VERIFIABLE CPD PAPER

IN BRIEF

- No matter how well the obturation of the root canals is performed, success will be dependant upon the initial cleaning and debridement of the entire root canal system.
- Cold lateral compaction of a master gutta percha point and accessory points remains the norm against which other obturation methods are assessed.
- The gold standard of obturation is the warm vertical compaction of gutta percha with a heated plugger.
- Research suggests that the coronal seal, achieved with a layer of glass ionomer cement on the floor of the pulp chamber, may be more important than the apical seal.

Endodontics: Part 8
Filling the root canal system

P. Carrotte[1]

The purpose of the obturation phase of a root filling is two-fold; to prevent microorganisms from re-entering the root canal system, and to isolate any microorganisms that may remain within the tooth from nutrients in tissue fluids. The seal at the apical end of the root canal is achieved by a well-fitting gutta-percha master point, and accessory points, although heated techniques may result in a better seal. The seal at the coronal end is achieved by the application of a layer of resin-modified glass ionomer cement as accessory canals may lead from the floor of the pulp chamber to the furcation area. It must always be remembered that success will only be achieved if the root canal system has been as thoroughly debrided as possible of infected material.

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In modern endodontic treatment the emphasis is placed far more on cleaning and preparing the root canal system than on filling it. This does not mean that root canal obturation is less important, but that the success of endodontic treatment depends on meticulous root canal preparation.

The purpose of a root canal filling, as illustrated in Figure 1, is to seal the root canal system to prevent:

- Microorganisms from entering and reinfecting the root canal system;
- Tissue fluids from percolating back into the root canal system and providing a culture medium for any residual bacteria.[1]

In the past, attention has been focussed on the importance of obtaining an hermetic apical seal. However, research has indicated that as well as sealing the root canal system apically, it is equally important to ensure that the coronal access to the canal itself has a fluid-tight seal, to prevent infection from the oral cavity.[2] Although numerous materials have been used to fill root canals, the most universally accepted is gutta-percha.

PROPERTIES OF ROOT CANAL FILLING MATERIALS[1]

Ideally, a root canal filling should be:

- Biocompatible
- Dimensionally stable
- Capable of sealing the canal laterally and apically, conforming with the various shapes and contours of the individual canal
- Unaffected by tissue fluids and insoluble
- Bacteriostatic
- Radiopaque
- Easily removed from the canal if necessary.

To these properties may also be added, incapable of staining tooth or gingival tissues and easily manipulated with ample working time.

Gutta-percha has a number of these desirable properties. It is semisolid and can be compressed and packed to fill the irregular shapes of a root canal using lateral or vertical compaction techniques. It is non-irritant and dimensionally stable. It will become plastic when heated or when used with solvents (xylol, chloroform, eucalyptus oil). It is radiopaque and inert, and can be removed from the canal when required for post preparation.

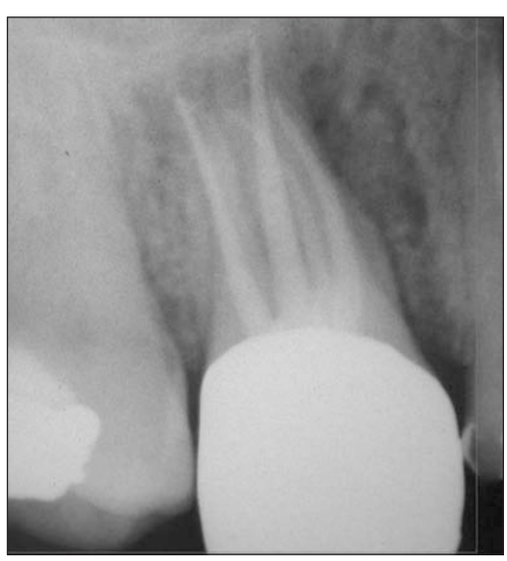


Fig. 1 A radiograph of a well-obturated upper molar.

