The American Academy of Oral and Maxillofacial Radiology (AAOMR) publishes 4 Parameters of Care for use by dentists who are responsible for the clinical management of patients with abnormalities in the oral and maxillofacial region. These Parameters of Care have been written by expert oral and maxillofacial radiologists and approved by the AAOMR for dissemination to health professional organizations and health care practitioners. Health care parameters like these are seen as a means for continuous improvement.

The purpose of these Parameters is to provide national guidelines for the use of radiographs prescribed for the diagnosis of disease, treatment planning, and follow-up care of patients with abnormalities of the oral and maxillofacial region. The Parameters are based on the best evidence available in the scientific literature. It is emphasized that clinical guidelines provide the rationale for clinical decision-making, but the professional judgment of dentists and physicians must be applied when individual exceptions are required. In addition, these Parameters were designed to promote the appropriate use of radiographs and contain health care costs.

The AAOMR is committed to monitoring the scientific literature in this field and publishing new Parameters when indicated. The existing Parameters will also be reviewed and updated triennially. The procedures for developing new Parameters and for the triennial review of these Parameters are described.

Development of a new Parameter of Care
1. Identify topic of a new Parameter of Care
2. Obtain concurrence from Executive Council that Academy endorses development of Parameter on that topic
3. Identify lead person(s) to write report
4. Obtain comments from Parameters of Care Committee members on draft report
5. Recirculate drafts until there is consensus on material
6. If appropriate, obtain comments on the Parameter from other experts on the topic
7. Publish draft Parameter in AAOMR Newsletter for comments from the membership
8. Hold open hearing at AAOMR Annual meeting to obtain comments
9. Incorporate appropriate comments into final Parameters document
10. Submit to AAOMR Executive Council for final approval

Review of existing Parameters
1. AAOMR Parameters will be reviewed and reevaluated triennially.
2. Identify lead person(s) to chair committee to review Parameter
3. Obtain comments from Parameters of Care Committee members on draft Parameter
4. Recirculate drafts until there is consensus on material
5. If appropriate, obtain comments on the Parameter from other experts on the topic
6. Publish draft Parameter in AAOMR Newsletter for comments from the membership
7. Hold open hearing at AAOMR Annual meeting to obtain comments
8. Incorporate appropriate comments into final Parameters document
9. Submit to AAOMR Executive Council for final approval

The AAOMR will publish and disseminate new and revised Parameters to professional and public organizations as appropriate. It will keep reprints of Parameters on file for distribution from the Office of the Executive Director.

AAOMR PARAMETER 1. RADIOGRAPHIC TECHNIQUES

Periapical, bitewing, and occlusal radiographic examinations, the most common forms of intraoral radiography, are indispensable adjuncts to patient care. Panoramic, cephalometric, and skull examinations also offer valuable radiographic information for diagnosis and treatment planning. These examinations may offer information regarding the patient’s condition that is not available through clinical examination or history. This radiographic information should be used to supplement other clinical information to aid the dentist in diagnosis and treatment planning. This Parameter will cover the means for making these examinations. Today the majority of radiographic examinations are made with film-based systems, and thus this will be the focus of this Parameter. Digital imaging will be treated briefly here. A separate Parameter dedicated to digital imaging is planned.

Goals
The goal of intraoral and extraoral imaging is to produce high-quality images of the oral structures with a minimum of radiation exposure.

Indications for radiographs
Professional judgment should be used to determine the type, frequency, and extent of each radiographic examination. Diagnostic radiography should be used only after clinical examination, consideration of the patient history, review of prior radiographs, and consideration of both the dental and the general health needs of the patient. The nature and extent of diagnosis required for patient care constitute the only rational basis for determining the need, type, and frequency of radiographic examinations, not the concept of routine use of radiography as a part of periodic examinations of all patients. It is important to recognize that because each patient is different from the next, so should the radiographic examination be individualized for each patient. The decision to use diagnostic radiography rests on the professional judgment of a dentist. A set of radiographic selection criteria developed in conjunction with a panel convened by the Food and Drug Administration (FDA) has been adopted and is considered to be a part of these recommendations.

Patients should not be exposed for administrative purposes. Routine requirements of postoperative radiographs to show proof of service provided or other exclusively administrative uses of radiographs are not recommended. It is desirable that radiographic records be transferred when a patient moves from one dental care location to another to avoid unnecessary repetitions of exposure. A facility may maintain radiographic records and also fulfill the transfer of records by means of duplicate radiographs.

Qualifications of personnel
It is the responsibility of the dentist to prescribe and interpret radiographs. The dentist must have a valid license or permit to practice and be aware of applicable regulations pertaining to radiation use. If the interpretation of the radiograph is not readily apparent, an oral and maxillofacial radiologist should be consulted. If allied dental personnel are used to expose and process
radiographs, they should have formal training of no less than 40 hours in the techniques of radiography and radiation safety. Their education and licensing should meet all state requirements. In the absence of such certifying requirements, it is the responsibility of the dentist to ensure that office personnel involved in radiography are properly trained in the techniques of film exposure, processing, and radiation safety.

Exposure techniques
A number of radiographic techniques will reduce patient exposure or improve the quality of the resultant radiograph. The x-ray machine must meet appropriate regulations for minimum distance from the focal spot to the patient, kilovolt (peak), and beam half-value layer. The following techniques should be used:

Collimation. For intraoral imaging, rectangular collimation should be used for all periapical radiographs. Round collimation where the diameter of the beam on the patient’s face is approximately 5 cm is an acceptable alternative. These methods will reduce patient exposure by a factor of 2 in comparison with round collimation using a 7-cm-diameter beam. These techniques require the use of film-holding devices with a beam alignment guide (position-indicating device) to prevent “cone” cuts.

