The role of imaging in oral medicine varies greatly with the type of problem being evaluated. Certain problems, such as pain in the orofacial region, frequently require imaging to determine the origin of the pain. For other conditions, however, such as soft-tissue lesions of the oral mucosa, imaging offers no new diagnostic information.

The variety of imaging techniques available to the clinician has grown in number and in degree of sophistication over the years. While this means that there is an imaging procedure that will provide the information desired by the clinician, it also means that choosing the best technique is not necessarily an easy process.

This chapter first explores the underlying principles the clinician should consider when deciding whether imaging is appropriate for the case in question and then discusses the imaging techniques that are available in dental offices and in referral imaging centers. Examples of specific imaging protocols are then described, followed by a discussion of risk-benefit analysis of imaging in oral medicine.

**SELECTION CRITERIA**

The decision to order diagnostic imaging as part of the evaluation of an orofacial complaint should be based on the principle of selection criteria. Selection criteria are those historical and/or clinical findings that suggest a need for imaging to provide additional information so that a correct diagnosis and an appropriate management plan can be determined. The use of selection criteria requires the clinician to obtain a history, perform a clinical examination, and then determine both the type of additional information required (if any) and the best technique for obtaining this information. The emphasis is on the acquisition of new information that affects the outcome, not just the routine application of a diagnostic modality.

There are many reasons for requesting imaging information, including the determination of the nature of a condition, the confirmation of a clinical diagnosis, the evaluation of the
extent of a lesion, and the monitoring of the progression or regression of a lesion over time. Each of these may require a different imaging strategy.

Over the years, there have been some attempts to offer guidance to the clinician in the selection of the most appropriate imaging protocol. In 1986, the Food and Drug Administration convened a panel of experts to develop guidelines for selecting appropriate radiologic examinations for new and recall dental patients, both those who present for routine examination without complaints and those with specific signs or symptoms of disease. These guidelines have been approved by the American Dental Association and all dental specialty organizations. A convenient chart of these recommendations can be obtained from Eastman Kodak Company, Rochester, New York (pamphlet No. N-80A).

Guidance for imaging of the temporomandibular joint (TMJ) and dental implant preoperative site assessment has been developed in the form of position papers published by the American Academy of Oral and Maxillofacial Radiology. That group has also produced a document describing parameters of care for a variety of imaging tasks.

Whether or not there are published guidelines, it is incumbent upon the individual clinician to use diagnostic imaging wisely. This means determining specifically what information is needed, deciding whether imaging is the best way to obtain this information, and (if so) selecting the most appropriate technique, after considering the information needed, the radiation dose and cost, the availability of the technique, and the expertise needed to interpret the study.

▼ IMAGING MODALITIES AVAILABLE IN DENTAL OFFICES AND CLINICS

Intraoral and Panoramic Radiography

There are a number of imaging modalities that are readily available to the clinician for evaluating patients’ conditions. Virtually every dental office has the equipment to perform intraoral radiography, and many offices also have panoramic x-ray machines. These two types of radiographic equipment will provide the majority of images needed for evaluating patients’ orofacial complaints.

Clinicians who treat patients who have oral medical problems should be able to make a variety of occlusal radiographs in addition to standard periapical and bite-wing radiographs. Occlusal radiographs may be valuable for detecting sialoliths in the submandibular duct, localizing lesions or foreign bodies (by providing a view at right angles to that of the periapical radiograph), and evaluating the buccal and lingual cortex of the mandible for perforation, erosion, or expansion. The advantage of intraoral radiography is the fine detail provided in its visualization of the teeth and supporting bone.

Panoramic radiography demonstrates a wide view of the maxilla and mandible as well as surrounding structures, including the neck, TMJ, zygomatic arches, maxillary sinuses and nasal cavity, and orbits although it does so with less sharpness and detail than are seen in intraoral views (Figure 3-1). Comparison of right and left sides is easier with a panoramic projection, and this view provides an excellent initial view of the osseous structures of the TMJ and of the integrity of the sinus floor. Additional views targeting these tissues can be obtained later if needed.

Some panoramic x-ray machines also have the capability of providing a variety of skull projections, including lateral, oblique lateral, posteroanterior, anteroposterior, and submentovertex views. Typically, these are done with a cephalometric attachment to the machine. Although these views are relatively easy to take and can provide valuable information in certain circumstances, they demonstrate complex anatomy and should be interpreted by someone with experience in the field, preferably an oral and maxillofacial radiologist.

