Chapter

1

Temporal Bone Dissection Laboratory Setting

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Surgery of the temporal bone and skull base is a challenging task in executing invasive procedure (Gulya and Schuknecht, 2007). It requires a thorough knowledge because of the complicated three-dimensional anatomy (Irugu et al 2016). Cadaveric temporal bone is one of the most important source of learning for residents and surgeons in the field of otology and lateral skull base surgery (Fig. 1.1). A well-equipped temporal bone laboratory is perhaps one of the greatest assets in achieving the microsurgical skill and understanding the temporal bone anatomy. Repeated microsurgical dissection under operating microscope allows the surgeon to acquire the requisite microsurgical skill and the knowledge of the complicated neurovascular anatomy that surrounds or passing through the temporal bone. Virtual learning method can also be adopted to improve learning the three-dimensional anatomy (Wang, 2006). The setting of a good temporal bone laboratory necessitates a lot of equipment and instruments that are used in a standard otologic operating room. This gives the surgeon, the ease and comfort while doing long hours of micro-dissection and to replicate easily the skill acquired to be used in the operating room.

Historical Perspective Microsurgery of Ear

The term 'microscope' came from the Greek word, where a system uses lenses for magnification. Although microscope was introduced in 17th century, the first microsurgery in the history of otology was done by Swedish otologist Carl-Olof Nylén (1921) by using a mono-ocular microscope. In the year 1922, Holmgren used binocular operating microscope for ear surgery. Until 1951, although various models were developed, the most suitable and perfected one for microsurgery for ear was developed by Littmann and Zeiss company (Murdy, 2000). Schwartz (1873) used gouge, chisel and mallet for mastoid surgery. Macewen introduced the electrical dental burr for mastoid surgery, but it remained largely unrecognised. At the beginning of the 1950s, the systematic use of the microscope in ear surgery allowed generalised use of the drill and improvement of the suction-irrigation system (Murdy, 2000).

Equipment

Bench/Table (Figs 1.1 and 1.2)**:** A bench or a suitable table is extremely important for a temporal bone laboratory. It should be large enough (about 30 to 33 inches) in height to allow the surgeon's knees to fit comfortably while using otologic drill for micro-dissection of temporal bone. The length can vary depending on whether single or multiple units/stations are being used simultaneously, where additional microscope and instruments are required to be accommodated. Each station requires separate, water tap necessary for proper functioning of microscope, drill system, irrigation and suction facility, etc.

Fig. 1.1: Temporal bone dissection in progress

Chair: A specially designed height adjustable chair with back rest is important for doing long hours of microsurgery (Fig. 1.1). A well padded operation stool with a foot pedal is recommended. Chair with wheels for mobility are very comfortable and allows the surgeon to move closer or farther away.

Drill: This should resemble the equipment in the operation theatre and should have varying sizes and types of burr points like cutting burrs, polishing burrs and diamond burrs. For a right handed dissector, the drill is held in the right hand and the suction in the left hand. The system should allow enough room for movement of drill (Fig. 1.2A).

The drill unit consists of a motor, handpiece and burrs of various types and sizes.

a. **Motor:** The micromotor type is commonly being used with a range of 30000–40000 rpm. The other types are being hanging motor type, stand type and table top type with a range of 12000 to 20000 rpm. Recently multipurpose high speed drill cum debridor developed by Storz and Xomed are available with very high speed drill. Use of low speed drill used to give a different tactile response and a change in sound while touching of burr over critical structure like dura and blood vessels. However, with modern high speed drill the need

Fig. 1.2A: Temporal bone is fixed to the temporal bone holder while temporal bone dissection is in progress with a straight handpiece micromotor drill

for digging and chatter has been reduced although at the expense of tactile and sound feedback.The high speed drill requires practice.

b. **Handpieces:** Two types are available:
   i. ***The straight type:*** It is preferred most of the time and especially at the beginning of surgery. It gives better hand control (Fig. 1.2B).
   ii. ***Contrangular type*** *(Fig. 1.3)*

c. **Burrs:** Three types are used.
   i. Cutting (Fig. 1.4)
   ii. Polishing diamond burrs
   iii. Cutting (coarse) diamond burrs (Fig. 1.5).