For extraoral imaging, the size of the beam shall not exceed the size of the image receptor.

For lateral cephalometric views, the beam should be limited to the facial and skull base regions to reduce unnecessary exposure to the cranium and neck. For some patients it may be necessary to include the cranium and neck when natural head position techniques are used for cephalometric analysis.

Paralleling technique. For intraoral periapical imaging, the paralleling technique should be used with the appropriate armamentarium, when possible, because it provides the most geometrically accurate image of the dentition and the surrounding structures.

Film speed. For intraoral radiography, E-speed or F-speed film or digital radiography should be used rather than D-speed film, because all of these will reduce patient exposure.

For extraoral radiography, high-speed (400 or greater) rare-earth screen-film systems or digital systems of equivalent speed shall be used except for specific circumstances in which slower-speed systems are indicated.

Digital imaging. Digital imaging typically requires about half the exposure of E-speed film and produces images largely comparable to film images and thus is an acceptable alternative.

Soft tissue profile. On lateral cephalometric views, the soft tissue profile may be enhanced by the use of a wedge filter. This filter should be positioned between the radiation source and the patient rather than between the patient and the film cassette.

Thyroid collar for patients under age 30. Because people under age 30 are at greater risk of radiation-induced thyroid cancer than are older individuals, thyroid collars should be used when intraoral radiographic examinations are made on this population, except in situations in which the collar would be in the path of the useful beam.

Leaded aprons. The value of leaded aprons is minimal compared with the benefits of the use of E-speed film, rectangular collimation, and thyroid aprons for patients under 30 years of age. The use of leaded aprons can be considered optional except where required by law.

Barriers. The operator should stand behind a protective barrier during the x-ray exposure. The barrier shall allow the operator to view and communicate with the patient during the exposure. In the absence of a barrier, the operator must stand at least 2 m from the tube head during the exposure and out of the primary beam. Some jurisdictions require a greater distance.

Infection control methods. Infection control measures need to be routinely employed to prevent cross-contamination between patients and office personnel and should conform to the principles of universal precautions. Barrier techniques that isolate all working surfaces from contact with the patient’s saliva are preferred. Such surfaces include counters, the components of the x-ray machine, and the exposure button. Non-disposable components of film-holding instruments should be sterilized between patients.

Pregnant patients. Because the exposure to an embryo or fetus from dental radiography is so low compared with background radiation, dental radiographs of the pregnant patient should be made when clinically indicated.

Radiation therapy patients. Patients who have received a course of radiation therapy to the head or neck region are at risk of developing complications such as xerostomia, radiation caries, and osteoradionecrosis. Because the absorbed dose from dental radiography is so low compared with that absorbed during radiation therapy and these patients are at increased risk for dental disease, it is recommended that these patients receive radiographic examinations to aid in detection and treatment of oral disease when clinically indicated.

Processing techniques
Darkroom. The darkroom should be light-tight. The darkroom should be equipped with a proper safelighting system that is safe for all types of radiographic films that will be processed in the room. The film manufacturers’ recommendations should be followed when selecting a safelight filter. The darkroom should be properly vented to remove fumes from processing solutions.
**Time-temperature processing.** To optimize the quality of radiographs, the manufacturers’ recommendations regarding the proper temperature of processing solutions and processing times should be followed carefully. Use of “sight processing” typically results in underdevelopment of images, reduced image contrast, and patient overexposure. Solutions should be changed when exhausted—typically every 2 to 4 weeks depending on the volume of the solutions, usage rate, and contact with air. The temperature of automatic processors should be checked monthly to ensure adequate time-temperature processing.

**Infection control methods.** In the darkroom the films should be opened and trash discarded in a fashion that prevents contamination of processing equipment and solutions from the patient’s saliva and conforms to the principles of universal precautions.

**EPA standards for heavy metals (fixer, lead foil, etc).** Heavy metals, exhausted fixer solutions, and rejected radiographs should be discarded in an environmentally approved fashion consistent with federal, state, and local regulations.

**Film mounting and labeling.** All radiographs should be mounted and labeled with at least the patient’s first and last name, the examination date, and the facility’s (dentist’s) name.

**Quality control**

Dentists should continuously evaluate the quality of the images produced in their offices to ensure that they are optimally exposed and processed. Proper processing conditions will optimize image density and contrast and thereby maximize the diagnostic quality of the image. The x-ray machine must also meet any state and local regulations for periodic examination of operating parameters such as accuracy of kilovolt (peak), milliampere, and timer, exposure rate, and leakage.

The following are guides for evaluating individual intraoral radiographic projections to determine whether a remake is necessary:

**Intraoral views**

**PERiapical views.** Show apices of teeth under investigation and at least 2 mm of surrounding bone

Show minimal distortion due to incorrect vertical angulation.

Open the contacts of the interproximal surfaces of the teeth.

**BITEWING VIEWS (HORIZONTAL AND VERTICAL).** Show open contacts (preferably without overlap but certainly with less than half the thickness of the enamel overlapping) in region of interest.

Show minimal distortion due to incorrect vertical angulation.

**OCCLUSAL VIEWS.** When occlusal views are made to supplement periapical views (eg, to show a right-angle view in the mandible or to provide greater periapical coverage in the maxilla), they should show the desired region of interest with minimal distortion.