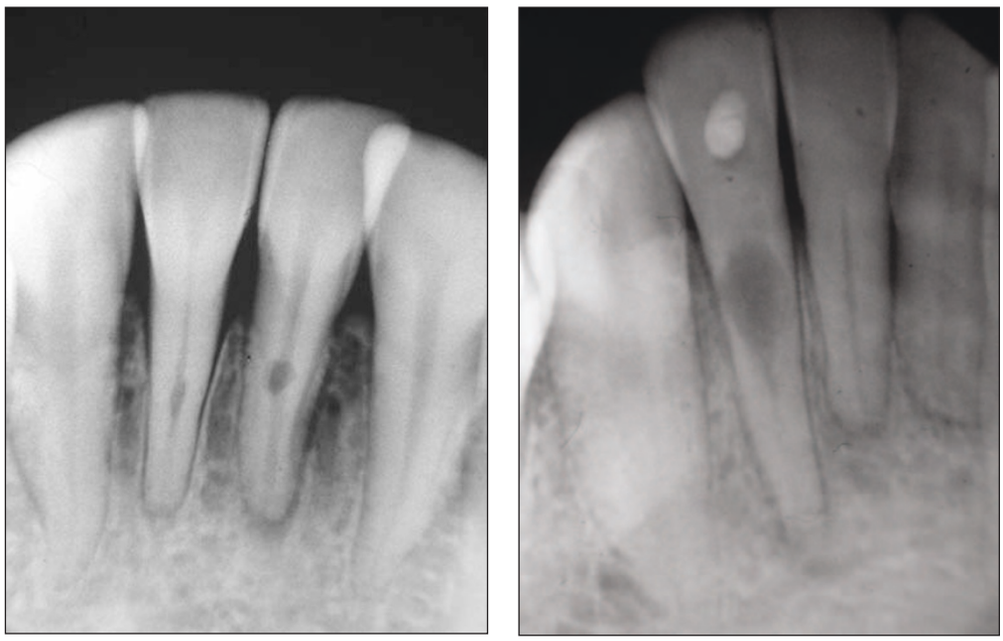


Fig. 2 These teeth with resorptive defects may be impossible to obturate with conventional methods.

Its disadvantages are few. It is distorted by pressure and, consequently, can be forced through the apical foramen if too much pressure is used, and it is not rigid and so can be difficult to use in smaller sizes. Also, a sealer is necessary to fill in the spaces around the filling material. Root canal scalers were considered in Part 5.

Gutta-percha points are manufactured in various forms. Standardised points match the ISO sizes, and have a 2% taper. Accessory points have fine tips and variable taper to facilitate and improve lateral compaction. Greater taper points are available in 4% and 6% taper to match modern preparation techniques. Feather-tipped points permit individual and specific cone fitting to the prepared root canal.

REMOVAL OF SMEAR LAYER

A smear layer is created by the action of metallic instruments on dentine, especially rotary instruments. It is composed of dentine filings, pulpal tissue remnants and may also contain microbial elements. It may occlude dentine tubules thus harbouring bacteria, and may contain a bacterial plaque on the canal walls. It has been shown that gutta-percha penetrates the dentine tubules when the smear layer has been removed.[3]

It is therefore suggested that the root canal should be irrigated with an EDTA solution to remove the smear layer, followed by a final irrigation with sodium hypochlorite, prior to drying and obturating the canal.

FILLING TECHNIQUES

The studious reader will have noted the use of the word 'compaction' rather than 'condensation'. In 1998, the American Endodontic Association recognised that this was a more appropriate term for the techniques used in obturation, and the term has been adopted in this text.[4]

Several techniques have been developed for placing gutta-percha into the root canal system. Nevertheless, the cold lateral compaction of gutta-percha is still the most widely taught, and the technique against which most others are compared. However, as there is a demand for saving teeth with complex pathology and root canal morphology (Fig. 2), it is sometimes easier to combine the merits of various techniques in a hybrid form to simplify the filling procedure. Studies have shown that these are satisfactory, although not always as easy as lateral compaction to carry out.[5,6]

Before a root-filling is inserted, it is essential that the canals are dry. Any serous exudate from the periapical tissues indicates the presence of inflammation. Calcium hydroxide may be used as a root canal dressing until the next visit (calcium hydroxide BP mixed with purified water or local anaesthetic solution to a thick paste – see Part 9).

LATERAL COMPACTION OF GUTTA-PERCHA

The objective is to fill the canal with gutta-percha points (cones) by compacting them laterally against the sides of the canal walls. The technique requires selection of a master point, usually one size larger than the master apical file, which should seat about 0.5 mm short of the working length (Fig. 3a). If the point is loose at working length, then either 1 mm should be cut from the tip and the point refitted to the canal, or a larger size point selected. It should be noted that gutta-percha points can not be as accurately machined as metallic instruments. There may be variance in the size stated, and if a matched point does not fit a prepared canal it may be worth either trying another point from the packet, or fitting the point in a measuring/sizing gauge, as illustrated in Figure 4.

