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Radiography in monitoring dentofacial growth and treatment

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First, I would like to emphasize that even though I have been active in various orthodontic organizations, I am here as an individual practitioner and not as a representative of any group.

Our profession has a long history of awareness and concern for radiation safety. That awareness centers on the fact that this is an area requiring a never-ending search for new and more specific information. Clinical decisions must be based on a careful consideration of potential diagnostic values, potential hazards, and other costs in optimizing the application of this important tool for patient care.

Children present unique challenges and concerns, yet the overall approach must still adhere to the same principles that are valid for other age groups. The differences lie more in emphasis than in any specific aspect of radiographic diagnosis. With most of their lives still ahead of them, children stand to gain the most from effective radiographic diagnosis, yet they obviously also present the greatest long-term exposure to risks. It is clearly imperative that they be afforded the most efficient and conscientious radiographic diagnostic services, which is why we are here today.

The most efficient use of X radiation in the care of child patients by the individual health care professional calls for attention to four very different but interrelated factors.

1. Selective prescription of the examination that will provide the highest ratio of information to exposure. This requires consideration of diagnostic needs that may extend beyond the immediate question.

2. Extracting the maximum amount of information from each exposure. This requires careful evaluation of radiographs by the prescribing professional. The initial reason for prescribing a radiographic examination should in no way limit the utilization of the information available in the radiograph that results from that prescription.

3. Minimizing exposure for each specific type of examination. Filtration, collimation, and high-speed image receptors can produce spectacular reductions in X-ray exposure. For example, a rectangular collimating film holder reduces the entry dose by well over 50%, but that is only the beginning. Most of the collimated beam is stopped at the film plane, sparing the tongue and opposite side almost all of the X-ray exposure. The unused peripheral part of an uncollimated beam will expose a volume of tissue *several times as great,* extending through the entire thickness of the face and sometimes even to more remote tissues.

4. Coordinating with other health care professionals serving the same child in the application of the first three.

Craniofacial growth and development

Craniofacial growth and development is inseparable from dental development. More accurately, dental development is a part of — and dependent on — the growth and development of the structures that support and nourish the dentition; they're inseparable.

The dentition is at the center of what is probably the most responsive-adaptive area in the head and neck region, if not in the whole body. At the posterior of the head, postural muscles keep the head upright by direct attachment of the cervical musculature to the occipital bone. The anterior antagonists of those muscles are attached primarily to the mandible, which is in turn suspended by the muscles of mastication.

While we call them muscles of mastication, that is only their part-time function. Their full-time function is postural, continuously adjusting to maintain mandibular position as head position and the balancing muscles changes.

The teeth and alveolar processes lie at the very mobile and active interface between those two force fields, continually adapting to a functional balance in that very changeable environment. Tooth position results from the net balance of all the forces acting in the area which impact on the teeth in any way.

The bone that supports the teeth also supports much of the musculature that influences their positions. Growing bones are exquisitely sensitive to their

environment, and under normal conditions these many forces and the resultant adaptations are smoothly integrated into an orderly pattern of growth. But such an active and complex system is subject to countless anatomical and functional aberrations that can disrupt and distort these natural processes during the growing years, producing lifelong handicaps.

The orthodontist is concerned with this overall picture, *including* the developing and erupted teeth, so there is a considerable overlap of clinical concerns that may require radiographic aids.

The importance of orofacial structures and functions.

The mouth is the only aperture available for the unaided entry of food into the body. It also provides initial processing for swallowing and subsequent digestion. This primary function is so obvious that it is easy to forget others that can be equally important, and even threaten that primary function.

The mouth is also the only full-time backup for the nasal airway. When sufficient air cannot reach the lungs through the nasal route, even momentarily, the mouth is immediately and automatically pressed into service. It serves this function so commonly that many fail to appreciate the problems imposed when the mouth is pressed into this service on more than an occasional basis.

Excessive use of the oral airway in childhood can exact lifelong impairment of health and happiness. Long-term mouth breathing can cause such effects as shallow and impaired breathing, decreased vital capacity, and drying of delicate tissues. From the viewpoint of facial growth, we also see facial disfigurement and malocclusion that may include uncorrectable open bite and secondary degradation of diet and nutrition.