Digital Imaging

While most intraoral radiography is still performed with film as the recording medium, the use of digital imaging techniques is rapidly increasing. Although it is possible to produce a digital image by scanning a film radiograph, that technique does not provide any of the advantages of speed and radiation dose reduction that are available when digital images are acquired directly.

There are two major techniques for acquiring digital images: (1) a single-step wired system using a charge-coupled device (CCD) or complementary metal oxide semiconductor (CMOS) sensor and (2) a two-step wireless system using a photostimulable storage phosphor (PSP) plate (Figure 3-2). The CCD or CMOS sensor is a device that transforms the energy from ionizing radiation into an electrical signal that is displayed as an image on a computer monitor within a few seconds. The sensor is housed in a rigid plastic case that is attached to the computer by a long cord. The sensor is placed in the mouth, the computer is activated, and the exposure is made. Once the image appears on the screen (generally within a few seconds) (Figure 3-3), a number of different software
“enhancements” can be applied although some studies have shown the unenhanced images to have higher diagnostic capabilities than the enhanced ones, most likely due to processing done before the image appears on the screen.5

With the PSP technique, the imaging plate (sensor) is thinner and more flexible and is not attached to the computer. After the exposure is made, a plate is inserted into a machine that scans it with a laser, converting the latent image into a visual image on the computer screen. This process takes from 30 s to 2.5 min, depending on the system. The sensor plate must then be discharged before reuse.

Both CCD and PSP digital imaging systems are available for both intraoral and panoramic radiography. They use a standard x-ray machine but replace the film or standard panoramic cassette with a digital sensor. Even though digital systems do not have higher diagnostic capabilities than their film-based counterparts do for the detection of dental caries,6 periodontal disease,7 and periapical lesions,8 there are a number of other advantages to using digital imaging, including reduced radiation exposure, reduced time of image acquisition, the ability to transmit images electronically, and the ability to be used with a number of image analysis tools.

Once the image is in the computer, a number of procedures can be done, depending on the software available. In addition to the standard contrast and brightness enhancements, there is a measurement tool that can be used to determine the dimensions of a lesion. Specialized software is available for digital subtraction, a method of evaluating changes in radiographs over time. Ideally, “before” and “after” radiographs should be identical other than for the area of interest (although algorithms are being developed that can take similar [although not necessarily identical] images and mathematically “warp” them so that the geometry is the same). The two images are then registered, and the gray levels of the same pixels of both images are compared. Typically, increasing mineral (tooth or bone gain) is portrayed as white, and decreasing mineral is shown as black (Figure 3-4). One commercially available program uses red and green to portray bone loss and gain, respectively. Digital subtraction can be useful for evaluating changes in bone height and/or density in periodontitis and for judging the degree of healing and remineralization of periapical lesions after endodontic therapy. Theoretically, any lesion (including bony cysts or tumors) with the potential of change over time can be studied by the subtraction technique, given a method for standardizing the images.

This need for standardization means that the decision to use digital subtraction must be made at the time of the initial imaging so that follow-up images can be made with the same technique since there is a limit to the amount of geometric image correction that can be done. In addition, a step wedge or other device must be incorporated into the imaging system to allow for correction of differences in density and contrast between radiographs, which would affect the subtraction outcome. Because of the difficulty in standardizing panoramic imaging, digital subtraction is currently more feasible for evaluating changes in lesions small enough to be visualized on intraoral views.

Other software is available for the evaluation of other aspects of the digital images, including software for histogram analysis and for a variety of pattern analyses of the trabecular bone.9 Although these are currently considered research tools, they may have clinical application in the future.

All of the analyses described above can be done on any type of digital image, whether acquired by CCD or PSP or scanned from a film image.

Some interesting new clinical applications of digital imaging will soon be available. With tuned-aperture computed tomography (TACT®), a series of digital images is acquired at slightly varying angles; the computer then reconstructs the

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**FIGURE 3-2** Digital imaging sensors. Left, photostimulable storage phosphor (Digora, Soredex/Orion, Helsinki, Finland); right, charge-coupled device (CCD) sensor (CDR [Computed Dental Radiography], Schick Technologies, Long Island City, N.Y.).

**FIGURE 3-3** Periapical radiograph made with a charge-coupled device (CCD) type of direct digital imaging system. The mesial root of the first molar was amputated 10 years previously due to a vertical fracture. Note the letter “E” in the corner of the image, indicating that the image has been exported from the program used to acquire it initially.
resultant data to provide information about depth. The image can be manipulated to bring various layers into focus, thus permitting determination of depths of lesions and relationships between structures\(^{10}\) (Figure 3-5).