Once the master point is fitted to length and demonstrates a slight resistance to withdrawal (tug-back), accessory points are then inserted alongside the master point and compacted laterally with a spreader until the canal is sealed

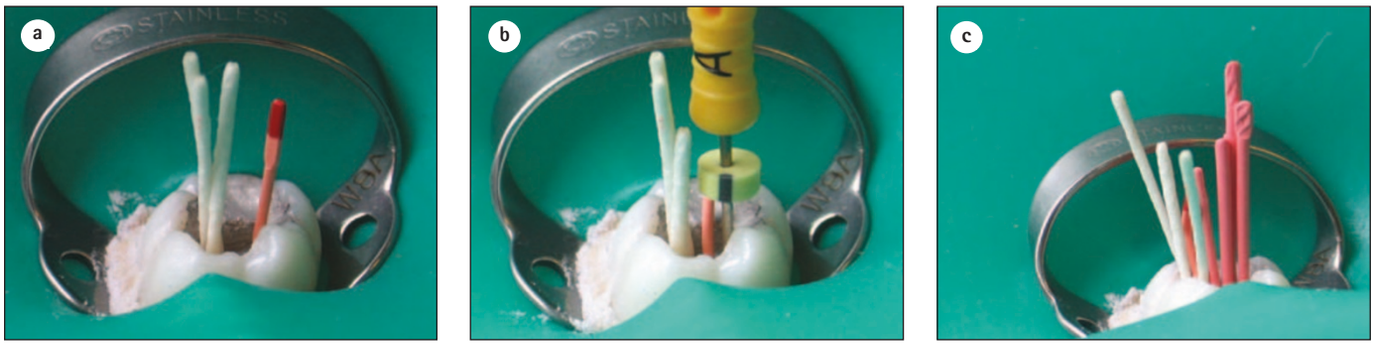


Fig. 3 a) In cold lateral compaction, the master point should exhibit 'tug-back' slightly short of the working lengths. (Paper points have been placed to protect the other canals.) b) A finger spreader inserted alongside the master point, is left in place for 30 seconds. c) The spiral of successive accessory points in an effective obturation.

(Fig. 3b). The most simple system of accessory points designates these from A, the finest, through B and C to D, the largest, shown in Figure 5. As each point is used the prepared, flared, canal is becoming progressively wider, and the accessory points may therefore be used sequentially from small to large. The resultant filling appears above the access cavity as a spiral, with each point extruded slightly further out of the canal (Fig. 3c).

There are two main types of spreading instruments for compacting gutta-percha: long-handled spreaders and finger spreaders. The main advantage of a finger spreader is that it is not possible to exert the high lateral pressure that might occur with long-handled spreaders. The chance of a root fracture is reduced and it is therefore a suitable instrument for beginners.

PROCEDURE

1. The canal should be irrigated, cleaned and dried.
2. A master point is selected and fitted to the canal as described above. It should be marked at working length, or grasped securely in endodontic locking tweezers.
3. The master point is coated with sealer and used to paste the canal walls with the sealer, using an in-out movement, before seating the point home into the canal at full working length.
4. A fine finger spreader is selected and the rubber stop set to working length. Place the spreader alongside the master point and compact using firm apical finger pressure only. Leave the spreader *in situ* for 30 seconds. This is important as continuous pressure from the spreader is required to deform the gutta-percha point against the canal walls and to overcome its elasticity.
5. Select an accessory point with locking tweezers and dip its tip into sealer. Do not leave the points in sealer while working (Fig. 6) as a reaction may occur between the zinc oxide in the points (up to 80%) and the eugenol in the sealer, softening the points and making insertion difficult.
6. This stage is best carried out using two hands. Assuming the operator is right handed, the tweezers holding the accessory point are aligned above the tooth in the right hand, while the left hand rotates the spreader a few times through an arc of 30–40° and withdraws it.
7. Immediately place the accessory point alongside the master point. Any delay will

Fig. 4 An endodontic gauge for accurately sizing gutta-percha points.