When occlusal views are made in lieu of periapical views (eg, in the anterior maxilla or mandible of children or in patients with limited opening), they should show the desired region without excessive distortion.

When occlusal views are made to examine the floor of the mouth, the beam should be oriented at right angles to the occlusal plane and made with a reduced exposure time.

**Extraoral views**

**PANORAMIC VIEWS.** These views should demonstrate both condyles, the inferior rim of the orbits, and the anterior inferior border of the mandible. The anterior teeth should not be magnified or minified. There shall be good contrast.

**LATERAL CEPHALOMETRIC.** The posterior border of each mandibular ramus should superimpose on the other, the Frankfort plane should be near horizontal, and the soft tissue profile should be evident.

**POSTERIOR-ANTERIOR CEPHALOMETRIC.** The sagittal plane shall be perpendicular to the receptor and the petrous ridges projected over the lower third of the orbits.

**WATERS VIEW (OCCIPITOMENTAL).** The sagittal plane shall be perpendicular to the receptor and the petrous ridges projected immediately inferior to each maxillary sinus.

**SUBMENTOVERTEX VIEW.** The sagittal plane shall be perpendicular to the receptor and the angle of each mandible superimposed over each mandibular condyle.

**REVERSE TOWNE VIEW.** The sagittal plane shall be perpendicular to the receptor, the mouth shall be open, the Frankfort plane shall be directed downward 30°, and the beam shall enter from the posterior.

**Exposure log.** Each patient’s dental chart should include an exposure log listing the radiographs made and the date.

**Film mounting.** All intraoral radiographs in a patient’s chart should be mounted in an opaque mount that obscures all extraneous light and is labeled with the patient’s name, dentist’s name, and date.

**Film viewing and reporting.** Radiographs should be viewed on an illuminator with masking, preferably in a dim, quiet room. A written entry of the findings shall be made in the patient’s record.

**Film processing monitoring.** Film processing conditions should be optimized to obtain the highest quality images. High-quality solutions (compatible with the films being processed) should be used. The developer and fixer should be replenished at least daily with fresh...
solution when using either manual or automatic processing. The developer and fixer should be changed regularly, typically every 2 weeks. Careful attention to time-temperature processing is critical to optimal images. Daily sensitometric/densitometric monitoring of solution quality is recommended. When test images have a low density (come out light), this indicates that the developer is becoming exhausted. Both the developer and the fixer should be replaced with fresh solutions.

Maintenance logs. Records should be kept of all servicing of x-ray machines and processors. These logs should conform to state or federal regulations, if applicable.

Quality improvement. A remake log is recommended to record the reason for all remakes. Periodic review of this log will quickly reveal any consistent problems that need to be addressed by the dental staff. If the reason for the problem is not readily clear, an oral and maxillofacial radiologist should be consulted. An alternative approach is to save all unacceptable radiographs and examine them monthly to determine the cause and correction of each problem. A retrospective audit of radiographs in charts selected at random also aids in the identification of poor radiographs.

Continuing education. Periodic continuing education in radiology is recommended for the dentist and allied personnel. Dentists will benefit from review of radiographic appearance of disease as well as updates regarding technologic advancement. Both dentists and allied personnel will benefit from review of radiographic technique and radiation safety.

REFERENCES

Selection criteria


Quality assurance


Infection control


AAOMR PARAMETER 2. RADIOGRAPHIC IMAGING OF THE TMJ

This Parameter is intended to guide the clinician responsible for the diagnosis of patients with temporomandibular joint (TMJ) disorders for optimal patient management. This Parameter is based on an AAOMR position paper that has been published (Brooks, 1997).

Indications

Indications for radiographic examination of the TMJ include, but are not limited to, signs and symptoms suggesting developmental disorders involving the TMJ; internal derangement; osteoarthritis (osteoarthrosis) and other arthritides; fracture; ankylosis; dislocation; functional disturbance; and neoplasia. Such signs include abnormal swelling adjacent to the joint, increased skin temperature or skin color adjacent to the joint, change in mandibular function, and occlusion such as anterior open bite and significant pain.

Qualifications and responsibilities of personnel

Those interpreting radiographic images of the TMJ should demonstrate evidence of training and competence in the subject, preferably achieved through successful completion of a graduate program in Oral and Maxillofacial Radiology (OMR) and certification by the American Board of Oral and Maxillofacial Radiology or an equivalent radiology certifying agency. It is assumed that the interpreter has training in the following:

- Anatomy, physiology, and pathophysiology of the TMJ and related structures of the head and neck
- Indications for the various imaging modalities applied in the radiographic examination of the TMJ and the optimal imaging techniques for various conditions
- Interpretation of images obtained by different modalities and techniques
- Functional knowledge of each modality and technique, including the possibilities and limitations of each.

If allied dental personnel or x-ray technicians are delegated to expose and process radiographs, they should have proper training in technique and safety measures. Their education and licensing should meet all jurisdictional requirements. In the absence of formal requirements, it is the responsibility of the dentist/physician to ensure that personnel are properly trained in these aspects.