Another computer reconstruction technique under development uses a Scanora panoramic x-ray machine (Soredex/Orion Co., Helsinki, Finland) and a special image intensifier to produce three-dimensional data of a cylindrical volume of tissue. The data can be reconstructed to provide an image at any angle through the volume, providing a high-resolution computed tomography (CT) scan at a radiation dose a fraction of that required by conventional CT.\(^{11}\) The developers have dubbed this technique “ortho-cubic CT” and expect to make it available soon (Figure 3-6).

**FIGURE 3-4** Digital subtraction images of a periodontal furcation defect. **A,** Reference radiograph showing a defect in the furcation of the mandibular first molar. **B,** Follow-up radiograph after placement of 2 mg of crushed bone in soft wax in the defect. The bone “graft” is undetectable. **C,** Subtracted and contrast-enhanced combination of reference and follow-up images. The bone “graft” is visible as a square white area in the furcation. (Courtesy of Dr. Onanong Chai-U-Domn, University of North Carolina School of Dentistry, Chapel Hill, N.C.)

**FIGURE 3-5** Tuned-aperture computed tomography (TACT\(^{\text{TM}}\)) images of the same periodontal defect shown in Figure 3-4. **A,** Reference image with the TACT\(^{\text{TM}}\) slice centered on the buccolingual location of bone apposition. **B,** Follow-up image in the same plane, after placement of 2 mg of crushed bone. **C,** Contrast-enhanced images after subtraction of the two TACT\(^{\text{TM}}\) slices. The bone mass is clearly visible in the furcation as a white area. (Courtesy of Dr. Onanong Chai-U-Domn, University of North Carolina School of Dentistry, Chapel Hill, N.C.)
Conventional Tomography

Plain (or conventional) tomography is a radiographic technique that has been available for many years, generally in institutions such as dental schools or hospitals, due to the size and expense of the equipment. However, tomographic capability has been added to some sophisticated computer-controlled panoramic x-ray machines, making tomography potentially more readily available in dental offices and clinics.

In conventional tomography, an image is made of a thin layer of tissue; tissues that are superficial and deep to the desired region blur out due to movement of the x-ray tube and film. Some machines use a relatively simple linear movement of the tube, which can unfortunately produce streaking artifacts. More complex tube movements (such as spiral and hypocycloidal movements) can blur out undesired tissues more completely, thus making the area of interest more prominent.

In the past, the primary use of tomography in dentistry has been for detailed evaluation of the osseous structures of the TMJ (Figure 3-7, A). However, some of the newer machines will also produce cross-sectional images of the jaws (see Figure 3-7, B). While these are excellent for the assessment of the bone prior to the placement of dental implants, they also can be used whenever a cross-sectional view of the jaws would be helpful, such as when determining the relationship between a lesion and the apex of the tooth or when evaluating the integrity of the buccal or lingual cortical bone.

For the evaluation of large or complex lesions such as facial fractures or tumors, conventional tomography has generally been superceded by CT or magnetic resonance imaging because of the clarity of the images, the lack of blurring from other structures, and the ability to produce images in multiple planes. However, plain tomography may still be of value in imaging lesions confined to the jaw bones.

IMAGING MODALITIES AVAILABLE IN HOSPITALS AND RADIOLOGY CLINICS

While the standard imaging modalities that are available in dental offices will suffice for many of the cases being evaluated in oral medicine, there are situations in which it is appropriate to refer the patient to a hospital or other facility for a specialized imaging procedure.

The decision of which type of imaging to request depends on the question to be answered. Is there a need for information on hard tissue, soft tissue, or both? Is the disease process...
apparently localized or widespread? Is functional information needed in addition to or in place of anatomic information? How much anatomic detail is necessary? Is three-dimensional reconstruction of the image contemplated?

The rest of this section discusses the imaging modalities that are available in most imaging centers today.

**Computed Tomography**

Computed tomography (CT) permits the imaging of thin slices of tissue in a wide variety of planes. Most CT is done in the axial plane, and many CT scans also provide coronal views; sagittal slices are less commonly used. During CT scanning, the x-ray source and detectors move around the desired region of the body while the patient lies on a table. Modern generations of CT scanners use a spiral motion of the gantry to produce the x-ray data that are then reconstructed by computer. The operator selects the region of the anatomy and the thickness of the slices of tissue to be scanned, along with the kilovolt and milliampere settings. Slice thickness is usually 10 mm through the body and brain and 5 mm through the head and neck, unless three-dimensional reconstruction is anticipated. In such cases, the slice thickness is 1.0 to 1.5 mm in order to provide adequate data.