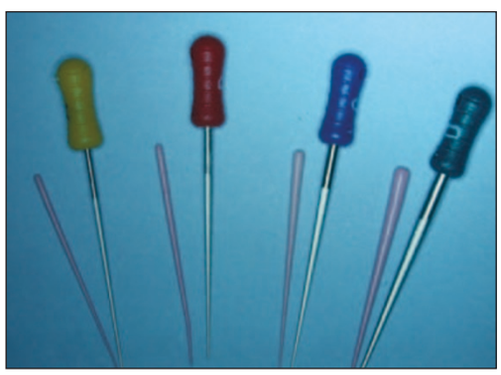


Fig. 5 Finger spreaders sized A to D with matching accessory points.

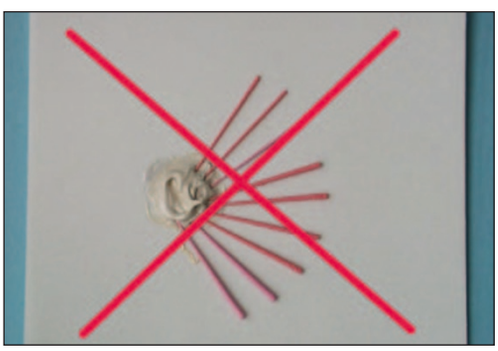


Fig. 6 Gutta-percha points should NOT be presented to the operator by the surgery assistant with the tips dipped in sealer.

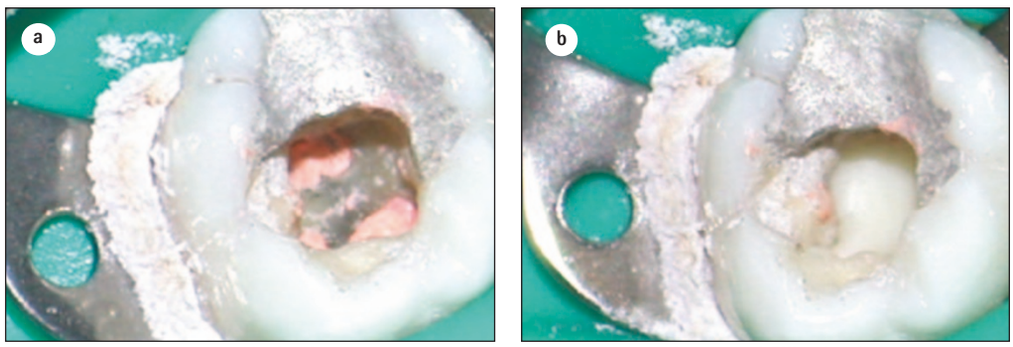


Fig. 7 The excess gutta-percha has been removed with a hot instrument, and the coronal filling has been compacted into the root canal orifice a), prior to the placement of a glass ionomer coronal seal b).

allow the master point to relax and space will be lost. Reinsert the spreader and laterally compact both points.

8. Repeat the sequence using gradually larger spreaders and gutta-percha points until the canal is filled.
9. Remove excess gutta-percha from the canal orifice with a heated plugger, and firmly compact the remaining gutta-percha to seal the coronal access to the canal (Fig. 7).
10. If post-space preparation is required it may be carried out at this stage.
11. If not, a layer of resin-modified glass-ionomer cement should be applied over the gutta-percha and the floor of the access cavity, completing the coronal seal.
12. A periapical radiograph should be taken on completion, using a long-cone parallel technique. This is primarily for subsequent monitoring of healing by sequential radiographs, taken if possible in the same film-holder system to ensure reproducible and comparable exposures.

LATERAL COMPACTION OF WARM GUTTA-PERCHA

A simple modification to the cold lateral compaction technique is to apply heat to the gutta-percha. The softened material is easier to compact and will result in a denser root filling. However, finger spreaders will not retain heat sufficiently for this procedure, and specially designed heat carriers should be used. The instruments illustrated in Figure 8 have a sharp tip for lateral compaction, and a blunt plugger tip for limited vertical compaction of the softened gutta-percha. Electrically heated spreaders are also available. It is important that the instruments are only gently warmed. If the spreader is too hot it will melt the gutta-percha, which will adhere to the instrument and be withdrawn from the canal.

SINGLE GUTTA-PERCHA POINT AND SEALER

With the tendency to preparation techniques of greater taper, gutta-percha points of matching taper may be used. These fit the prepared canal so well that some operators are using a single gutta-percha point and sealer. The only advantage of this technique is its simplicity. The disadvantage is that the majority of sealers are soluble. As the canal will not be fully filled in three dimensions, tissue fluids may leach out the sealer over time. This technique cannot therefore be recommended.