Imaging modalities and techniques

The following modalities and techniques are currently applied in the radiographic imaging of the TMJ: plain films (including cephalometric, lateral skull, PA or AP skull, submentovertex, transcranial, transmaxillary, transorbital, and transpharyngeal projections), panoramic radiography, tomography, arthrography (including plain films, corrected tomography, and fluoroscopy), fluoroscopy, computed tomography (CT), magnetic resonance imaging (MRI), and nuclear medicine. For all the imaging modalities and techniques listed earlier, current standards for optimal imaging should be followed. X-ray machines and equipment should be tested regularly for their performance and adherence to standards. Plain-film imaging should be carried out with equipment that allows standardization and control of projections and with receptors that ensure optimal combination of speed and contrast and resolution. Panoramic radiography should be done with machines that ensure sufficient layer thickness and coverage of the TMJ area. Tomography should preferably be executed with a complex tomographic motion to ensure the best possible rendition of osseous structures. Layer thickness should be 1 to 2 mm for sagittal sections and 1 to 3 mm for frontal sections, when needed. CT and MRI should fulfill current requirements and standards with regard to slice thickness and other imaging parameters.

Selecting imaging modalities and techniques

The following paragraphs may assist referring clinicians as well as radiologists in determining the optimal imaging protocol in terms of diagnostic yield, radiation doses, and costs.

Corrected tomography is currently considered the most practical choice for a large number of conditions of the TMJ. It offers relatively detailed views in both the sagittal and coronal planes at a moderate cost. These views reveal osseous changes such as flattening, osteophyte formation and sclerosis. Corrected tomography can also accomplish the diagnosis of hard tissue changes, but tomography may also be able to supply adequate information at lower costs and radiation doses. Plain films and panoramic radiography can, in many cases, supply information about osseous changes needed for diagnosis and treatment decisions. Although the majority of cases of displaced disks can be diagnosed with clinical and patient history information, MRI or arthrography should be considered when there is a particular need for imaging of the soft tissues. Its unique ability to differentiate among different types of soft tissues has made it an indispensable diagnostic tool for depicting internal
derangement of the TMJ. Unfortunately, its high cost greatly restricts its usage.

**Developmental disorders**

**Imaging objectives.** The objective of an imaging examination in this situation is to determine the extent of the osseous changes and to elicit the etiologic conditions of the asymmetry, if possible.

**Patient selection.** Craniofacial asymmetry can be caused by a variety of conditions, including condylar aplasia, hypoplasia, and hyperplasia, as well as other developmental anomalies.

**Imaging procedures.** An initial radiographic evaluation should include a hard tissue examination in at least 2 planes and frequently 3. Lateral and frontal (PA) cephalometric radiographs, supplemented by a submentovertex projection, can demonstrate the nature and extent of osseous changes and suggest the possible need for additional imaging. Oblique cephalometric views (made at 45°) are also useful for evaluating the mandibular length bilaterally.

Sagittal and frontal tomography may supply important information if condylar hyperplasia or hypoplasia is suspected as the cause of the asymmetry. In complex deformities, CT with 3-dimensional (3-D) reconstruction is preferred. Panoramic radiographs should be viewed with caution because an asymmetrical appearance of the joint areas may result from positioning errors.

**Internal derangement**

**Imaging objectives.** The objective of imaging is to determine the status and function of the soft tissues as well as to evaluate osseous changes that may be contributing to the condition.

**Patient selection.** Patients with clicking on mouth opening and closing who had no other signs and symptoms usually do not require imaging. If the patient has pain or dysfunction associated with the joint, the physical examination suggests internal derangement, and the condition is refractory to conservative therapy, then imaging may be required to establish a definitive diagnosis and help determine the appropriate treatment modality.

**Imaging procedures.** For evaluation of both hard and soft tissues, MRI is the preferred modality. Disk position and function can also be determined by arthrography, whereas conventional tomography may depict osseous changes. Both joints should be imaged for comparison.

**Inflammatory disorders and osteoarthritis/arthritis**

**Imaging objectives.** The objective of imaging in suspected arthritis is to determine the extent and nature of osseous changes. The evaluation of soft tissue changes may also be appropriate if rheumatoid arthritis is suspected.

**Patient selection.** When a patient presents with pain or dysfunction associated with the TMJ and the clinical examination suggests the possibility of a degenerative or inflammatory condition affecting the joints, imaging may be indicated. Patients with asymptomatic crepitus usually do not require imaging.

**Imaging procedures.** Several imaging modalities can provide information about the osseous structures, including conventional and computed tomography. The extent and subtlety of the expected abnormality should determine the appropriate technique. MRI can depict both pannus formation in rheumatoid arthritis and joint effusion and is recommended when soft tissue information is required. Nuclear medicine should be considered for septic arthritis. Both joints should be imaged for comparison.

**Ankylosis**

When ankylosis is suspected as the cause of limited jaw motion, imaging is indicated to determine the extent and nature of the ankylosis and to rule out other causes. CT is the modality of choice because tomography and plain films are not reliable for this condition.

**Dislocation**

**Imaging objectives.** The objectives of imaging the joint in cases of suspected dislocation are to rule out fracture, to determine the location of the condyle relative to the temporal bone, to evaluate the total TM joint osseous morphology, and to evaluate the state and integrity of the associated TMJ capsule, articular disk, and retrodiskal tissues.

**Patient selection.** Condylar dislocation may be of traumatic origin in that it may have occurred suddenly (eg, external blow); it may also be spontaneous in nature and develop over a longer period of time due to excessive mandibular movement (eg, yawning, dental appointments). It could essentially be expected to represent excessive condylar movement anteriorly with an inability of the condyle to retrude. Dislocation could be expected to present with signs of inability to fully close the mouth and deviant mandibular movements; it also may be associated with varying degrees of pain.

**Imaging procedures.** Panoramic radiography may assist in ruling out osseous fractures; TMJ tomography would display the TMJ anatomy and location of the condyle in relation to the temporal bone; and MRI would display the integrity of the capsule and the position of the articular disk. How far one should progress
along this imaging continuum would in large part depend on the patient’s response to treatment of the dislocation, which, in effect, loops the decision back to the area of “Patient selection.”