CT scans are usually evaluated on computer monitors although they may also be printed on radiographic film. The contrast and brightness of the image may be adjusted as necessary although the images are usually viewed in two modes: bone windowing and soft-tissue windowing. In bone windowing, the contrast is set so that osseous structures are visible in maximal detail. With soft-tissue windowing, the bone looks uniformly white, but various types of soft tissues can be distinguished (Figure 3-8). Viewing the images in these different formats does not require rescanning the patient.

There are many advantages to CT of the head and neck region compared to imaging this area by plain films or conventional tomography. Thin slices of tissue can be viewed in multiple planes without superimposition by adjacent structures or the blurring out of other layers. Fine detail of osseous and other calcified structures can be obtained. Various soft tissues can be differentiated by their attenuation of the x-ray beam. Fascial planes between muscle groups can be identified, as can lymph nodes and blood vessels. Three-dimensional images that may make it easier to visualize certain abnormalities can be produced, and some software programs will color certain structures (such as tumors) to simplify visualization of the lesion. Three-dimensional models can also be milled out of plastic, based on data from CT scans. Cross-sectional images can also be reconstructed from axial CT scans, producing, for example, views of the mandible for use in preoperative assessments for implant placement.

The major disadvantages of CT relate to the relatively high cost and high radiation dose of this examination compared to those of plain-film radiography. In addition, resolution of fine structures of the head and neck may be less than optimal although the newly developed super-high-resolution ortho-CT described above is attempting to address these problems. Careful attention must also be paid to the imaging plane through the jaws if the patient has metallic restorations; these restorations produce streak artifacts that may obscure portions of the anatomy (Figure 3-9).

CT is typically used in dentistry to evaluate (1) the extent of lesions suspected or detected with other radiographic techniques, (2) the degree of maxillofacial involvement in cases of trauma, (3) the integrity and condition of the paranasal sinuses, and (4) the quality and quantity of bone in proposed dental...
implant sites, particularly when there are multiple sites or when there has been bone grafting. CT is rarely indicated for evaluation of the TMJ since the osseous structures can be visualized adequately with less expensive techniques such as conventional tomography or panoramic radiography, and disk displacement and other joint soft-tissue information can be better obtained with magnetic resonance imaging. CT may be of value in complex TMJ situations, such as in cases of suspected ankylosis or severe joint destruction or when there is a history of polytetrafluoroethylene or silicon-sheeting TMJ implants.

**Magnetic Resonance Imaging**

Magnetic resonance imaging (MRI) uses electrical and magnetic fields and radiofrequency (RF) pulses, rather than ionizing radiation, to produce an image. The patient is placed within a large circular magnet that causes the hydrogen protons of the body to be aligned with the magnetic field. At this point, energy in the form of RF pulses is added to the system, and the equilibrium is destabilized, with the protons altering their orientation and magnetic moment. After the RF pulse is removed, the protons gradually return to equilibrium, giving up the excess energy in the form of a radio signal that can be detected and converted to a visible image. This return to equilibrium is called relaxation, and the time that it takes is dependent on tissue type. “T1 relaxation” describes the release of energy from the proton to its immediate environment, and “T2 relaxation” designates the interaction between adjacent protons. This whole sequence of applying RF pulses and then picking up the returning signal later is repeated many times in forming the image.

By manipulating the time of repetition (TR) of the pulses and the time of signal detection (time of echo [TE]), the various tissues can be highlighted, allowing the determination of tissue characteristics. For example, when both TR and TE are short (eg, 500 ms/20 ms), the image contrast is due primarily to differences in T1 relaxation times (ie, T1-weighted image) (Figure 3-10, A). Fat produces a bright signal whereas fluids and muscle produce an intermediate signal. If the parameters are adjusted so that both TR and TE are long (2,000 ms/80 ms—a T2-weighted image), fluids become bright and fat.

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**FIGURE 3-8** A, Bone window computed tomography (CT) scan of the same patient as in Figure 3-1. The left condyle exhibits alterations in size, shape, and degree of sclerosis, with an osteophyte in the anterior lateral aspect. Soft-tissue densities can be seen in the maxillary and ethmoid sinuses, consistent with chronic sinusitis and mucous retention cyst on the left. B, Soft-tissue window CT scan in the same imaging plane.

