K. J. Lee: Essential Otolaryngology and Head and Neck Surgery (IIIrd Ed)

Chapter 24: Head and Neck Radiology

Radiographic Examination of the Temporal Bone

Radiographic examination of the temporal bone consists of standard projections (Law's, Schüller's, Mayer's, Owen's, Chausse's III, Stenvers', submentovertical and Towne's), tomography, and polytomography (hypocycloidal or multidirectional), and special studies (carotid arteriography, retrograde jugular venogram, posterior fossa myelography, combined polytome and posterior fossa myelography) and, more recently, computerized tomography.

Standard Projections (Fig. 24-1, a and b)

Law's View

Law's view is a lateral view of the mastoid obtained with the sagittal plane of the skull parallel to the film and with a 15° cephalocaudal angulation of the x-ray beam. The external and internal auditory canals are superimposed. An excellent view of the cellular development and disease of the mastoid portion of the temporal bone is obtained. It also shows the tegment, the anterior wall of the lateral sinus, the external auditory canal, the temporomandibular joint, and the pneumatization of the anterior part of the squamous portion of the temporal bone. This view does not show the key area of the attic, aditus, and antrum (Fig. 24-2).

Schüller's View

Schüller's view (Runstrom) is a lateral view of the mastoid obtained with the sagittal plane of the skull parallel to the film and with a 30° cephalocaudal angulation of the x-ray beam.

This view is quite similar to the Law's view except that the x-ray tube is angled caudally 30° instead of 15°. Thus it displaces the arcuate eminence of the petrous bone downward and shows the antrum and the upper part of the attic.

It also gives an excellent view of the extent of the pneumatization of the mastoid, the distribution and the degree of aeration of the air cells, the status of the trabecular pattern, and the position of the vertical portion of the lateral sinus.

Mayer's View

Mayer's view is obtained with the head of the patient rotated 45° toward the side under examination and the tube adjusted so that the central ray passes through the external auditory meatus nearest the film at an angle of 45° toward the feet.

This gives an axial view of the petrous bone and the mastoid cells. The mastoid antrum, the external auditory meatus and the upper part of the tympanic cavity are well shown. The obliquity of the Mayer's position, although necessary to free the key area from the shadow of the labyrinth, produces a distortion that may confuse the surgeon.

Owen's View

Owen's view resembles the Mayer's view but offers the advantages of less distortion. The patient's head is first positioned as for a Schüller's projection and it is then rotated with the face away from the film at an angle of approximately 30°. The x-ray beam is directed cephalocaudal with an angle of 35°.

This view gives a "surgeon's eye view" of the key area of the attic, aditus and anterum. It usually shows the malleus and the incus (a portion of it) in the natural position within the tympanic cavity.

Chausse's III View

Chausse's III view is obtained by positioning the occiput on the film, the head is rotated approximately 10-15° toward the side opposite to the one under examination and the chin flexed on the chest. There is no angulation of x-ray beam.

This view provides visualization of the attic, aditus, mastoid antrum, and especially the anterior two-thirds of the lateral wall of the attic. In contrast, the Owen's view shows the posterior or aditus portion of the attic.

Transorbital View

Transorbital view is obtained with the patient's occiput to the film to magnify the orbit. The chin is slightly flexed until the orbitomeatal line is perpendicular to the film.

In this view, the petrous pyramid, especially the internal auditory canal, is clearly visualized through the radiolucency of the orbit. It also shows the cochlea, vestibule, and semicircular canals (Fig. 24-3).

Stenvers' View

Stenvers' view is obtained with the patient facing the film with the head slightly flexed and rotated 45° toward the side opposite to the side under examination. The x-ray beam is angulated 14° caudad. The long axis of the petrous pyramid becomes parallel to the plane of the film and the entire pyramid is well visualized, including its apex.

This view clearly shows the entire pyramid, arcuate eminence, internal auditory canal, porus acusticus, horizontal and vertical semicircular canal, vestibule, cochlea, mastoid antrum, and mastoid tip. The internal auditory canal may appear foreshortened because of rotation (Fig. 24-4).

Heavy exposure will bring out details of the petrous apex, while a lighter exposure will permit visualization of details of the mastoid structure.

Submentovertical View

Submentovertical (axial, basal) view taken from "under the chin" has the advantage of showing both temporal bones on the same film so that comparison of both sides can be made.

This view shows the external auditory canal, the eustachian tube, the middle ear with the incus and the head of the malleus, the mastoid air cells, the styloid process, the internal auditory canal, and petrous apex. It also shows such structures of the base of the skull as foramen ovale, foramen spinosum, and jugular foramen (Fig. 24-5). This view has the disadvantage of loss of clarity and detail of the ear structures because of increased antrum-to-film distance.

Towne's View

Towne's view is the anteroposterior projection with 30° tilt (from "above and in front"). As in the submentovertical view, the view allows comparison of both petrous pyramids and mastoids on the same film. The petrous apex, internal autidory canals, arcuate eminence, mastoid antruma, and mastoid process can be clearly identified. This is useful for evaluation of apical petrositis, acoustic neuroma, and cerebellopontine angle tumor (Fig. 24-6).