**Fracture**

*Imaging objectives.* The objectives of imaging the TMJ in cases of suspected fracture are to evaluate the integrity of the condyle and the relationship of the condyle to the mandibular neck (ie, condylar displacement); to determine the relationship of the condyle to the temporal bone (displacement); to evaluate the total TMJ osseous morphology, including whether there are pathologic lesions present; to evaluate the integrity of the associated TMJ capsule, articular disk, and retrodiskal tissues; and to assess the effusion or foreign bodies.

*Patient selection.* Fractures involving the TMJ are almost always of traumatic origin and occur suddenly (eg, external blow, surgical accidents); alternatively, a pathologic fracture may occur in association with localized osseous destruction. Patients with fractures may present with signs of inability to open the mouth, inability to fully close the mouth, malocclusion, deviant mandibular movements, possible crepitus or fremitus, external clinical evidence of contusions/effusion or foreign bodies.

*Imaging procedures.* Panoramic radiography complemented with a right-angle view, such as a reverse-Towne view or coronal tomogram, may help to rule out gross osseous fracture, foreign bodies, and osseous pathosis; TMJ tomography would display the TMJ anatomy and location of the condyle with respect to the mandibular neck and temporal bone; CT may reveal hairline fractures; MRI would display the integrity of the capsule, the position of the articular disk, effusion, and soft tissue pathology. How far one should progress along this imaging continuum would in large part depend on the findings of initial imaging (probably panoramic) and the patient’s response to treatment of the fracture. Pretreatment and post-treatment imaging assessment may again loop the decision back to the area of “Patient selection.”

**Neoplasia**

*Imaging objectives.* In cases of known or suspected neoplasia, the objectives are to evaluate the total TMJ osseous morphology and assess it for anatomical changes, quality of bone, quantity of bone, and interrelationships of bone, as well as to evaluate all soft tissues for condition, changes, involvement, and extension—both intracapsular and extracapsular.

*Patient selection.* TMJ neoplasia may be of primary or metastatic origin, odontogenic or nonodontogenic, and benign or malignant. It may be detected serendipitously or may present with facial swelling, TMJ dysfunction, neurologic disturbances, or discomfort.

*Imaging procedures.* CT and MRI scans are required to examine neoplasia of the TMJ. A nuclear medicine examination is indicated to look for metastatic lesions.

**Masticatory muscle disorders**

*Imaging objective.* The objective is to rule out possible TMJ osseous abnormalities.

*Patient selection.* Masticatory muscle disorders are extracapsular conditions that do not involve specific TMJ pathosis or dysfunction. Therefore, whereas these patients may present with generalized facial pain, tenderness, and limitation of movement, they lack detectable TMJ noise, pain, and tenderness.

*Imaging procedures.* Screening panoramic radiography may help to rule out gross osseous abnormalities; and, if necessary, TMJ tomography could be obtained for confirmation. Initial muscle-based therapy could be implemented and the patient’s response to treatment used to determine how far along this imaging continuum one should proceed.

**REFERENCES**


**AAOMR PARAMETER 3. DISEASES OF THE JAWS**

Intraoral radiographs are most commonly made to examine the teeth for caries and the bone of the supporting alveolar process. By far the most common diseases detected are caries and bone loss resulting from periodontal or periapical disease of pulpal origin. In addition, numerous other conditions may be detected that contribute to patient diagnosis and treatment planning. Here we specifically discuss optimizing radiographic examinations for caries, periodontal disease, and periapical disease. When other conditions are observed that fall outside the range of normal, consultation with maxillofacial radiologists who have specialized experience is recommended.
Caries

Imaging objectives. The purpose of radiographic examination for dental caries is to examine tooth surfaces at risk (see also “Patient selection”), which cannot be readily visualized by direct methods. Thus, the primary purpose of radiographic examination is to visualize interproximal surfaces in the posterior region (i.e., the distal surface of the canine to the distal surface of the terminal tooth in the arch). Periapical or anterior bitewing views of the anterior dentition may also be used to augment clinical examinations in cases in which the presence or extent of carious involvement is in question.

Patient selection. Patient selection for the radiographic identification of dental caries should be guided by clinical examination and history (see also Selection Criteria guidelines of the FDA). Patients with a history of compromised oral hygiene, dietary or fluoride factors, and/or with clinical evidence suggestive of, or with frank evidence of, caries are considered candidates for radiographic examination of dental caries.

Imaging procedures. Radiographic detection of dental caries in the posterior quadrants is best accomplished by bitewing radiographic technique (see “Standard 1 on Intraoral Imaging” for technique Parameters). In adult patients with a full complement of teeth, 4 bitewing projections of size #2 image receptor (film packet, charge-coupled device sensor, or imaging screen) should be used. Adult patients with missing teeth or pediatric patients may require fewer than 4 projections or smaller film sizes, respectively. Periapical projections made with the paralleling technique are generally used for the anterior dentition because of the buccolingual inclination of the teeth. Where there are extensive metallic restorations, periapical views of the posterior teeth may augment bitewing views in detecting recurrent caries.