**FIGURE 3-9** Streak artifact on a computed tomography (CT) scan as a result of metallic dental restorations in the imaging plane.
becomes darker (see Figure 3-10, B). By running a variety of different sequences, significant information about tissue character can be obtained. The addition of an intravenous contrast agent (gadolinium-diethylenetriamine pentaacetic acid [Gd-DTPA]) allows even more tissue differentiation because certain tumors enhance (i.e., produce a brighter signal) in a characteristic way due to increased blood flow.

Similarly to CT, MRI produces images of thin slices of tissue in a wide variety of planes, including oblique angles. Quasi-dynamic motion studies can also be performed, as can three-dimensional reconstruction.

MRI is used primarily for evaluating soft tissues because bone always produces a low signal (black) due to a relative paucity of hydrogen protons. While some information about osseous tissue can be obtained (particularly about alterations in the bone marrow), detailed study of bone is usually reserved for CT. Due to signals emanating from flowing blood, MRI can also be used to evaluate blood vessels, with differentiation between arteries and veins possible. Three-dimensional magnetic resonance (MR) angiography can rival conventional angiography in detail but without the need for the injection of a contrast medium.

Although MRI was first introduced clinically for the evaluation of the brain, it is now used throughout the body, not only for soft tissue but also for the assessment of joints since ligaments (both intact and torn), menisci, surface cartilage, bone marrow abnormalities, and synovial membrane proliferation can all be studied with MRI.

In dentistry, the primary uses of MRI have been the evaluation of various pathologic lesions (such as tumors) and the assessment of the TMJ. A number of cadaver and clinical studies have demonstrated that MRI can accurately depict the location, morphology, and function of the articular disk, thus allowing the diagnosis of internal derangement to be made or confirmed12 (Figure 3-11). Information on joint effusion and pannus formation can also be obtained, and some osseous changes can also be evaluated.13,14 Recent reports have also described the correlation of MR appearance with histology in cases of bone marrow edema or necrosis.15

**FIGURE 3-10** A, T1-weighted (time of repetition [TR]/time of echo [TE] = 500 ms/11 ms) magnetic resonance imaging (MRI) scan in a patient with squamous cell carcinoma of the maxillary sinus and nasal cavity on the right side, coronal plane. **B**, T2-weighted (TR/TE = 5,901 ms/90 ms) MRI scan in the same patient, axial view. The carcinoma has invaded the right alveolar ridge and palate.

**FIGURE 3-11** Magnetic resonance imaging (MRI) scan of the temporomandibular joint, closed-mouth view. C indicates the condyle, D indicates the disk, E marks the articular eminence, and F marks the articular fossa. The disk is anteriorly displaced.
The typical MRI examination of the TMJ consists of both closed- and open-mouth views in an oblique sagittal plane, with the sections oriented perpendicular to the long axis of the condyle. Some institutions also routinely obtain images in the coronal plane for easier identification of a lateral or medial displacement of the disk.

The sagittal images are used to evaluate disk position with respect to the head of the condyle. The disk is considered to be in a normal location when the posterior band is superior to the condyle (the so-called twelve-o’clock position) when the mouth is closed, but there is not complete agreement about how far the disk must be from twelve o’clock before anterior displacement is diagnosed. Because there can also be a rotational component to the disk displacement, all slices through the joint should be evaluated, not just the ones that show the disk most clearly. In the open-mouth views, the disk can be seen to be interposed between the condyle and articular eminence (normal or reducing) or to remain anterior to the condyle (nonreducing).

MRI has many advantages over other imaging techniques, including the capability of imaging soft tissue in virtually any plane. It also uses no ionizing radiation and is thus generally considered safe although there are limits on the magnitude of the magnetic field used and although animal studies have shown teratogenicity resulting from MRI in pregnant mice. MRI is contraindicated for certain patients, including those with demand-type cardiac pacemakers, due to interference by the electrical and magnetic fields. Patients with ferromagnetic metallic objects in strategic places (such as aneurysm clips in the brain and metallic fragments in the eye) also should not be placed in the magnet. Most machines have weight and girth limits for patients because of the size of the bore of the magnet. Some patients feel claustrophobic inside the magnet and may need to be sedated for the procedure. Because of the length of time for each scan in the series (typically several minutes), patients who cannot remain motionless are not good candidates for MRI.