Tomography and Polytomography

The use of special projections with various angulations of x-ray beam or of the patient's head, which are indispensible in conventional radiography to visualize certain structures, is not required in tomography. It has the following advantages: the positioning is simple and the projection easily reproducible; the ear structures can be visualized under the same angle of surgical approach; it can follow the same plane as used in the histologic section; and the cut of certain structures can be made at a right angle to the axis.

Of the five tomographic projections, two of them, frontal and lateral, are basic; the other three (axial, horizontal, and Stenvers') are complementary according to the area of pathology and examination desired. Tomography is a technique which allows visualization of a desired structure while obscuring those structures in front of and behind it. With the Philips-Massiot polytome which furnishes a sufficiently thin cut and a high coefficient of distinction, it is possible to visualize clearly the small structures of the ear. The tomographic examination of the temporal bone consists of multiple sections obtaine 1 or 2 mm apart. In all projections both sides are examined so that the corresponding structures may be compared.

This type of multidirectional or hypocycloidal tomography is excellent for the study of: (1) congenital malformations, (2) inflammatory processes (cholesteatoma) Fig. 24-7, (3) traumatic effects (transverse and horizontal fractures, ossicular fractures, and/or dislocation), (4) neoplasm (glomus tumor, acoustic neuroma, and carcinoma (Fig. 24-8), and (5) otodystrophy (otosclerosis, Paget's disease, osteogenesis imperfecta, and fibrous dysplasia).

Carotid Arteriography

This is useful in vascular anomalies of the temporal bone (glomus tumor, aneurysm, etc). They may show soft tissue displacement of may show a tumor stain.

Retrograde Jugular Venogram

The jugular vein is catheterized and dye injected retrograde under pressure, filling the jugular vein and its tributaries. This is extremely useful in evaluation of collateral flow before ligation of the jugular vein, and for evaluation of the jugular bulb in anomalies and glomus tumors.

Posterior Fossa Myelography (Cisternogram)

Two to three millimeters of Pantopaque (iophendylate) are injected in the subarachnoid space by lumbar puncture. Under fluoroscopic control the contrast media is then moved into the posterior cranial fossa in Trendelenburg's position. This material outlines structures in the posterior fossa and is probably the most conclusive diagnostic test for acoustic neuroma. The absence of filling of the internal auditory canal and the demonstration of a filling defect in the cerebellopontine cistern are positive evidence of a space-occupying lesion.

Posterior fossa myelography is indicated: (1) when the audiometric, vestibular, and tomographic studies are indicative of a retrocochlear lesion, (2) when the audiometric and vestibular tests are suggestive of a retrocochlear lesion, and a tomographic study is positive, and (3) whenever the audiometric and vestibular tests consistently indicate a retrocochlear lesion in spite of a negative tomographic study to rule out the presence of a tumor limited to the cistern, or a tumor that is too small to produce changes in the bony outline of the internal auditory canal.

Combination Technique

A combination of the polytomography and posterior fossa myelography is useful in the diagnosis of a small tumor within the internal auditory canal.

Computerized Tomography

(See section Computerized Tomography).

Radiography of the Paranasal Sinuses

Radiographic examination of the paranasal sinuses consists of four standard projections (Waters', lateral, submentovertical, and Caldwell's), tomography, contrast radiography, and angiography.

Standard Projections

Waters View (Occipitomental, "Chin-Nose" Position

This posteroanterior occipitomental projection is taklen with the patient's head tilted upward so that his nose and chin are against the film surface. The petrous portion of the temporal bone is projected below the level of the maxillary sinus.

The maxillary sinuses are best shown in this view, followed by the frontal sinuses. The ethmoid sinuses are not well shown. A good view of the sphenois sinus and its septum is obtained through the open mouth (Fig. 24-10).

This view also shows such maxillofacial structures as nasal bones, frontal process of the maxilla, zygoma and its arch, and mandible (especially the coronoid process).

Other structures to be recognized include the oblique orbital line, the rim and floor of the orbit, superior orbital fissure (cranial nerves III, IV, V1, VI, ophthalmic vein), foramen rotundum (V2 - maxillary nerve), foramen ovale (V3 - mandibular nerve), zygomaticofacial foramen, infraorbital foramen, nasal ala, and upper lip.

Lateral View

In this view the sphenoid sinuses are shown to best advantage followed by the frontal, ethmoidal, and maxillary sinuses in that order (Fig. 24-11).

It also shows such maxillofacial structures as nasal bones, frontal sinus walls, the zygomatic process of the maxilla, the posterior wall of the maxillary sinus, the pterygoid plates, and the mandible. Other structures to be recognized in this view include anterior walls of the middle cranial fossa, the roof of the sphenoid sinus, the cribriform plate, the inferior turbinate, the coronoid process of the mandible, the zygomatic recesss, the pterygomaxillary fissue, caroticoclinoid foramen, carotid sulcus and soft tissues (tonsils, adenoids, earlobe, soft palate, and base of tongue).

Submentovertical View (Basal or Base View)

This view is obtained by passing x-rays at right angles through the base of the skull with the orbitomeatal line perpendicular to the central ray. In this view the sphenoid sinuses are shown to best advantage, followed by the posterior ethmoidal, maxillary, and frontal sinuses in that order (Fig. 24-12).

It shows such maxillofacial structures as the zygomatic arch, the body of the zygoma, and the mandible (especially condyle).