Periodontal disease

Imaging objectives. The radiographic images must provide a complete view of all of the dental structures, including the apical region of each tooth and the interproximal bone, with minimal horizontal overlap of adjacent dental structures. Ideally, the radiographic image should be able to provide the following:

- A clear depiction of the density and internal bone pattern of the alveolar processes
- The relationship of the crest of the alveolar process to the roots of the teeth
- The shape and distribution of bone destruction
- Evidence of any loss of bone in the furcation regions
- Evidence of any abnormal width of the periodontal ligament space
- Evidence of abnormalities of the apical regions of teeth
- The proximity of the bone loss to paradental structures, such as the maxillary antrum and nasal fossa
- Evidence of discontinuity of the lamina dura.

The radiographic image also has the potential to reveal the presence of related conditions such as severity and distribution of calculus deposits, faulty margins of dental restorations, and root resorption.

These images will aid in creating the treatment plan and discovering the presence of contributing factors; they also will serve as a base-line record that is important in determining the success or failure of treatment and the progress of disease.

Patient selection. A clinical examination of the patient must precede the prescription of radiographs. The radiographic images act as an aid—not a substitute—in a thorough clinical examination. The presence of signs and symptoms of periodontal disease will determine the need for and the extent of the radiologic investigation. This investigation may vary from images of one particular site to images of all of the alveolar process of both jaws. Any previous radiographs should be obtained before prescribing radiographs.

The clinical examination should include periodontal probing—as well as an assessment of the color, texture, consistency, and other features of the gingiva, and of tooth mobility—and an evaluation of the amount of attached gingiva.

The clinical signs that suggest the presence of periodontal disease may include soft tissue inflammation, bleeding, purulent exudate, and edema. More direct evidence of bone loss would include abnormal probing measurements, resorption of the alveolar crest, and tooth mobility. Other factors such as presence of systemic disease, age, immune system status, occlusal trauma, and stress may increase the suspicion and prevalence of the disease.

If the clinical exam indicates that periodontal disease is present and that more information is required concerning the status of the surrounding bone, then radiographs may be prescribed.

Imaging procedures. To maximize the information obtained from the radiographs, images with optimal density and resolution are required. The film developing system for conventional radiographs must be optimized. In addition, the image geometry must reproduce an accurate representation of the relationship of the dental structures and the surrounding bone and the image should include all of the dental structures, including the apical region, with minimum overlap of adjacent dental structures.

The bitewing projection is very effective because the projected x-ray beam approximates a right angle to the
long axis of the tooth and plane of film. This projects the alveolar crest–tooth relationship more accurately. A thin bitewing tab allows closer approximation of the occlusal surfaces of the maxillary and mandibular teeth, which permits more of the root structure and the surrounding bone to be included in the image. In cases where there has been moderate to severe bone loss, the vertical bitewing (long axis of the film positioned in a vertical alignment) may permit more of the alveolar process to be viewed. When making a periapical projection, the paralleling technique should be used. In this technique the film is placed farther away from the teeth in a deeper part of the oral cavity, which allows the film to have a more upright position, permitting the plane of the film to be as parallel as possible to the long axis of the tooth. Steep vertical angulation of the projected x-ray beam should be avoided to maintain a true relationship between the images of the crest of the alveolar process and the roots of the teeth.

When periodontal disease is extensive and in cases in which there are extensive restorations, a complete series of mouth radiographs has the advantage of providing more than one view, at slightly different angles, of each area of interest. In addition, multiple views at different angles permit the examiner to develop a mental 3-D model. The radiologic technique used should be standardized as much as possible to facilitate reproduction of these images at a later date. This will ensure an accurate assessment of the success of treatment and of the progress of disease.

Limitations. When employing radiographs as a diagnostic aid, it is important to consider the limitations of these images when weighing the significance of the findings. The following represent some of the limitations:

- The radiographic image is a 2-dimensional representation of 3-D objects, thus osseous defects may occasionally be obscured.
- Changes to the bone may occur before there are any perceptible changes to the radiographic image.
- The tooth structures obscure the view of the buccal and lingual bone.
- The radiographic image does not include a clear representation of the soft tissue level and therefore may provide no information regarding the depth of soft tissue pockets.

Periapical diseases

Radiographic objective. The purpose of the radiographic examination of periapical diseases is to identify dentoalveolar structures at risk for or involved with periapical pathoses. Thus, the radiographic examination must include the tooth (teeth) and surrounding structures. Failure to identify periapical pathoses in the presence of clinical findings should necessitate closer examination of the available information (eg, confirm or rule out root fractures) or should necessitate the consideration of alternative diagnostic possibilities.

Patient selection. Patient selection for the radiographic identification of periapical disease should be guided by clinical examination and history. Patients presenting with a history of pain or swelling in relation to a local or regional dentoalveolar area or with the clinical identification of caries, large restorations, compromised restorations, or with previous endodontic treatment can be considered at risk for periapical disease.

Radiographic procedure. Periapical views are most appropriate for detection of periapical lesions, and should be performed with the paralleling technique (see also “Standard 1 on Intraoral Imaging”). Identification of pathoses extending beyond the field of view of the intraoral radiograph may be imaged with alternative views such as occlusal views, panoramic views, or oblique lateral views. Pathoses having no clear etiologic or radiographic relationship to the dentition and supporting structures should be worked up with diagnostic algorithms appropriate to the clinical presentation and radiographic appearance.

Other diseases

Radiographic objective. Dentists will often detect diseases other than caries, periodontal disease, and periapical disease. These conditions may affect the teeth or the facial bones. Developmental abnormalities of the dentition and jaws may be present. The effects of recent or historical trauma may affect the teeth or jaws. Inflammatory diseases of the jaws, paranasal sinuses, and TMJ may be present in dental films. Primary benign and malignant tumors and metastatic tumors can be visualized on dental films; oral manifestation of systemic diseases also may appear. These other conditions may be identified as the result of radiographic examination of the jaws because of a patient sign or symptom; or they may be a serendipitous finding. In either case, the objective is to obtain suitable visibility of the lesion to ensure radiographic interpretation and development of a treatment plan.