**Ultrasonography**

Ultrasonography (US) uses the reflection of sound waves to provide information about tissues and their interfaces with other tissues. This is a noninvasive and relatively inexpensive technique for imaging superficial tissues in “real time.” The operator applies a probe over the area of interest and receives information immediately on the computer monitor. In regard to the head and neck region, there has been a great deal of recent interest in the imaging of salivary glands (Figure 3-12). Several researchers have studied the ultrasonographic features of a variety of tumors and other conditions in the parotid gland, in an attempt to make a diagnosis before biopsy as the surgical management of these tumors may vary. Others have looked at the heterogeneity of sonic echo production within the parenchyma of parotid glands affected by a variety of inflammatory or autoimmune conditions.

Efforts are being made to categorize lymph nodes in the neck as metastatic, reactive, or normal in patients with head and neck neoplasms. Evaluation of stenosis of carotid arteries is also usually done with US.

US has been used to assess some joints in the body for evidence of inflammation, tears in ligaments and tendons, and other abnormalities. Unfortunately, US does not appear to be useful for determining internal derangement of the TMJ at this time although work is continuing in this area.

**Nuclear Medicine**

In radionuclide imaging (nuclear medicine, scintigraphy), a substance labeled with a radioactive isotope is injected intravenously. Depending on the specific material used, the substance will be taken up preferentially by the thyroid (technetium [Tc] 99m-labeled iodine), salivary glands (Tc 99m pertechnetate), or bone (Tc 99m methylene diphosphonate [MDP]). Gallium 67 citrate is also sometimes used to assess infections and inflammation in bone. At various times after radionuclide injection, a gamma camera is used to count the radioactivity in the various organs and tissues of the body and to display the results visually. High concentrations of the isotope show up as “hot spots” and generally indicate high metabolic activity (Figure 3-13). Nuclear-medicine scans are used to assess conditions that may be widespread, such as metastasis to bone or other tissues or such as fibrous dysplasia in an active phase. Unfortunately, areas of dental periapical and peri-
odontal inflammation also take up the tracer, presenting as hot spots in the jaws, and must be differentiated from other pathologic conditions.

A variation of bone scintigraphy that can be used to localize and quantify bone activity is single-photon emission computed tomography (SPECT). In this technique, the gamma rays given off by the Tc 99m MDP are detected by a rotating gamma camera, and the data are processed by computer to provide cross-sectional images that can later be reconstructed as images in other planes. Volumetric measurements may also be obtained to quantify the distribution of radioactivity in the tissue, allowing better assessment of tissue function. A recent study demonstrated the use of SPECT in the evaluation of osseointegration in dental implants. However, in another study, both the sensitivity and specificity of SPECT were low for the detection of painful sites in patients with idiopathic jaw pain.

Contrast-Enhanced Radiography

Radiography with the use of contrast agents is still performed in some facilities, but its usage has decreased significantly with the evolution of advanced imaging techniques. The major contrast-enhanced examinations used in dentistry are arthrography and sialography.

In arthrography of the TMJ, radiopaque material is injected into the lower (and sometimes also the upper) joint space under fluoroscopic guidance. Once the dye is in place, fluoroscopic recordings of the joint in motion may be made in order to assess the shape, location, and function of the articular disk. Radiography or tomography may also be performed afterwards (Figure 3-14). Arthrography is invasive and technically difficult and has been replaced by MRI in most institutions.

In sialography, contrast medium is injected into the major duct of the salivary gland of interest. The distribution of the ductal system, along with any patterns such as narrowing or dilation of ducts or such as contrast extravasation or retention, can provide helpful information regarding the inflammatory, obstructive, or neoplastic condition affecting the gland (Figure 3-15). In many institutions, CT, MRI, or US is used more often than sialography to evaluate the salivary glands.
IMAGING PROTOCOLS

Orofacial Pain

In deciding whether to use imaging during the assessment of a patient with orofacial pain, the clinician must first obtain enough information from the history and clinical examination to determine the nature and probable cause of the problem and to decide whether imaging will provide any benefits in the diagnosis and management of the patient. In many cases, it may be necessary to rule out the teeth as a source of the pain. Select intraoral and/or panoramic radiography combined with the clinical examination can generally help in this situation.