Other structures to be recognized include pneumatization of the pterygoid process and the greater wing of the sphenoid; the lateral three lines (1) orbital line - a straight line formed by the lateral wall of the orbit, (2) antral line - an S-shaped line formed by the lateral wall of the antrum, and (3) middle cranial fossa line - a C-shaped curve with concavity backward formed by the anterior wall of the middle cranial fossa; the pterygoid plate and pterygoalar bar; nasal cavity; the lacrimal canal; incisive foramen; greater and lesser palatine foramina; inferior orbital fissure; choana; foramen ovale (V3 - mandibular nerve); foramen spinosum (middle meningeal artery); foramen lacerum; carotid canals; eustachian tube; internal and external auditory canals and jugular foramen; and soft tissues (nasal turbinates, adenoids, uvula, lateral wall of the nasopharynx, and membranous external auditory canal).

Caldwell View ("Forehead-Nose" Position)

This is obtained by positioning the nose and forehead against the cassette with the external auditory meatus and outer canthus of the eye forming a line perpendicular to the cassette. The x-ray tube is tilted caudally 15-20°.

In this view the frontal sinuses are best shown. The ethmoidal sinuses, particularly the orbital margin (lamina papyracea) are also well shown. The main cavity and lateral extensions of the sphenoid sinuses are recognizable. The posteromedial and inferolateral portion of the maxillary sinuses are usually visible (Fig. 24-13).

It shows such maxillofacial structures as the orbital margins, the zygoma, the zygomaticofrontal suture, the maxilla and the mandible.

Other structures to be recognized include the nasal cavity and its contents, floor and rim of the orbit, the infraorbital canal, the superior orbital fissure, the supraorbital foramen, Hyrtl's foramen (ophthalmomeningeal vein), lambdoidal suture, the foramen rotundum (always inferolateral to th lowermost portion of the superior orbital fissure) and soft tissues (palebral fissure and "pony-tail" hair style).

Tomography

Tomography is of great value in determining the presence or absence of fractures or bone destruction in the paranasal sinuses and nasal structures, particularly in the planning of surgical or radiotherapeutic procedure. It is essential in the preoperative study of the diseases of the posterior ethmoid and sphenoid sinuses, and transsphenoidal hypophysectomy.

Multidirectional tomography (polytomography) is significantly superior to linear tomography.

Contrast Radiography

Radiopaque contrast media is used to outline anatomic or pathologic abnormalities within the paranasal sinuses, nasal cavity, and nasopharynx, such as cysts, polyps, neoplasms, oroantral fistula, and choanal atresia.

Carotid Arteriography

This may help delineate both benign and malignant lesions of the sinuses. In malignant lesions, soft tissue displacement, abnormal vascular pattern, or a tumor stain may be shown. It is particularly useful for evaluation of angiofibromas of the nasopharynx. By the use of subtraction techniques, excellent visualization of occult extensions of the tumor with its vascular connections may be obtained.

Selective arteriography is extremely useful in the investigation and management of persistent and uncontrollable epistaxis prior to any surgical intervention.

Table 24-1 lists the foramina found at the base of skull, their contents, and the radiologic view in which they are best visualized.

Table 24-1. Foramina in the Base of Skull

Anterior Cranial Fossa

Foramen caecum --> Emissary vein from nose to superior sagittal sinus ==

Anterior ethmoidal foramen --> 1. Anterior ethmoidal vessels
2. Nasociliary nerve
--> Lateral

Foramina in cribriform plate --> Olfactory nerves ==

Posterior ethmoidal foramen --> Posterior ethmoidal vessels/nerves
--> Lateral

Middle Cranial Fossa

Superior orbital fissure --> 1. Ophthalmic vein
2. Orbital branch of middle meningeal artery
3. Oculomotor nerve (III)
4. Trochlear nerve (IV)
5. Ophthalmic division of trigeminal (V1)
6. Abducens nerve (VI)
7. Recurrent branch of lacrimal artery
--> 1. Caldwell's
2. Waters'

Optic foramen --> 1. Optic nerve
2. Ophthalmic artery
--> Oblique orbital (Rhese)

Foramen rotundum --> Maxillary division of trigeminal (V2)
--> 1. Caldwell's
2. Waters'

Foramen ovale --> 1. Mandibular division of trigeminal (V3)
--> 1. Base
2. Waters'

Foramen lacerum (carotid canal) --> 1. Internal carotid artery

2. Sympathetic carotid plexus
3. Superficial petrosal nerve
4. Vidian nerve
5. Meningeal branch of ascending pharyngeal artery

--> Base

Foramen spinosum --> 1. Middle meningeal artery
2. Recurrent branch of mandibular nerve
--> Base

Posterior cranial fossa

Internal auditory canal --> 1. Facial nerve (VII)
2. Auditory nerve (VIII)
3. Internal auditory vessels
--> 1. Stenvers'
2. Transorbital
3. Towne's
4. Base

Jugular foramen --> 1. Internal jugular vein
2. Inferior petrosal sinus
3. Transverse sinus
4. Meningeal branch from occipital and ascending pharyngeal arteries
5. Glossopharyngeal nerve (IX)
6. Vagus nerve (X)
7. Spinal accessory nerve (XI)
--> 1. Base
2. Towne's

Stylomastoid foramen --> 1. Facial nerve (VII)
2. Stylomastoid artery
--> Base

Hypoglossal canal --> 1. Hypoglossal nerve (XII)
2. Meningeal branch of ascending pharyngeal artery
3. Emissary vein from transverse sinus
--> 1. Stenvers'
2. Towne's

Foramen magnum --> 1. Medulla oblongata and spinal cord
2. Spinal accessory nerve (XI)
3. Vertebral arteries
4. Anterior and posterior spinal arteries
5. Membrana tectoria
6. Apical ligament

--> 1. Base
2. Towne's.