Other major functions of the oral structures center on communication, both oral (speech) and visual (facial expression and appearance). The outer face is the only part of the body that cannot be hidden or enhanced by clothing or surface prosthesis, and its configuration and function are almost totally dependent on underlying structures. Effective function in all modes of communication can be crucial to economic and social competence.

The growing years are the time of greatest risk for maldevelopment of those vital structures. They are also the time of the greatest — and often only — opportunity for effective therapeutic support.

Adverse changes in the growth of the craniofacial complex are often progressive, requiring early diagnosis and carefully planned and executed therapy. Health and function in the adult, for better or worse, are built on the foundation laid in childhood. While major growth may end in the late teens, the periodontal membrane that supports the teeth retains its adaptability throughout life. Trends and functional patterns established in childhood can haunt the patient for a lifetime.

Orthodontic changes are actually orthopedic changes, wrought in the bone rather than the teeth. Therapy consists of modifying the interlacing environmental force fields in the craniofacial complex to elicit desirable changes in the skeletal components. Our sphere of concern and influence includes the entire face and surrounding structures. As with all therapy, responsible care requires the fullest possible knowlege of the initial problem and of changes that may occur in the course of therapy and supervision.

The role of Radiography

With most of the sphere of concern and influence hidden from direct view, radiography plays a key role in the early identification and evaluation of developmental aberrations of the craniofacial complex and resulting related therapy. Nevertheless, it is still a supplementary, rather than a primary, diagnostic modality.

Direct clinical observation is still an indispensable diagnostic tool, and the one that should always be applied to the fullest possible extent in all of these developmental conditions. A clinical examination is the only valid basis for prescribing a radiographic examination, and it is absolutely essential to selectively prescribe the most clinically productive radiographic examination.

I could not possibly overemphasize the importance of a clinical examination by a fully qualified professional both before and after a radiographic examination. Radiography should serve to expand the information derived by clinical exam, not vice versa. The postradiographic examination is an essential part of radiography in the growing child, but in many cases the radiograph may provide information suggesting deferral for a period of time. Follow-up clinical examinations become much more meaningful and productive when conducted in the light of information derived from previous radiographs.

When a clinical examination shows a need for supplementary radiographic diagnosis, the selection and prescription should be based on the following criteria.

Need for radiography (prescription criteria)

1. Indication of a condition that can be further identified or evaluated radiographically.
2. A reasonable expectation of clinically useful information (could the findings influence clinical actions, or will they merely satisfy curiosity?).

Choice of examination

Which radiographic examination will provide the most advantageous overall information/exposure ratio.

1. Which will provide all needed information?
2. What related or coexisting situations that may also require radiographic evaluation could be studied with the same exposure?

Full diagnostic utilization

Once an exposure has been made, the film should be read completely to discover all possible information of patient benefits.

The typical patient that we are talking about here is the otherwise normal child with actual — or suspected — problems in dentofacial development. We are not considering exceptional children with severe congenital anomalies or injuries that require unique special handing — often intensive diagnosis and therapy. It is the "mostly healthy" children that account for the overwhelming majority of radiographic examinations, though they may not individually receive as much exposure. The same rules that apply to this group also apply to the more severely afflicted, except that they will often require additional, more intensive efforts.

The radiographic options

Before considering specific clinical situations, I would like to maintain the emphasis on radiography with a brief review of diagnostic potentials and exposure levels of different types of radiographic examinations that are available for monitoring dentofacial development.

There is a great overlap in the information coverage of the three types of radiographic examination used in dentistry and dentofacial orthopedics, so selection of the examination to be used in each situation can be a major factor in the effective use of this important diagnostic tool.