However, in difficult anatomical cases it may be necessary to create a custom-fitted cone. A slightly large cone is selected and the apical part softened, either by solvents such as chloroform, rectified turpentine or oil of eucalyptus, or by immersion in hot water. The softened cone is fitted to working length with gentle pressure. The cone is carefully marked for orientation, and the process repeated until a satisfactory fit is obtained. The cone should then be cleaned of all solvents, and the canal obturated using sealer in the usual way.

As with all single-cone techniques, if the excess sealer resorbs in the apical tissue fluids, microleakage may allow the ingress of tissue fluids, and failure of the stated criteria of obturation. Really, an attempt should always be made to improve the fit of a single cone with warm or cold lateral compaction of accessory points.

THERMATIC COMPACTION OF GUTTA-PERCHA

In 1979, McSpadden devised a handpiece-

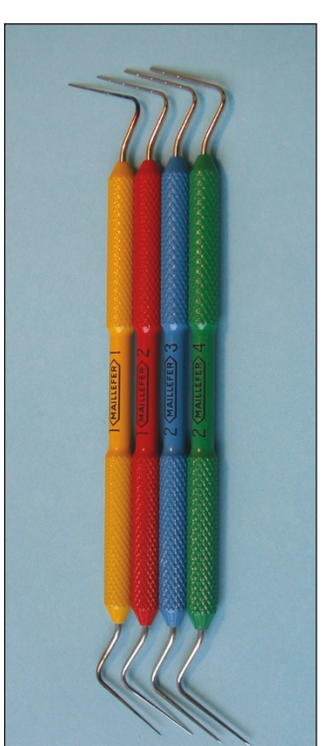
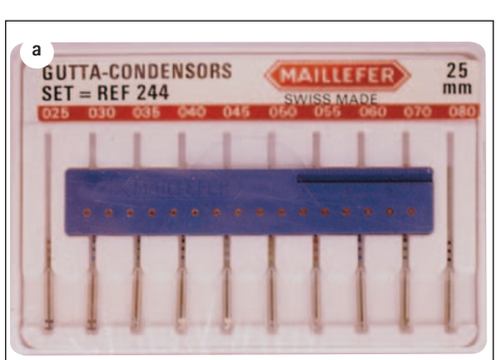


Fig. 8 Machtou heat carriers/ pluggers for warm compaction.



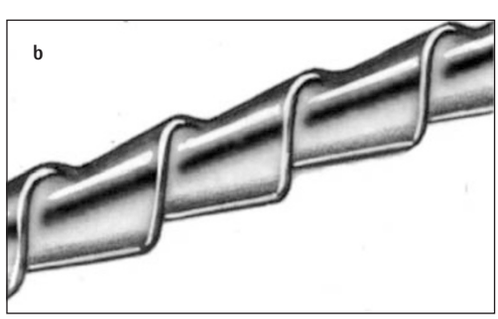


Fig. 9 a) Maillefer Gutta Condensors, with b) showing the apically directed thread structure.

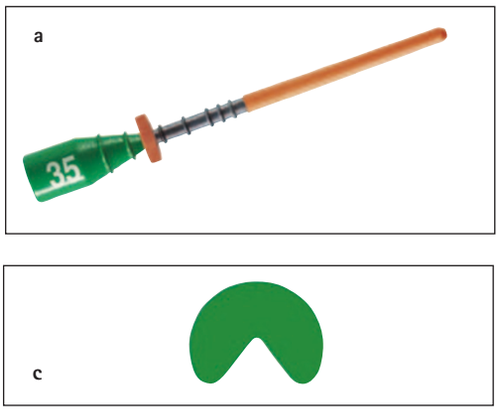


Fig. 10 An example of a Thermafil device a), a heated gutta-percha carrier, with an oven necessary for accurate softening b). The U-shaped cross-section of the plastic carrier is shown in c).

driven compactor, which is effectively an inverted Hedstroem file.[7] Although no longer made, other similar devices, such as the gutta condensor (Fig. 9), are available. The frictional heat from the compactor plasticises the gutta-percha and the blades drive the softened material into the root canal under pressure. The main problem found was lack of control over the apical portion of the gutta-percha, which may be extruded through the apex in its softened state. To overcome this problem, the technique was modified by Tagger, who recommended laterally condensing a master point and two or three accessory points, and then using the condensor to plasticise the gutta-percha in the coronal part of the canal.[8] The laterally compacted material in the apical half effectively prevents any apical extrusion.