Radiography of the Larynx

Radiographic examination of the larynx consists of conventional projections (anteroposterior and lateral), tomography, positive laryngography, air-contrast laryngography, and cinefluorography.

Conventional Radiography

The anteroposterior (AP) and lateral views are commonly used.

Anteroposterior View

The AP view is of limited value in evaluation of the larynx itself because of the superimposition of the cervical spine. However, masses of the neck lateral to the larynx and distortion and/or displacement of the upper airway are shown.

Lateral View

The lateral view is of greater value and shows the outline of the base of the tongue and epiglottis, the vallecula, the hyoid, the aryepiglottic folds and arytenoids, the ventricles, the thyroid and cricoid cartilages, the subglottic space, and the prevertebral soft tissues (Fig. 24-14). This view is useful for evaluatiuon of tumors and fractures of the larynx, a foreign body in the larynx, hypopharynx, and upper esophagus, detection of calcification of normal and abnormal tissues, and evaluation of acute inflammatory conditions such as acute epiglottitis and retropharyngeal abscess. It also is useful for both pre- and postoperative evaluation of a thyrotomy and tracheotomy. The accuracy of the stent or mould placement for fractured larynx is also determined in this view.

Differential diagnosis of foreign body in the larynx, hypopharynx, and upper esophagus include:

1. Sialolith
2. Tracheal rings
3. Semiopaque ear rings
4. Osteophytes of the cervical spine
5. Calcareous streaks in scar tissues
6. Ossified centers of the hyoid bone
7. Calcified cervical nodes

8. Redisual dye from arteriography

9. Calcification in the laryngeal cartilages

10. Accessory ossification centers in the cervical spine

11. Calcified stylohyoid ligaments

12. Sesamoid laryngeal cartilages

13. Calcification in the vessels of the neck.

Tomography

Tomography is usually performed in the AP position and demonstrates laryngeal structures extending from the false cords to the upper trachea. The disadvantages of this technique are the amount of time consumed, difficulty of prevention of patients' movement between or during exposures, and radiation exposure to the patient. The most useful information provided from this study is obliteration of the laryngeal ventricles or subglottic extension of neoplasms.

Positive Contrast Laryngography (Fig. 24-15)

Instillation of contrast media under fluoroscopic guidance provides a means of studying and recording on film or videotape the physiologic and pathologic processes. This diagnostic study is particularly useful in the selection of patients for conservation surgery of the larynx since it helps to outline the extent of the tumor and identify areas of involvement that cannot be directly or indirectly inspected.

Under topical anesthesia the tip of the catheter is positioned in the pharynx just above the tip of the epiglottis. The contrast media (Dionosil) is instilled slowly as the patient inspires, phates, expires, and executes the Valsalva maneuver. Two major drawbacks are: need for a topical anesthetic and the amount of time required for this study.

Powdered tantalum has been used as a medium for laryngography. Several features of powdered tantalum must be recognized: (1) is potentially explosive, (2) particle size is not uniform, and (3) prolonged retention has been demonstrated in animal studies.

Air Contrast Laryngography

Laryngography using high kilovoltage and heavy filtration provides information similar to positive contrast studies in the evaluation of laryngeal tumors. It is useful in the examination of patients with neoplasms who are unable to tolerate a positive contrast study.

Xeroradiography

This technique, which is well accepted in mammography for its remarkable ability to record differences in soft tissue density, provides excellent images of soft tissues of the neck with great contrast in the lateral projection.

Xeroradiography may be combined with zonography using the polytome machine - xeroradiographic zonography. It gives an excellent tomographic view of soft tissues of the larynx and hypopharynx in the frontal projection.

Roentgen exposures of approximately four times that of conventional soft tissue x-ray views are required for this method. Xeroradiography permits excellent imaging of mucosal surfaces, calcifications, and cartilages. It may obviate the need for repeated endoscopy, particularly in children with subglottic and tracheal stenoses, making this a major area of application.

Radiography of the Tracheobronchial Tree

Conventional chest films and tomograms provide considerable information concerning the tracheobronchial tree. However, bronchography is far more fruitful. It offers valuable information concerning not only congenital, inflammatory, and neoplastic lesions of the bronchi but provides information in certain parenchymal diseases such as alveolar lymphoma, alveolar cell carcinoma, and organized or unresolved pneumonia.

Methods of Bronchography

In those patients in whom the studies of all bronchial segments ("lung mapping") is desired, after suitable topical anesthesia, a soft rubber catheter is passed through the nose or the mouth into the trachea. When selective bronchography or brush biopsy of a lesion is desired, a trancricoid approach is used. The latter method is faster and less annoying to the patient. It requires a smaller amount of topical anesthetic and has the advantage of permitting selective studies of individual bronchi and allowing for brush biopsy. Dionosil (oily or aqueous) is the contrast media of choice. Aqueous media is slightly more irritating to the bronchial mucosa and requires a greater amount of topical anesthetic. Recently, the use of barium sulfate and powdered tantalum for bronchography has been suggested. Both have the advantage of being chemically inert.