Patient selection. Patient selection for the radiographic identification of these diseases should be guided by clinical examination and history.

Radiographic procedure. The imaging strategy for these conditions must be designed to answer questions derived from the clinical findings and radiographic location of the lesion. When dealing with osseous disease, it is important to identify all the boundaries of the lesion; it also is often important to obtain 2 views.
at right angles to each other. Periapical views are often sufficient for small lesions in the alveolar ridges. Occlusal, panoramic, other tomographic views, or skull views may be indicated for larger lesions. Pathoses having no clear etiologic or radiographic relationship to the dentition and supporting structures should be worked up with diagnostic algorithms appropriate to the clinical presentation and radiographic appearance.

REFERENCES

Caries

Periodontitis

Periapical disease

AAOMR PARAMETER 4. DENTAL IMPLANTS

It is a long-established radiologic principle that optimum viewing of osseous structures is achieved by viewing the same structure from 2 directions—preferably at right angles to one other. For the most part, however, dental imaging strategies have not involved 2 views. This is due in part to the limitation of existing x-ray systems and the nature of common dentoalveolar disease (caries and periodontal disease). For tooth-related diseases, cross-sectional or right-angle information is not readily achieved—nor is it deemed important. However, for skeletal imaging the limitations described earlier for dentoalveolar diseases do not necessarily apply. Cross-sectional information concerning a qualitative and quantitative assessment of preoperative implant site bone is now readily achievable and needed. Such information is essential for optimum implant selection, which depends in large part upon the architecture of a patient’s dentoalveolar bone.

The goal of presurgical dental implant treatment planning is to position the optimum number and size of implants for the best restorative results. This can only be done if the location and axial angulation of each implant are determined by a thorough knowledge of the patient’s bony anatomy is provided in a complete radiographic examination that includes the third dimension. Complete imaging should reveal information about the following: (1) the presence of disease, (2) location of anatomic features that should be avoided when placing the implant (eg, the maxillary sinus, nasopalatine canal, inferior alveolar canal, mental canal and foramen, and anterior extensions of inferior alveolar canal), (3) osseous morphology, including knife-edge ridges, the submandibular fossa, developmental variations, post extraction irregularities, enlarged marrow spaces, cortical integrity and thickness, and trabecular bone density, and, finally, (4) anatomical quantification, including the dimensions available for implant placement and, equally important, the orientation axis of alveolar height. Lingual inclination of mandibular contours, such as that which occurs near the posterior region of the mandible, should also be considered. These may lead to osseous undercuts that would make the fabrication of sub-periosteal implants difficult and may compromise the prognosis of an implant treatment plan or the integrity of the lingual artery.

Selection criteria
The goal of selection criteria in implant radiography is to identify the most appropriate imaging technology for each stage of patient care. Successful treatment planning requires that the clinician evaluate the suitability of the remaining bone for placement of implants. The clinician must determine if there is enough height, density, width of bone, and an appropriate axis of orientation for a successful prosthetic result.

To assess the suitability of an implant site, the clinician must first see a mesial/distal view of the region of the arch where implant placement is being considered. In general, the appropriate image for this purpose is a panoramic radiograph because it provides a wide view of both jaws. Periapical views may be added in cases in
which more detailed images are indicated. Such a view may be needed if the panoramic view shows some unknown structure or lesion in an area being considered for placement of an implant.

If analysis of the panoramic radiograph suggests that there may be sufficient bone for implant placement, the practitioner should next identify the potential implant sites and obtain cross-sectional images to evaluate these sites more thoroughly.

Cross-sectional information can usually be acquired with either conventional tomography or CT. Conventional film tomographic views are most useful (free of streaking artifacts) when complex tube/film motions (such as spiral or hypocycloidal patterns) are used instead of linear movement.

The selection of conventional rather than computed tomography should be based on the complexity of the case and the technology and expertise available. Radiation dose and cost should also be considered if more than one technique could provide the desired information. Conventional tomography usually costs less and requires less radiation than CT.

Panoramic imaging alone is not sufficient to provide all of the necessary information described earlier for optimum implant selection and should be augmented with tomography, either conventional or computed. Following are several reasons for this:

- Accurate measurements are difficult to obtain because panoramic views produce a variable magnification distortion of anywhere from 20% to 25% or greater in different regions of the same film.
- Parallax errors may cause images of facial structures to be cast inferior to those of lingually positioned structures in the same horizontal plane, thus possibly leading to a less than optimum placement of an implant.
- Positioning artifacts are common in panoramic imaging and can affect interpretation of the image.
- Panoramic radiographs are unable to demonstrate the presence of anatomical variants such as large marrow spaces, anterior loops of the mandibular canal and poor quality bone.
- Panoramic radiographs are unable to demonstrate the axis of orientation of the alveolar bone.

**Conventional tomography**

Conventional tomography for implant site assessment has been available for many years. Current systems may use cephalostats for positioning the patient in the machine or may incorporate other registration alternatives such as lasers or plastic positioning devices. Cross-sectional image placement may be performed manually by the operator or controlled by computer. Tomographic landmarks on the patient are best identified through surgical stents containing metallic markers, balls, rods, or radiopaque tooth contours. Regardless of the method used, some means of relating the cross-sectional image to the traditional panoramic image or the actual implant site in the oral cavity is absolutely necessary. Software is also available to display the images and assist in planning implant placement with electronically simulated fixtures.