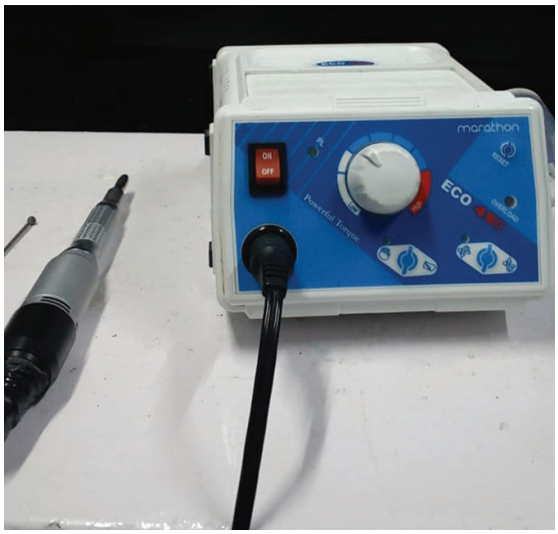

Fig. 1.2B: Straight handpiece attached to the micromotor

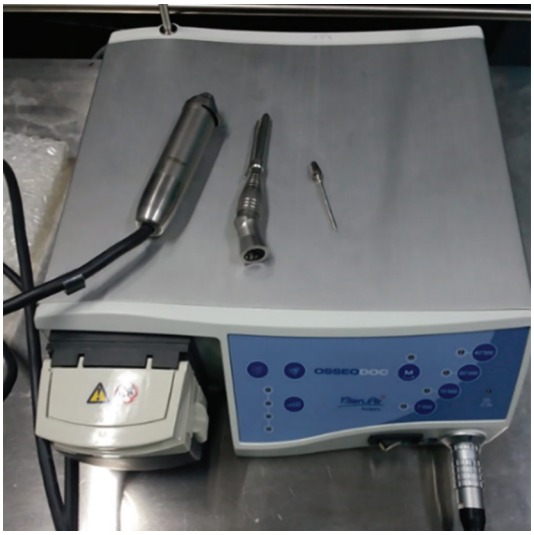

Fig. 1.3: Contrangular type handpiece

Fig. 1.4: Cutting burrs of various sizes for ear microsurgery

Fig. 1.5: Polishing and coarse cutting diamond burrs

Each of them is available within a size range of 1 to 10 mm. Tungsten carbide is used as the cutting edges in all of them. These again may be of the ordinary type or of the gear fitting type.

For smooth drilling and prevention of accumulation of bone dust, irrigating fluid will be required during drilling. In live operations, ringer lactate or any other isotonic solution may be used for this purpose. The drill handpiece should be held closer to the rotating shaft of the burr for better control without compromising the field of vision. To prevent jumping of drill and to drill with a smooth motion, the burr should be brushed along the bone surface in a direction, opposite to the burr rotation (Fig. 1.6).

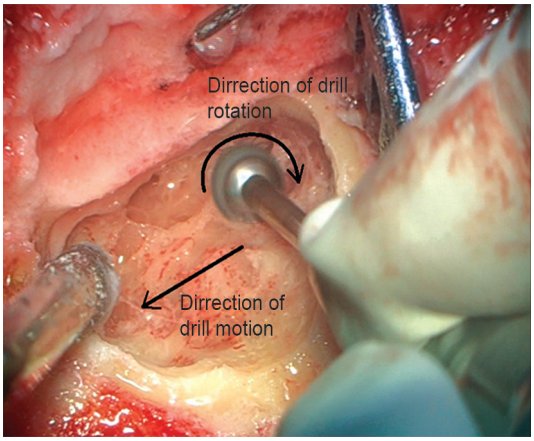

Fig. 1.6: Correct method to hold the handpiece and drilling while doing temporal bone dissection. Note the direction of rotation of burr and the motion of drilling

Piezoelectric electric device: Recently piezoelectric bone surgery is gaining popularity in mastoid surgery. The device has two piezoelectric handpieces and two inserts that are attached to the main unit. The device supplies power and has holders for the handpiece and peristaltic pumps with irrigation fluids for cooling during surgery with a jet of physiological solution that discharges from the inserts (Salami et al, 2007). Piezo electric bone surgery is very selective in cutting that recognizes tissue hardness and works only on mineralized structures, without soft-tissue damage, so facial nerve, chorda tympani can be spared without thermal damage while doing bone removal.

