of panoramic examinations for children. More complete dosimetry measurements in various child-sized phantoms are urgently needed in order to assess the potential for harm.

Even under conditions of existing knowledge, the thyroid gland dose can be greatly decreased during skull examinations, such as those used in cephalometrics. The thyroid shield described by Block reduced the thyroid exposure up to 85%. Myers also found a thyroid dose reduction using a thyroid shield during panoramic examination.

### **Specific Organ/Site Doses**

Specific organ and site doses during intraoral examinations have been extensively studied. However most

study formats have been directed to the adult model. Depth doses in full-mouth examinations, have been measured by McKlveen, who found the highest doses at the level of the upper and lower teeth in the oral pharyngeal area.<sup>6</sup> The differing periapical exposures tend to include the pharynx in each case. Antoku and coworkers found the highest doses in full-mouth examinations in the ethmoid sinus areas, though pharyngeal sites were not sampled.<sup>7</sup> In both the McKlveen and Antoku studies, measurable doses to the thyroid area were found. What significant doses to the thyroid are, is not known for what is considered low-level exposure, but these doses are only one twentieth to one thirtieth of doses known to have produced thyroid cancer. There is a suspicion that thyroid doses would be higher in child model studies, even though a lesser number of periapical films might be used. The possible cumulative effect of periodic dental radiograph examinations on the thyroid is not known; conversely, the ability of the thyroid to repair radiation injury is not known.

Specific site dosimetry studies have produced information which provokes, in turn, two important questions. These are; the possible effects on lymphoid tissue and the significance of periodic low dose upon sensitive tissues.

**C**hildren are particularly rich in lymphoid tissue and the amount of lymphoid tissue is contained in a smaller total tissue volume. The findings of specific site dosimetry which show the largest dose is in the oropharyngeal area (which is the site of Waldyer's Ring, a conglomeration of palatine tonsils, lingual tonsils, adenoids and the lymphopoietic focal sites in palate and pharyngeal wall commonly found in children). Also, the panoramic type of examination usually has bilateral axis of rotation in the lingual and palatine tonsil areas. Lymphoid tissue is particularly sensitive to cell death as a consequence of irradiation. The lymphoid effects of acute total body irradiation have been well studied. However, with surprise, one will discover that very little, if anything, seems to have been done to study lymphatic radiation effects as a consequence of diagnostic radiology. No remarkable increase in the incidence of such neoplasms has been noted in American Cancer Society statistics over the last 25 years. On the other hand, the diagnostic irradiation of children for dental purposes has presumably increased over the past 20 years. The number of certified pedodontists increased from 148 to 1,225 in that time. Presumably more children are receiving a higher level of dental care which, in turn, may mean that more radiographic examinations are being done. What may be indicated at this time are studies of the previous diagnostic radiograph pattern in patients with lymphatic neoplasms and immunodeficiency diseases.

This combined with data on frequency and type of radiograph examination in comparable populations and in children, would allow for mathematical analysis of the probability of harm. Presently there seems to be no information on frequency and type of dental radiographic examinations in children. It is known that children, 6-16 years of age, who live in metropolitan areas, have more dental visits, about 2.2 per year, than do rural children, whose dental visits range from 1.1 to 1.5 per year. Also, in recent years, children from higher income groups, tend to have about 50% more dental visits per year than children from lower income groups.

### **Characteristics of Dental Radiography**

The amount of X-ray exposure in dental radiology seems to be small in both amount of radiation and body area involved, when compared to most medical radiographic examinations. However, it must be noted that dental radiographic examinations are extraordinary in numbers. Last year, over 400 million intraoral films were exposed. There is no estimate on the additional number of panoramic or jaw and skull films exposed by dentists. This is a large number of small exposures spread over a large number of people. In 1976, an estimated 102,620,000 persons made 335,702,000 dental visits. Of these, 82% of patients received radiology services, which makes radiology the most common dental service provided (although radiology comprises only 7.3% of total charges). The total radiation dose burden placed on humans as a consequence of dental radiology is very large, but is delivered in small increments over a large number of people. Information on the amount of radiologic service delivered for children is not directly available. It is known that children, those under 17 years of age, comprise about 28% of all dental visits.

The kind of X-ray exposure found in dentistry, and for that matter, most of medical diagnostic radiology, is at the level of low-dose biological effects. Knowledge of low-dose effects is incomplete and a subject of controversy. Data has been obtained from observations of human experience and measurements utilizing experimental models such as animals. At the involved low-dose levels, experiments and observations are influenced by a number of biologic variables, such as ability to repair damage, leaving no lasting effects, and varying sensitivity states of cells and tissues due to metabolic and endocrine activity.

### **DNA and X rays**

It is presumed that the most profound radiation effects are on DNA. In most human cells, DNA undergoes a cyclic pattern of replication, and it has been demonstrated that different stages of this cyclic pattern are relatively radioresistant or radiosensitive.

Under such conditions, a lasting tissue radiation effect may depend upon the phenomenon of a critical number of cells being sensitive at the same time, the time of the radiation event. Should a less than critical number of cells be affected, the usual body defense mechanisms may be able to overcome the presence of abnormal cells. The possibility that a critical number of groups of cells exist in tissue renewal has been demonstrated by Glass and Goepp, and Lin and Goepp.<sup>8,10</sup>

The principle late somatic effect of radiation exposure is the advent of cancer in a variety of organ systems. Induction of leukemia is a generally known possible somatic effect of radiation exposure. However, long time-period studies have shown that the induction of solid tumors, especially of glandular tissue, is greater than the incidence of leukemia induction. Both the National Academy of Sciences and the National Council on Radiation Protection and Measurements have examined the aspects of low-level radiation exposure. Both groups agree that there is great uncertainty in determining the lower levels of a dose response curve between radiation and cancer induction. Also, both groups agree that particulate radiation with a high linear energy transfer is far more destructive in tissues, and appears to follow a linear response curve at low levels. Nonparticular radiation, such as X rays, when subjected to a linear dose curve, produces an overestimate of the observed biologic damage. This suggests to some workers that there may be a threshold for injury. However, the reason for the apparent threshold may be based in the biological variability, defense posture and ability to repair. Hence, a biologic threshold may exist, but cannot be universally applied to all radiation recipients. Biologic variability, defense and repair ability can have their basis in both genetic and environmental origins. Thus, there can be variations in susceptibility between individuals and within the same individual at differing times. More recent studies have demonstrated that age at time of radiation exposure, can be a major determinate of radiation-caused cancer. The ages of liability are the younger ages, children.

Presently, it is difficult to draw direct relations between low-dose radiation and cancer induction. But that the phenomenon exists is not disputed. The benefits of good oral health are more directly measured and demonstrated, and generally it is not possible to provide good oral health service without the use of radiograph examinations. The prudent professional posture to assume at this time is to keep radiation doses to a minimum and avoid all unnecessary exposure. Such goals are served by quality control systems for technology, the use of operator and patient protection devices — such as barriers, aprons and collars — and most of all, by good decisions made by practitioners.

Dr. Goepp is Professor and Director, Zoller Dental Clinic, 950 East 59th Street, Chicago, Illinois 60637. Requests for reprints should be sent to him at that address.

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