Radiography of the Esophagus

Radiographic examination of the esophagus usually is achieved by barium swallow, using both thick (better coating of the mucosa) and thin barium mixtures.

Fluoroscopy and spot films are often sufficient to fulfill the diagnostic needs. However, cineradiography improves the functional and anatomic evaluation especially in the study of pathophysiology of swallowing.

A small cotton pedget soaked in barium and swallowed may catch or hold on a foreign body. Capsules of various sizes filled with barium and swallowed may demonstrate a stricture and its severity. A water-soluble contrast is used when an esophageal perforation is suspected.

The examination is conducted in both upright and recumber positions, using posterior, anterior, lateral, and oblique views. Inspiration, expiration, and the Valsalva maneuver also are used to note the esophageal position and intrathoracic dynamics.

Miscellaneous

Sialogram

Injection of radiopaque material into the salivary glands via the duct orifice will demonstrate abnormalities of the ductal system such as stricture, fistula, ectasia, or neoplasm and abnormalities within the ductal system such as radiolucent calculi.

To perform sialography the duct orifices of the parotid (Stensen's) and/or submandibular (Wharton's) first must be topically anesthetized and dilated to permit a no. 60 PE catheter. Pantopaque is slowly injected into the catheter until the patient complains of discomfort in the gland. It is important to fill the duct to the patient's tolerance rather than to a predetermined volume. Usually, about 1 mL will produce a satisfactory filling. After the x-ray examination the patient is instructed to chew on a fresh lemon for 1 minute. The normal gland will expel the contrast material within 5 minutes in response to this potent salivary stimulus.

The radiographs are taken with the patient seated in the PA, tangential, and lateral projections. These same views are repeated following injection of contrast, and again following emptying of the glands.

Sialography is helpful in determining if a lesion is inflammatory or neoplastic, whether it is an encapsulated or invasive lesion. The location of calculi in the duct or gland may be ascertained. Sialography is contraindicated in the presence of acute inflammatory disorders and when a history of sensitivity to iodine exists.

Plain films are made routinely to determine the adequacy of exposure and to detect radiopaque abnormalities in or around the salivary glands such as foreign bodies, calculi or calcifying disorders, and to determine if abnormalities or adjacent osseous structures exist.

Radiosialography (Salivary Gland Scanning)

A salivary gland scan utilizes the same instrumentation and basic scintiscan techniques employed for thyroid scanning with technetium 99m pertechnetate. This is a newer diagnostic technique and not yet widely adopted. Radiosialography is useful in the following situations:

1. Diagnosing a Warthin's tumor.

2. Searching for occult primary tumors in cases of cervical metastases.

3. Confirming the presence and extent of neoplasm.

4. Occasionally, to distinguish between benign and malignant disease.

Tympanogram (Tympanic Clearance Study)

This is a method for studying eustachian tube function using radiopaque material in the middle ear.

Eaustachian tube function can be determined by introducing not more than 1 mL of radiopaque material such as Pantopaque into the tympanic cavity through an intact or perforated tympanic membrane. A film is taken immediately in the Stenvers' position. After 10 minutes a second film taken in the same position will fail to show contrast material in the tympanic cavity if the eustachian tube function is normal. Retention of the dye indicates tubal disease.

Nasopharyngogram (Contrast Nasopharyngography)

Examination consists of submentovertical and lateral projections. The submentovertical view demonstrates the lateral walls of the nasopharynx while the lateral projection demonstrates the roof and posteriro walls of the nasopharynx as well as the nasopharyngeal surface of the soft palate. If tumor growth is suspected to involve the eustachian tube, additional films are taken during a modified Valsalva maneuver. This study is useful for precise location and extension of tumors of the nasopharynx and adjacent structures. Premedication is not necessary. The patient is placed in a supine position with shoulders and trunk elevated to permit maximal extension of the neck, thus assuring a satisfactory submentovertical view of the base of the skull. The nostrils are sprayed with local anesthetic; contrast medium, 15-20 mL for adults, is then used.

Evaluation of Facial Bone Injuries

For the evaluation of the nasal bones, the right and left lateral, the superoinferior axial occlusal, and the Waters' views are usually taken. Lateral views reveal depression or elevation of nasal bone fragments, whereas superoinferior axial views show medial or lateral displacements of nasal fractures. The Waters' view also will show fracture and displacement of each nasal bone and the frontal process of the maxilla.

A facial bone series should include, in addition to the four standard sinus projections, an underexposed submentovertical view of the zygomatic arches, and the exaggerated Waters' view to demonstrate fracture of the infraorbital rim and fracture-dislocation of the zygoma and zygomatic arch.

Pantomography (Panoramic Radiography)

A Panorex dental x-ray machine provides a panoramic view of the entire mandible and the anterolateral aspects of both maxillary sinuses. The x-ray beam has an aluminium filter and a narrow slit-beam which moves horizontally from right to left (or vice versa) producing successive images on the film which in turn moves at a synchronized speed. The film is 12 in long and requires approximately 24 seconds for total exposure. It is useful for evaluation of pathologic conditions of the mandible and maxilla particularly for pre- and postoperative evaluation of mandibular fractures and tumors.