Operating Microscope (Fig. 1.7)

Basic Principles

Although many different types of microscopes are available in the market, the same general principles are applied in most cases. Most of the microscopes are designed to the par

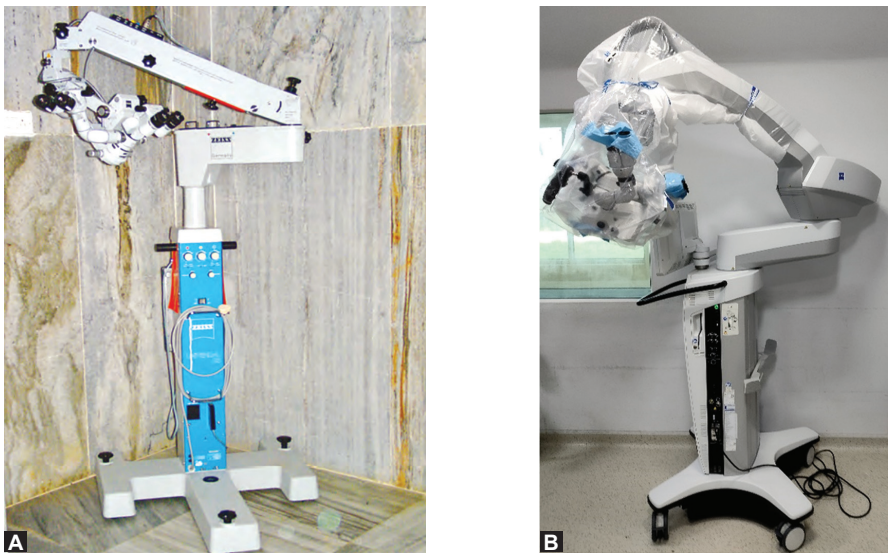

Fig. 1.7: (A) Zeiss operating microscope and the headpiece, **(B)** advanced Zeiss operating microscope with autofocus is draped before surgery

focal, but this ideal is not always achieved and one may find it necessary to make minor adjustments in focus while moving from one magnification to another.

Parts of a Basic Microscope

a. Optical system or optics
b. Lighting or illumination
c. Stand

The optical system consists of the following:

i. Binocular assembly
ii. Magnification changer
iii. Objective lens

Binocular assembly: This consists of 2 eyepieces. Various eyepieces with different magnifications are available. They include 10x, 12.5x, 16x, 20x and others. Generally 12.5× is used. These eyepieces have a diopteric scale of +5 to –5 and this can be adjusted according to the refractive error of the dissector.

Magnification changer: Magnification changer or the turret is a rotating device between the object and binocular assembly. With this the magnification can be changed from 6 to 40. For routine ear work a magnification of 10 is used. For finer work a magnification of 16 is used. As the magnification becomes higher, the field of vision becomes narrower. Nowadays zoom and magnification can be controlled through foot control or hand grips pannel attached to the microscope.

Objective lens: This is fitted at the bottom of the head. It can be easily screwed and unscrewed. The focal length of the microscope is the distance between this lens and the object. For the ear surgery it is usually 200 mm/250 mm, for the nose it is 300 mm and for the larynx it is 400 mm.

Illumination: Adequate illumination is necessary for good microscopic work. The lighting should not be too bright. Usually incandescent lamps of 6 V 50 W bulbs are used if brighter light is needed. Other sources are:
(i) Halogen lamp, and (ii) Fiberoptic source

Stand: The microscope should run easily on the stand and can be fixed on the stand tightly with knobs provided. The arms and their control are arranged on the stand that the head of the microscope can be tilted in any direction at any level convenient to the operator.

Microscope Suspension System

Proper Usage

i. Interpupillary distance is adjusted to get a single image with the binoculars.
ii. Dioptric adjustment should be made accordingly if needed. Those with astigmatism should wear suitable glasses.
iii. Focusing can be done by moving the microscope and with the fine focus control.
iv. One should note that under higher magnification the margin of error is less than one millimeter while drilling doing exploration or dissection in the important areas like facial canal, endolymphatic sac decompression, translabyrinthine approach, jugular bulb and carotid artery for infratemporal fossa approaches.

Photography Through the Microscope

A surgical microscope by its inherent design, naturally lends itself to photo differentiation. The operative field is defined by the view obtainable through the microscope and is well illuminated. There is no need for separate focusing and composition of operative photograph. No extra personnel are needed and asepsis is never compromised.