If the patient’s symptoms are suggestive of temporomandibular disorder (TMD), a thorough clinical examination may provide enough information to establish a diagnosis and to select a management strategy without imaging, even though it has been shown that clinical examination alone will not detect all cases of internal derangement.28

When there appears to be a bony component to the temporomandibular problem or if the patient is refractory to conservative treatment, it may be useful to obtain information on the condition of the osseous structures of the joints.2 A number of techniques can be used to confirm or rule out a variety of developmental, inflammatory, degenerative, traumatic, or neoplastic processes. Panoramic radiography provides a good overview of both joints as well as the rest of the maxillofacial complex. Although only gross structural abnormalities will be visualized with this type of radiography, this degree of detail may be adequate in many cases to determine the presence or absence of bony changes.29 If more detail is necessary to make the diagnosis or prognosis, conventional tomography should be performed, generally in oblique sagittal views, corrected for condylar angle, in both open- and closed-mouth positions.30

Coronal or frontal tomography complements the lateral view by providing images at 90° to the first view. While some studies show that TMJ tomography provides additional information not anticipated clinically,31 others show mixed results as to the effect of the findings on the management of the patient.32,33

If an internal derangement is suspected and if patient management depends on confirmation or rejection of this diagnosis, the position and function of the articular disk can be determined by either MRI or arthrography. In most institutions, MRI is the preferred examination because it is noninvasive and can provide information about the disk as well as other soft-tissue and bony structures.

There are other causes besides TMD for pain in the head region. Panoramic radiography may be helpful in the initial evaluation of the maxillary sinus if that structure is thought to be the origin of the facial pain. The floor of the sinus is well visualized, and discontinuity of the bony margins, thickening of the mucous membrane, partial or total opacification of the antrum, and the presence of mucous retention cysts can be noted on the resultant radiograph (Figure 3-16). A full imaging evaluation of the paranasal sinuses usually requires CT although a series of plain films may be made at some institutions.

If a central lesion is suspected of being the cause of the pain, an evaluation of the skull by CT or MRI is in order. The choice of the specific imaging examination depends on the presumptive diagnosis and should be determined in conjunction with the treating clinician and the radiologist.

Disease Entities Affecting Salivary Glands

There are a number of disease entities that can affect the salivary glands: these entities include obstructive, inflammatory,
autoimmune, and neoplastic processes. In addition, swellings or enlargements in the region of the major salivary glands can arise in structures outside the glands, including lymph nodes, cysts, nonsalivary neoplasms, and muscle hypertrophy. Imaging may be of value in differentiating between various diseases and in staging the degree of tissue destruction.

Plain films are frequently helpful when an obstructive disease is suspected, although about 20% of the sialoliths in the submandibular gland and 40% of the sialoliths in the parotid gland are not well calcified and will thus appear radiolucent on radiographs. Occlusal radiography can be used to demonstrate submandibular sialoliths, with a standard topographic or cross-sectional view and with the beam entering under the chin and striking the film at 90° (Figure 3-17). In the posterior region, a more oblique angle may be needed to visualize the stone, projecting it forward onto the film. In general, a reduced exposure time is needed because the stone is less calcified than bone or teeth. Periapical radiography in the buccal vestibule may demonstrate a sialolith in the parotid duct. Various extraoral views may also be needed to visualize a stone, depending on its location.

Sialography, in which a radiopaque contrast medium is instilled into the duct of a salivary gland prior to imaging, permits a thorough evaluation of the ductal system of the major glands. It can demonstrate the branching pattern as well as the number and size of the ducts. Radiolucent sialoliths that are not visible on plain films can be seen as voids in the contrast medium. Sialography is indicated primarily for the evaluation of chronic inflammatory diseases and ductal pathosis, but other imaging techniques are preferred for the investigation of space-occupying masses.

Tumors in the salivary glands or surrounding areas may be investigated by a variety of techniques, including CT, MRI, and US. The selection of specific examinations should be made in consultation with a radiologist. In many institutions, CT is the procedure of choice for evaluating the salivary glands and particularly the extent of a mass since glandular tissue usually can be readily distinguished from surrounding fat and muscle. MRI, however, may better delineate the internal structure of the tumor and demonstrate extension into adjacent tissues. Ultrasonography has typically been used to differentiate solid lesions from cystic lesions in the salivary glands, but recent studies have begun to look more closely at the ultrasonographic features of various salivary tumors in an effort to aid the differential diagnosis by using a noninvasive and relatively inexpensive technique.