Orbitogram (Orbitography)

This may be used for diagnosis of a blowout fracture of the orbit. Five to ten milliliters of water-soluble contrast media (Hypaque) are injected into the extraconal space along the floor of the orbit in conjunction with hyaluronidase (Wydase). Typical orbitographic appearance of blowout fractures include demonstration of fluid level of contrast medium in the maxillary sinus, herniation of the orbital contents through the orbital floor, and depressed bony fragments. Complications from this procedure include perforation of the eyeball, retrobulbar hemorrhage, central retinal artery spasm, drug idiosyncrasy, transient or permanent loss of vision, and excessive swelling of eyelid. This procedure is not recommended for evaluation of blowout fracture. The conventional Waters' view and laminogram are sufficient for diagnosis of blowout fractures.

Xerosialography

Sialography using xeroradiography is a superior method of examining the salivary glands, and affords better details, especially in ducts overlying bone, than does film recording.

Advanced Radiology in Otolaryngology

Diagnostic Ultrasound

Diagnostic ultrasound has application to otolaryngology in the evaluation of lesions of the orbit and neck.

Sound waves can be recorded as they are reflected back (echoed) from surfaces they encounter. Diagnostic ultrasound employs high-frequency sound waves in a similar manner to sonar, the military technology to which ultrasound owes its origins.

Low-energy sound waves with frequencies between 2.5-10 million Hertz (MHz) are introduced into cervical structures by a hand-held transducer that can be moved over the skin by the examiner. Unimpeded sound transmission is ensured by coating the skin with a coupling agent such as vegetable oil. As sound waves pass through the skin and underlying tissues, they encounter interfaces with different impedance characteristics between tissues and organ structures. At any interface, these sound waves may be reflected, refracted, or transmitted; those sound waves that are reflected back to the transducer, which serves the dial purpose of sound generator and receiver of returning echoes, are converted into electric impulses that can be displayed on an oscilloscope screen as a spike (A mode scan) or a dot (B mode scan).

As A mode scan echoes are represented as deflections arising from a baseline on the oscilloscope screen, the distance of any given spike or deflection from the left end of the base line varies with the actual distance from the patient's skin to the echo-reflecting surface. These distances may be measured against a scale of known magnitude.

Orbital and Sinus Ultrasound

This can now accurately detect, delineate, and differentiate many secondary orbital massess and infiltrates, including mucocele, infection or abscess, or tumor, originating in the surrounding paranasal sinuses. Primary intraorabital disease also can be identified. An A mode ultrasound is a simple, useful diagnostic tool in the evolution of maxillary sinus diseases. It can distinguish fluid from solid masses within the antrum.

Cervical Ultrasound

This already has been extensively used in the assessment of thyroid disease, but it can well be applied to a variety of other cervical lesions, beyond the thyroid gland.

Cystic structures, such as branchial cleft and the thyroglossal duct cysts, appear as sharply defined structures containing virtually no echoes within the circumference. These phenomena are related to the discrete walls cysts tend to have, and to the absence of echogenic tissue interfaces within the confines of these walls. Solid masses, on the other hand, such as salivary gland tumors, are not well defined and their central portions contain many echoes. They are not so well defined because their acoustic properties are not much different from those of the surrounding tissue structures. They contain many echoes because the multiple tissue interfaces within them easily reflect sound waves.

With the use of ultrasonography, it is now possible to recognize disruption of the normal integrity of the thyroid alae by infection, fracture, or tumor.

Nuclear Medicine

Nuclear medicine, aside from its essential therapeutic applications, provides a relatively noninvasive form of nonroentgenographic diagnostic imaging. Nuclear medicine utilizes a variety of radioactive drugs that become localized in specific organs to produce diagnostic images. Images are recorded on cameras or scanners sensitive to the gamma ray emissions of radioactive pharmaceuticals. These pharmaceuticals are chosen for their physicochemical propensity to accumulate in specific organs, organ systems, or pathologic tissues; thus, the anatomic distribution of a physiologic process can be recorded.

Thyroid Scanning

Thyroid scanning is one of the most well-established and best-known imaging procedures of nuclear medicine.

The normally functioning thyroid gland traps and organizes iodine, and the rate of accumulation and pattern of distribution within the gland are useful indicators of thyroid disease. Twenty-four hours after an oral or intravenous dose of approximately 50 microCi of iodine 131, images of the gland are obtained and these images are correlated with physical examination of the neck.

Recently, technetium 99m pertechnetate ion has been used in place of 131I. This radionuclide has a 6-hour half-life and emits pure gamma rays, affording a substantial reduction in thyroid irradiation when compared with radioiodine.

Palpable nodules may be identified as "hot" (functioning) or "cold" (nonfunctioning). A neck mass may be shown to be related to or remove from the thyroid gland. The presence of ectopic thyroid tissue, as in lingual thyroid or thyroglossal duct cyst, may be assessed. When ectopic thyroid tissue is demonstrated, the presence or absence of functioning thyroid in the normallocation is of significance if surgical removal of the ectopic thyroid can be considered.