High quality, reasonably priced equipment is available to facilitate photo documentation by 35 mm photography, video recording and 18 × 16 mm cinematography. The images so produced may be used for many purposes including documentation of findings and teaching at a number of different levels and later analytical review. With the dynamic studies (video and movies), surgical techniques can be analyzed and improved upon.

Use of video also offers a major improvement in the operating room environment, because this technology allows the entire surgical staff to participate in the surgical procedure. Combination of a small field and physical barrier of the operating microscope itself often isolated the surgical assistants and the scrub nurses from a view of the operating field. So isolated, attention of these surgical personnel may wander, especially during the long procedures. The use of continuous closed circuit televised viewing of the operation reverses this. Attention is fostered when assistants can see the surgery on video monitors in the operation theatre, and they are thus able to again anticipate the needs of the surgeon and assist him accordingly. An additional advantage is that, the ability to achieve an 'instant replay' via a video tape is seen. This on occasions has defined a problem, such as the site of intraoperative facial nerve damage and aided the surgeon in dealing with it properly.

Use of dual photo-adapter with the help of additional internal beam splitter allows both 35 mm and videography to be done simultaneously with various focal length combinations.

The use of high speed film and improved sensitivity of the video cameras has helped for good photography with additional illumination facility. The flask information system may be used in the laboratory without moving the flask closer to the field. This

system consists of an eyepiece mounted, light emitting diode (LED), which enables the surgeon to be aware of the flash status signal normally appearing in the camera's view finder. The flash when charged sends a signal which makes the LED bulb glow steadily. If the flash is totally discharged by the exposure the LED is extinguished, the surgeon may be informed when the next picture may be taken by the glowing LED. With the addition of the winder, the film is advanced automatically and multiple sequences are possible.

Color video cameras have improved remarkably in the last few years and a number of small light weight cameras, which are suitable for microsurgical applications are readily available. Apfelbaum RI recommends Hitachi 9017 camera for excellent resolution with reasonable price.

Three-Dimensional Microsurgical Videos

The use of 3-dimensional technologies can be divided into 4 areas. The first area is in developing better teaching methods. Second in the development of better imaging technology, the third area is that of adapting procedures now done in 2D or 3D. The last area for the future of 3D technology is merging technology. With the use of stack computer arrays, 3D images can be created and manipulated.

Bone Holders

There are many bone holders available. These include:

1. The Houston urban stainless steel bone holder
2. Dr Mahadeviah's bone holder
3. Vijaya's bone holder
4. Prabhu's bone holder
5. Hazarika's temporal bone holder designed by Prof Produl Hazarika, Co-author and former Head, Department of ENT–Head and Neck Surgery, Kasturba Medical College, Manipal.

This holder has the following features:

- It is made of brass
- Has 3 points for firm holding
- Has a lead base for stability
- The bowl is placed on a sports ring ball made up of rubber for easy maneuverability

Suction Irrigation

Ideally both suction and irrigation should be provided on the same handpiece. The hand-piece is held in the left hand and is advantageous in the sense that there is no need for an assistant to pour the saline or irrigation fluid. However, simpler set ups incorporating separate suction apparatus and irrigator can also be used but requires an assistant to do the suction while the dissector is performing the drilling work. This can be used to continuously irrigate the field with a separate irrigation channel during dissection.

Surgical Instruments

1. Suction cannula of various sizes
2. Sickle knife
3. Bone curette
4. Alligator forceps

5. Scalpel
6. Straight pick
7. Right angle pick
8. Aditus seeker
9. Periosteal elevator

Bone

Both dry and wet bones can be used for dissection. It is better to start dissection with dry bones first. Dry bones are soaked in decalcifying agents to soften the bones. Details of various decalcifying agents are given later. Stapedectomy, facial nerve decompression, etc. are better done with fresh bones or wet bones.

Fresh bones can be usually obtained during postmortem examinations, without mutilating the external appearance of the cadaver using proper technique of removal. Temporal bones cut from specimens should include mastoid air cells, a small portion of squamosal part of the bone, the tympanic ring and petrous tip. The collected temporal bones should be fixed in a 10% neutral buffered formalin solution for a period of 2 weeks at 4°C temperature or in a high concentration of alcohol (Fennessy et al., 2009).