For many years, sialography has been considered the “gold standard” for evaluating the salivary component of autoimmune diseases such as Sjögren’s syndrome. The presence of
punctate (< 1 mm) or globular (1 to 2 mm) collections of contrast medium (sialectasis) may be seen throughout the glands, progressing over time into larger pools of extraductal contrast material that may signal more advanced gland destruction.

Recently, there has been increased interest in the use of US to examine the glands in patients with Sjögren’s syndrome, primarily in respect to the degree of homogeneity of the parenchyma. While its diagnostic accuracy is not as high as that of sialography, particularly in the early stages of the disease, US may be useful in those cases in which sialography cannot be done. It has also been suggested that US could be done first, followed by sialography only in those cases that yield abnormal or equivocal ultrasonographic results.

Scintigraphy with Tc 99m pertechnetate can be used to evaluate the function of all of the salivary glands simultaneously. However, there is disagreement over how useful this technique is in determining the cause of xerostomic states. One recent study concluded that scintigraphy was not useful in determining which patients would respond to pilocarpine after radiotherapy-induced salivary dysfunction.

**Jaw Lesions**

The imaging evaluation of jaw lesions may range from a combination of intraoral and panoramic radiography to CT, MRI, US, and/or scintigraphy, depending on the size, location, margins, and behavior of the lesion. For small well-defined lesions occurring in the jaws, standard dental radiography may be adequate to characterize the lesion and permitting the development of a differential diagnosis prior to confirmation by biopsy.

However, if the jaw lesion is large, causes jaw expansion, has indistinct or irregular margins, or appears to be a tumor originating in soft tissues, additional information is usually needed either before or after biopsy, to determine the extent of the lesion and its relationship to adjacent tissues. If the lesion is malignant, evaluation for metastasis is necessary. Although CT is frequently used to examine the lymph nodes of the neck, recent reports have suggested that US can reliably distinguish metastatic nodes from reactive and normal nodes. In some cases, CT and MRI may be of more value in planning the treatment than in making the diagnosis since appropriate treatment is predicated on knowing the full extent of the lesion, including any invasion of adjacent structures (Figure 3-18).

**BENEFITS AND RISKS**

In determining whether to order a particular type of imaging, the clinician first must decide what information is needed and whether diagnostic imaging can provide it. If the answer is yes, the next step is to determine the best imaging technique for the situation. It is possible that several techniques could provide the desired data. For example, an expansile lesion in the mandible may be viewed with panoramic radiography, perhaps supplemented with an occlusal view. However, it could also be visualized with plain-film radiography (at various...
angles), CT, MRI, or a combination of techniques. How much information is necessary? If a lesion is contained and well defined, panoramic radiography alone may be adequate. However, if a lesion is large and poorly defined, the information on lesion extension and effects on adjacent structures may be critical to the management of the patient, and CT may be almost mandatory. On the other hand, if the results of the CT or MRI studies will not affect the diagnosis or management of the case, the procedure could be considered superfluous and a waste of time, money, and radiation risk.

All imaging techniques, with the exception of US and perhaps MRI, carry some type of radiobiologic risk. Current practice is to convert the absorbed dose from the radiation to an effective dose, which is a quantity weighted for radiation type and dose and for radiosensitivity of the tissues. This practice allows expression of a dose to a limited portion of the body equivalent, in terms of detriment, to a smaller dose to the entire body, thus allowing comparison between radiographic techniques. Reported average effective doses for several imaging examinations of the head and neck, along with days of equivalent natural exposure, are listed in Table 3-1.

The cost of imaging procedures varies significantly. Intraoral and panoramic radiography is the least expensive; an examination typically costs less than $75.00 (US). Plain films of the skull may be obtained for about $135.00 (US) each in a hospital radiology facility. A typical ultrasound examination of the neck costs about $250.00 (US). CT scans of the maxillofacial region are in the range of $850.00 to $1,000.00 (US) and cost more if there is three-dimensional reconstruction of the image whereas MRI scans usually cost more than $1,200.00 (US). (All stated fees are based on the fees at a Midwestern teaching hospital in the year 2000.) The majority of advanced imaging procedures will be billed to medical insurance rather than to dental insurance. The regulations of the patient’s health care insurer must be followed if payment is not to be denied. For example, in a health maintenance organization (HMO), CT or MRI may need to be ordered by the patient’s primary care physician for payment to be authorized.

A prudent principle to follow when ordering an imaging study is to select the technique that has the lowest cost and radiation dose but that is still capable of providing the needed information. Consultation with an oral and maxillofacial radiologist can help the clinician select the best study for the particular situation.

### REFERENCES