Radiotherapy treatment in childhood is an important cause of thyroid cancer. The patients who received radiation to the neck in childhood for the treatment of thymus and other conditions should undergo periodic thyroid scanning, even when the thyroid is normal to palpation, to detect the early development of thyroid cancer.

In the 1930-1950 era, radium irradiation of the nasopharynx was used to control hyperplastic adenoids. Because of the technical characteristics of this applicator, sufficient radiation was not applied to the thyroid by this technique to stimulate the development of thyroid malignancies. No malignancies have been reported thus far as a result of this treatment.

Salivary Gland Scanning

A salivary gland scan utilizes the same instrumentation and basic scintiscan techniques employed for thyroid scanning with technetium 99m pertechnetate. This radionuclide is physiologically trapped by the thyroid and concentrated in the salivary glands and excreted in the saliva.

The parotid and submandibular glands show prompt and symmetric accumulation with an intensity approximating that of the thyroid gland. After 20 minutes the patient is given a sour candy or lemon drops and the images show a washout of activity from the glands and indicate patency of the ducts.

Salivary gland dysfunction is demonstrated by focal or generalized delay in accumulation of activity. Xerostomia, caused by Sjögren's syndrome or Frey's syndrome, produces a delay or a reduction or even absence, of a concentration within the salivary glands. Focal lesions, as in sialadenitis, salivary gland tumors, abscesses, and duct obstruction due to calculus, also may be identified.

Mixed salivary gland tumors may show a normal pertechnetate concentration or reduced function, depending on the mixture of cell types and the integrity of the duct system. Warthin's tumors, however, are generally hyperfunctioning on the scan, and this may make possible an appropriate differential diagnosis of a mass lesion.

Bone Scanning

Polyphosphates, pyrophosphates, and diphosphonates labeled with 99mTc ("technetium phosphates") are avid bone localizers.

Technetium phosphate localization in bone is related to the metabolic activity of the bone. The uptake of the radioactive tracer demonstrates the rate of osteoblastic activity, the presence of collagen or immature osteoid, and the integrity of the blood flow to the region. Local increases in uptake may occur in response to bone stress, in the reparative process in the presence of trauma or inflammation, or in reaction to osteolytic or osteoblastic tumor deposits.

Bone scanning is useful in detection of:

1. Traumatic conditions.

2. Inflammatory conditions.

3. Neoplasm.

4. Temporomandibular arthritis (a focal hot spot at TMJ indicates articular disease).

Brain Scanning

Technetium 99m pertechnetate is used.

Rapid sequential images taken over the head in the anterior, posterior, or vertex projection show the first transit of the bolus through the carotid arteries and into the hemispheres. The region of the circle of Willis and the middle cerebral and anterior cerebral artery distributions are visualized. Local areas of hypervascularity or ischemia may be defined. Immediate blood pool images in the first 3 minutes show areas of hypermia within the brain or calvarium.

Delayed brain scan images viewed approximately 2 hours following injection of the radiopharmaceutical show abnormal accumulation of radioactivity in intracranial lesions.

The normal blood-brain barrier prevents the diffusion of pertechnetate ion into normal brain substance, but in the presence of tumor, infarct, abscess, contusion, or hematoma, the affected tissues with increased capillary permeability permit "staining" of the lesion by the radioactive tracer. On the basis of the location, configuration, and appearance of the lesion in the flow, blood pool, and delayed brain images, a differential diagnosis may be made with reasonable accuracy.

Brain scanning is useful in:

1. Primary brain tumors (tumor as a "hot" area surrounded by the normal "cold" brain tissues). Acoustic neuromas show an avid uptake of pertechnetate, but despite this favorable property, these tumors frequently are not detected on the brain scan if they are small at the time of examination.

2. Meningioma.

3. Arteriovenous malformation.

4. Brain abscesses.

Tumor and Infection Seeking Radionuclides

Gallium 67 citrate has an avidity for certain neoplasms and pyogenic infections. The exact mechanism is unclear, but the radiopharmaceutical appears to be concentrated in the lysosomes of macrophages and reticuloendothelial cells. Thus, there is nonspecificity of uptake in both tumors and infections. Other agents such as bleomycin lebeled with indium III have been used for tumor localization, and in vivo labeled leukocytes have been used for inflammation scanning.

Although gallium does not localize equally well in all types of neoplasm, it is particularly well suited to the staging of a lymphoma detected in the cervical nodes or nasopharynx. The gallium scan is most useful in areas not accessible to conventional lymphangiography. The accuracy below the diaphragm is less than that in the chest and axilla, partly because bowel accumulation of gallium may confuse the image.

Computerized Tomography

Computerized tomography (CT), also called computerized axial tomography (CAT) is a major advance in diagnostic radiology. Since its introduction and clinical application in 1973 computed tomography (CT) has made enormous contributions in the areas of diagnostic medicine, treatment planning, and follow-up.

Clinical Application

CT scanning may be of value in any clinical situation in which tomography and/or contrast examinations may prove useful.