**Indications and contraindications.** Conventional tomography should be used for most cases in which the technology and expertise are available rather than in cases in which bone grafts or complex trauma are involved, for which CT might be more appropriate. CT may also be needed if adequate interpretive expertise is not available for conventional tomography.

**Qualifications and responsibilities of personnel**

**DENTIST.** The interpreting practitioner should either be a board-certified oral and maxillofacial radiologist or a dentist with adequate training and experience for interpreting implant tomograms.

**TECHNOLOGIST.** The technologist should have training beyond that required of a dental assistant or hygienist but not necessarily that of a radiologic technologist, although that would be ideal. A dental assistant or hygienist could be trained through a special short course designed by an oral and maxillofacial radiologist.

**Specifications and performance of examination.** The AAOMR recommends that the dentist or radiologist be closely involved in office implant imaging. The dentist or radiologist should complete or supervise the following steps in conducting a conventional tomographic implant imaging examination: (1) make a “scout” radiograph as appropriate for the imaging system being used, (2) verify implant sites using stents with radiopaque indicators, preferably based on diagnostic wax-ups, (3) obtain longitudinal or parasagittal images along with the cross-sectional images so that cross-correlation is possible, and (4) write a complete report, with appropriate tracings as needed, for each tomographic study.

**Quality-control procedures/quality improvement.** Quality control for tomographic systems would include all that is required for any film-based system plus the addition of tomographic test tools or phantoms for image layer verification.

**Reporting.** A full radiographic report should be included with each set of tomograms. Each report should include the following:

1. Tracings of the bony outlines of the cross-sectional images
2. Reference marks on any longitudinal images obtained, indicating the plane of section represented by the tomograms.
3. A narrative description of image quality, bone
Computed tomography

Reformatted CT has been used in recent years for cross-sectional imaging of the jaws, usually with dedicated software. Through the use of this method, multiple thin axial slices obtained through the jaws are directly acquired and then the data are reformatted to produce cross-sectional and curved linear "panoramic images." Software is also available to display the CT scans and assist in planning implant placement with electronically simulated fixtures.

The advantages of CT systems are (1) uniform magnification, (2) a high-contrast image with a well-defined image layer free of blurring, (3) identification of bone grafts or hydroxyapatite materials used to augment maxillary bone in the sinus region is easier than with conventional tomography, (4) multiplanar views, (5) 3-D reconstruction, (6) simultaneous study of multiple implant sites, (7) shorter acquisition time than conventional tomography when multiple sites are being evaluated on an individual arch, and (8) the availability of image evaluation software (also available for a few tomographic systems).

Disadvantages of CT include (1) limited availability of reconstructive software for implant site imaging, (2) expense, and (3) higher doses of radiation than those received during conventional tomography (except when multiple sites are being evaluated in an arch).

Indications and contraindications. CT should be used for cases in which the technology and expertise are available and under the following conditions:

- When cases involve bone grafts or complex trauma
- When many potential implant sites are being considered
- Where there are not extensive metallic restorations or foreign objects present in the axial planes of interest
- When adequate interpretive expertise is available.

Qualifications and responsibilities of personnel

DENTIST. The interpreting practitioner should either be a board-certified oral and maxillofacial radiologist or a dentist with adequate training and experience in interpreting implant CT studies.

TECHNOLOGIST. The technologist should be a radiologic technologist credentialed by an appropriate regulatory agency.

Specifications and performance of examination.

The AAOMR recommends that the dentist or radiologist be closely involved in CT implant imaging. The dentist or radiologist should complete or supervise the following steps in conducting a reformatted computed tomographic implant study: (1) position patient in CT scanner with occlusal plane parallel to the plane of section and determine region to be imaged, (2) verify implant sites using stents with nonmetallic radiopaque indicators, preferably based on diagnostic wax-ups (eg, gutta percha, radiopaque composite resin, or barium paste), (3) evaluate the axial images to ensure minimal patient movement, (4) reformat the study using an appropriate multiplanar software program, and (5) write a complete report that includes the remarkable findings from both the direct axial images and the reformatted images.

Quality-control procedures/quality improvement.

Quality control for CT systems includes all procedures required for CT units by appropriate regulatory agencies.

Reporting. A full radiographic report of CT-based implant imaging should be included with each set of images. Each report should include the following:

1. Adequate descriptions or tracings of osseous morphology
2. Adequate correlation between scout, cross-sectional, and longitudinal images
3. A narrative description of image quality, bone quality, axis of orientation considerations, and other factors pertinent to the case
4. Description of any other remarkable findings (anatomical anomalies or pathology) in either direct acquisition axial or reformatted images
5. Under no circumstances should the radiologist render an opinion regarding the suitability of implant placement unless it is in the form of suggestions. Certainly, the radiologist should never indicate to patients the suitability of their jaws for implant placement. That is a decision to be made only by the ordering practitioner.

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The authors of this report, all members of the ad hoc Parameters of Care Committee of the American Academy of Oral and Maxillofacial Radiology, acknowledge the following individuals for their assistance: Byron W. Benson, president, AAOMR; Alan G. Lurie, councilor for Public Policy and Scientific Affairs; and others who contributed to this report, including prior committee members Sharon L. Brooks, Robert A. Goepp, Stephen R. Matteson, M. Kevin O Carroll, Michael J. Pharoah, Thomas F. Razmus, and Donald A. Tyndall.

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