Procedure for Removal of Temporal Bones

Legal issues still a problem in harvesting and transporting temporal bone in India besides preservation and infection transmission being the major issues. Because of this problem, newer modalities like simulation and virtual reality are being used as teaching tool which may replace the existing system. It can be collected in supervision of forensic department based on anatomy act as published under the government gazette. The cadaveric temporal bone gives the opportunity to study anatomical variations (Naik et al, 2014). Temporal bones may be removed by either the use of block method or the core method while performing postmortem (Fennessy, 2009). The great demand of dissection of temporal bone by the otologists made it essential to establish a temporal bone laboratory in institutes and hospitals.

Block Method

It requires four bone cuts to remove temporal bone to help remove single temoral bone. Walvekar et al. 2010 described a modified block method, where two temporal bones can be removed from the cadaver with just four cuts.

Block method is preferred over the Core method (Shambaugh) (Fig. 1.8) because:

i. More structural features are retained in a larger sample
ii. Eustachian tube can be removed
iii. Related cranial nerves can be viewed
iv. It is easier to teach on a larger sample

Steps

1. Skull cap is removed in such a way as to leave two pyramidal eminences anteriorly and posteriorly to avoid slipping of the cap over the skull bone later on.
2. Brain is removed

Four saw cuts are made to remove the temporal bone. 1st and 2nd cuts are at right angles to superior angle of the petrous bone.

1st cut is made near the apex of the bone as the size and shape of the posterior cranial fossa permits (well anteromedial to the cochlea). The further forward it is made, larger the portion of the Eustachian tube removed. 2nd cut is made roughly

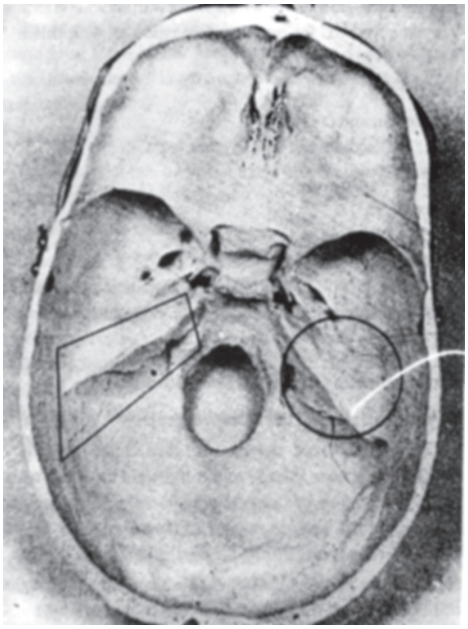

Fig. 1.8: Outline marked for Block and Core method of temporal bone removal

parallel to cut 1 and through the middle mastoid region as near to its lateral wall as the saw can be held.

Cut 3 is made vertically in the floor of the middle cranial fossa about one inch in front of the petrous ridge and laterally as close to the cranial wall as possible. This should join the forward ends of cuts 1 and 2. If done correctly this lies 3/8 inches laterally and in front of the tympanic membrane. The block tissue removed includes the deeper part of the osseous external auditory canal.

Cut 4 is an undercut of block tissues outlined by the above 3 cuts. It is made along an anatomical horizontal plane as near to the floor of the posterior cranial fossa as the saw can be placed. Posterolateral end of this cut is made first and then advanced slowly to apex of the petrous bone.

The removal of the block outlined above is the most difficult job and is accomplished with the help of a lion-jaw forceps. The block is grasped by placing the prongs of the jaw of the forceps in cut 4 and closing down the other jaw in such a manner that its prongs grasp the superior angle of the petrous bony pyramid, because this region of the surface is usually more free of underlying pneumatised or narrow spaces than the more lateral positions of the superior surface.

With gentle back and forth movement of the handle, the unsevered connections are broken without damage to inner structures. After the bone becomes completely loose, it is elevated with the forceps to allow insertion of a knife along cuts 3 and 4 to severe the dense connections remaining. A wide sharp chisel is useful especially in the region of the styloid process.

After the removal of the bone the following two important steps are carried out:

i. The internal carotid artery is grasped and ligated
ii. The external auditory canal is sutured with silk with a piece of muscle plugged in between the sutures

iii. Any defect in the bone of the skull is filled with plaster of Paris to prevent leakage of embalming fluids. This method of removal of the temporal bone leaves no external deformity of the skull.

Core Bone Plug Cutter Method

Cylindrical block of bone is removed by centering a 'Bone plug Cutter' on the acoustic eminences as shown in Fig. 1.9A and B. The block is removed in the same way as described above for block method.