CT scanning has been found to be of considerable clinical value for the evaluation of anatomic and pathologic conditions (trauma, benign and malignant tumors, congenital anomalies, inflammatory diseases, etc) of such structures of head and neck as:

1. Temporal bone.

2. Paranasal sinuses.

3. Orbit.

4. Nasopharynx, oropharynx, parapharyngeal space, and floor of mouth.

5. Larynx and hypopharynx.

6. Salivary glands.

Accurate, highly detailed, cross-sectional images of the internal auditory canal, vestibule, cochlea, vestibular aqueduct, semicircular canals, ossicles, and middle ear space are not attainable because of recent advances in CT technology and image quality. Zoom reconstruction and the ability to scan 1.5 mm thins sections are examples of these advances. Zoom reconstruction allows high-resolution, magnified-image reconstruction of selected regions of interest without the need for additional radiation exposure or scan time for the subject.

Acoustic Neuroma

At present, a major application of CT scanning is its role as the initial radiologic study in the investigation of acoustic neuroma, meningioma, and other lesions in the cerebellopontine angle.

It is now agreed that computed tomography provides an excellent screening technique permitting diagnosis of acoustic neuromas over 2 cm in size when the examination is carried out with contrast enhancement. Since acoustic neuromas have tissue densities equal to those of surrounding brain, enhancement with contrast is necessary to produce increases in density and well-circumsised margins.

All tumors over 2 cm in diameter usually are shown with contrast enhancement. The 20% false-negative studies may occur in patients with tumor sizes less than 2 cm.

While a positive CT scan eliminates the need for pneumoencephalography and posterior fossa myelography, angiography is necessary to rule out a vascular lesion such as an aneurysm or an elongated ectatic basilar artery.

It has become clear that the conventional CT scan cannot detect acoustic tumors in the cerebellopontine angle (CPA) less than 1.5 cm in size, or tumors that lie wholly within the internal auditory canal (IAC). However, acoustic neuromas as small as 0.8 cm have been demonstrated on computed tomographic scanning. A promising adjuvant is the introduction of water soluble myelographic contrast agents to the basal cisterns (via lumbar puncture). This intrathecal enhancement should lower the limit of reliable resolution for acoustic neuromas to well below 2 cm.

When screening studies such as conventional film and polytomography are positive and agree with the clinical and audiometric examinations, a CT scan should then be performed. If the latter is negative, Pantopaque myelography or air CT should follow.

The decision to proceed to an invasive radiologic study for a small tumor has been recently based on results from brain stem evoked audiometry (BSEA). When BSEA is negative together with other audiometric studies, then invasive radiologic studies are not indicated.

A positive BSEA test indicating a retrocochlear lesion and combined with a negative CT scan should be followed by posterior fossa myelography or cisternography combined with CT.

Posterior fossa myelography with Pantopaque remains the best diagnostic procedure for the small acoustic tumor (>90% accuracy). No false-negative studies have been reported. False-positive studies can occur rarely because of (1) a small IAC, (2) adhesions at the porus due to arachnoiditis, (3) large loops of the anterior inferior cerebellar artery causing either a filling defect or obstruction to the flow of Pantopaque.

Brain Abscess Secondary to Ear and Paranasal Sinus Infections

Computerized axial tomography has revolutionized the treatment of intracranial abscesses optimizing the timing for medical and surgical management. Serial CAT studies, either preoperatively or postoperatively, at regular intervals allow accurate documentation of the abscess site, encapsulation, and extension of surrounding cerebral edema. This excellent noninvasive technique has made better medical and surgical management of brain abscess possible. The morbidity and mortality of sick patients is greatly reduced with the availability of the CAT scan.

Maxillofacial Trauma

1. Computed tomography (CT) has become the key diagnostic modality in the evaluation of head trauma.

2. CT is of great value for evaluation of zygomatic, orbital floor, nasoethmoidal complex, LeFort, temporal bone, frontal sinus, and mandible fractures.

3. More importantly, concomitant intracranial injuries including epidural and intracerebral hematomas, traumatic encephalocele, and pneumoencephalus are readily recognized.

4. In addition, facial and orbital soft tissue structures including the globe, optic nerve, orbital fat, and extraocular muscles are easily examined by adjusting the CT level and window settings. Overall, CT yielded additional information not available from polytomography.

Laryngeal Diseases

1. CT provides a noninvasive, quick, and effective radiologic investigation for the larynx.

2. It can be done without risk in cases of respiratory obstruction and after suspected laryngeal injury.

3. CT gives an accurate assessment of laryngeal anatomy and involvement by tumor, particularly of the preepiglottic space, parachordal area, anterior commissure, and cricoarytenoid area. These are all areas not well assessed by conventional tomography.

4. A major limitation of CT is its inhability to define a transition zone from the false to the true cords. The ventricle is identified in approximately 10% of patients. CT is felt to be entirely complementary to conventional tomography. Conventional tomography is superior in showing the ventricles, the thickening of the false and true cords, and subglottic extension.

5. CT is recommended as the initial radiologic procedure when additional diagnostic information is required to supplement the findings of laryngoscopy. CT provides information

regarding deep penetration of tumor, including cartilaginous invasion, and about the inferior extension of neoplasm, including the subglottic area. This knowledge helps to determine whether conservation surgery as opposed to total laryngectomy is possible.

6. With the newer technology, the reduced radiation (which is less than one-half that of conventional tomography), and the decreased expense (now comparable to that of laryngography alone), eliminates the need for conventional laryngography and tomography examinations.