The three major classes are:

1. Intraoral
   periapical, bitewing, occlusal

   Typical minimum entrance skin exposures in this group are in the range of 200 mr, with lesser values for most of the exposed tissues.
2. Panoramic tomographic

   Exposures for this examination have already been discussed, and their variability precludes any numerical evaluation here. The geometry of the exposure produces much higher radiation levels in some intervening tissues than this level that is required at the film. It is important to note, however, that the image receptor sensitivity is in the same range as cephalometric and other intensifying screen techniques, requiring a relatively low exposure at the plane of the film.
3. Cephalometric

   The geometry of the long focal distance, usually over 150 cm to the subject midline, requires minimal patient exposure levels, essentially the same as that required at the film.

   Rare earth imaging systems require only about 5 to 15 mr for a lateral view and 15 to 50 mr for a lateral view. Since these are usually single exposures, there is no localized overlapping as with multiple intraoral exposures.

A look at background levels will place these exposures in perspective. Background in the United States ranges between about 75 and 220 mr, with the average of just over 100 mr applying in most areas. This means that a high-speed lateral cephalometric film requires an exposure equivalent to only about two weeks of background (and that, of course, is limited to the head, while background is whole-body exposure). One could get much more exposure by hiking in the mountains.

In selecting radiographic examinations, we can easily find ourselves in the common health care situation; where care is selected more on the basis of readily available skills and services than on patient needs. Most practitioners are not equipped to provide all radiographic services, so I would like to suggest that this calls for a special effort to keep *all* possibilities in mind; including a capability and readiness to refer when that will best serve the patient.

The following summary (p. 436) reviews the essential characteristics and information potential of the different types of examination. It is obviously an oversimplified generalization, but can give some guidance in selecting an initial exam in individual situations. Any of these may provide information indicating a need for further examination with another type of examination.

Developmental Diagnosis and Treatment Monitoring

Monitoring both treatment and growth are actually concurrent activities, so little distinction can be made between the two. Once a condition has been identified, the objective becomes either passive monitoring or active control. In either case, it is incumbent on the practitioner to keep abreast of the inevitable changes that will take place.

As mentioned earlier, clinical observation remains the primary modality, with radiographic supplementation used as required.

The following table (p. 436) outlines some of the broad categories of problems as they relate to age. The ages shown are the earliest at which radiographic diagnosis may be clinically useful; when meaningful clinical decisions must be made. Of course exceptions will always arise, so this should not be interpreted as an indication that earlier diagnosis is out of order.

The ages shown are the *usual* earliest ages for beginning evaluation. Some patients will arrive at these developmental stages at markedly different chronological ages. A five-year range is not unusual in the parapubertal ages.

These initial evaluations must usually be followed by periodic updating evaluations. Where the patient is not seen until a later age, the beginning may be at any time — even into adulthood.

Diagnostic Information and Subject Age

This is a very minimal outline of conditions that may require radiographic evaluation of developmental status and possible therapy. The ages shown are very approximate; clinical findings should always govern in the individual case, adjusting these ages up or down as may be appropriate for the individual. Many patients do not present for these evaluations at these ages, of course so it goes without saying that later evaluations are often required.

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Primary Adequate Variable O = inadequate

	INTRAORAL Periapical Bitewing Occlusal	PANORAMIC	CEPHALOMETRIC Lateral P-A 45 deg.
Teeth:			
Root development of erupted teeth	A O O	A	A V O
Pathology involving erupted teeth	P V V	A	V V V
Developmental status and position of unerupted teeth	A O V	A	A A A
Congenitally missing teeth	V O V	A	P V P
Alveolar processes:			
Margins	P P O	AV	V V V
Thickness and conformation	O O O	O	P O O
Craniofacial anatomy			
Basal bone relationships			P P
Craniofacial relationships			P P
Soft tissue relationships			P P

An important concept to keep in mind is the value of using a different type of radiographic examination instead of a retake whenever further verification or additional information is needed.

Table 1. Broad categories of problems as related to age.

Under 6 Years	6-8 Years	8 Years	10-12 Years
Crossbites	First molar eruption	Cuspid position	Bicuspid Aberrations
Anodontia	Incisor eruption	Skeletal Aberrations	*missing, malformed*
Severe skeletal aberrations		Most Malocclusions	*slow, disoriented*
			Second Molars
			Third Molars