Use of Decalcifying Agents for Dry Temporal Bone

It is often difficult to get wet cadaveric temporal bone. A dry temporal bone can be used to understand basic surgical anatomy of temporal bone. But it is very difficult to drill in such bone to open up the mastoid antrum and perform common surgical procedure.Use of gouge/chisel and mallet can cause crack and break the specimen before being used (Tremble, 1930). Decalcifying agent can make the job easy in such situation. These agents can be classified broadly into three main types:

1. **Based on strong mineral acid:** Can be used as 5–10% for a period of 12–14 hr for temporal bone to prevent total demineralization. Can be used as 10% nitric acid in 5% in distilled water. Hydrochloric acid also can be used but should be washed of formalin preserved bone before used.
2. **Based on weaker organic acids:** Formic acid aqueous solution or in combination of formalin can be used. Alternatively acetic acid can also be used. Bone can also be put in simple vinegar for 48 hr. before taking it for temporal bone dissection when standard acid is not available.
3. **Composed of chelating agents:** EDTA is commonly used for this purpose, in the form of its disodium salt. However, it can bind only ionized calcium and hence can act only on the outer layer.

Factors affecting the rate of decalcification:

1. **Concentration of the active reagent:** In general, more the concentration, more rapid is the decalcifying process. Steady concentration of the active reagent can be maintained

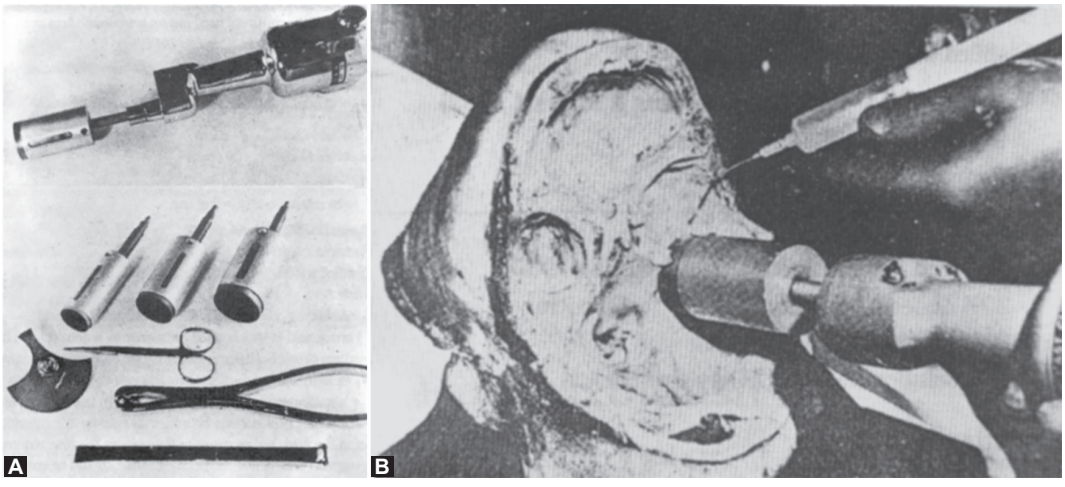

Fig. 1.9: (A) Instruments to cut and remove temporal bone, **(B)** Core method of temporal bone removal

by using large bulk of this agent compared to the specimen (volume ratio of 20 : 1 approximately) or by renewing the fluid several times during the decalcifying process. It is recommended that strong acids are changed 2–3 times during 24 hours, weak acids daily and EDTA once a week.

2. **Temperature:** Increased temperature hasten decalcification. However, increase beyond an optimum temperature can damage other normal structures. Moreover a partial decalcification helps better temporal bone drilling of dry temporal bone. Wet temporal bone does not require decalcification.
   Optimum temperature for acid decalcification has not been determined properly. Twenty five degree centigrade (summer heat) is a useful standard temperature but in practice the temperature of a working lab is suitable (Smith, 1962). Thus EDTA can be used at a temperature of 60°C with good effect (Brain, 1966).
3. **Agitation:** Hastening effect of agitation on decalcification, though appears logical, is quite controversial. Shaking manually once or twice a day can be done, keeping the above point in mind.

Completion of Decalcification

Constant surveillance will be needed to obtain optimum decalcification. A complete decalcification makes the bone unsuitable for drilling. A partial decalcification with weak acid like formic acid or acetic acid for short period is more suitable for temporal bone dissection.

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