The technique is particularly useful for the rapid and effective obturation of the coronal part of a root canal after placement of an accurate apical seal.

HEATED GUTTA-PERCHA CARRIERS

Several manufacturers now supply these devices, illustrated in Figure 10. Alpha-phase gutta-percha is attached to a rigid carrier, in a variation of the technique originally described by Johnson in 1978.[9] Most carriers are now plastic. The excess material is removed, and the carrier remains in the canal as a central core. The softened gutta-percha flows well in to canal aberrations, fins, etc., giving very good three-dimensional obturation.[10] Success depends, as with all techniques, upon thorough canal cleaning and shaping. The carriers have a 4% taper, and an underprepared canal will be difficult if not impossible to obturate to working length with these devices. A range of sizes is presented, and most systems employ a method of ensuring the fit of the device before obturation is commenced. This may either be a blank carrier with no gutta-percha attached, or preferably a file of the same dimensions as the carrier. The apical preparation may then be refined to ensure an accurate fit of the device.

The canal should be cleaned and dried, and a very fine coating of sealer applied to the canal orifice only. Excess sealer may be extruded under hydraulic pressure through the apical foramen, with resultant pain and inflammation. In the meantime the rubber stop on the selected device is set to working length, and the device placed in a special oven to soften the gutta-percha. When ready, the device should be swiftly and smoothly inserted to working length, and held in place for a few seconds. Using a high-speed bur the excess carrier may be sectioned and removed from the canal orifice, and a plugger used to compact the gutta-percha in this area. A layer of resin-modified glass ionomer completes the obturation.

Some carriers are manufactured with a U-shaped cross-section to facilitate removal with a drill should retreatment be necessary. However, although it may be possible to drill out the carrier, this technique may not be appropriate if a post and core may be indicated in the future.

VERTICAL COMPACTION OF WARM GUTTA-PERCHA

Heated gutta-percha has been shown to flow extremely well into all canal irregularities. It is particularly useful in situations such as internal resorption, C-shaped canals, and those with fins or webs. As referred to earlier, when the smear layer is removed the gutta-percha has been shown to penetrate dentine tubules.[3] This technique is now considered the gold standard for endodontic obturation. The principle of vertical compaction of increments of warm gutta-percha was first described by Schilder in 1967.[11] Although delivering excellent results, the method was difficult to master and time-consuming.

The state of the art at present is the method first described by Buchanan employing the System-B heat source (Fig. 11), which delivers a precise heat to the tip of the plugger.[12] A non-standardised (4%, 6% or feathered tip) gutta-percha cone is carefully fitted to the canal. Using a selected plugger, a continuous wave of heat is applied to soften and downpack a cone, resulting in very well-compacted obturation of the apical portion of the canal. The remainder of the canal may be obturated by further increments, or by another method. Briefly, the technique is as follows.

1. Fit a gutta-percha cone and mark it at working length.
2. Select one of the System-B pluggers that binds in the canal 5–7 mm short of the working length. Set a rubber stop at this level, and

Fig. 11 The System-B heat source. When the ring on the handpiece is pressed as shown the tip of the plugger is immediately heated to the temperature selected.

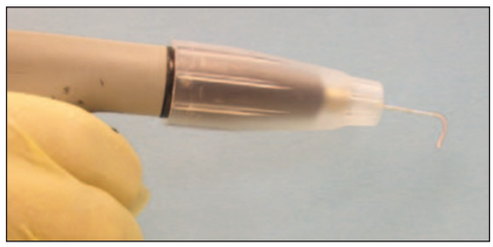


Fig. 12 Heated alpha-phase gutta-percha being extruded from the silver needle of the Obtura II machine.

select a conventional plugger to fit at this length as well.

3. Dry the canal with paper points.
4. Apply a thin layer of sealer to the apical third of the selected cone, and insert it to working length.
5. Set the temperature of the System-B at 200°C, with full power. Heat is applied to the plugger via the finger-tip microswitch, and the part of the cone extruding from the canal orifice is seared off.
6. The tip of the plugger is placed in the centre of the gutta-percha cone, heat applied, and the plugger is carefully pushed down the canal in one slow, even movement to the depth marked. This should take about 3 seconds. The heat is turned off, and the plugger held in place for a further 10 seconds.
7. With a brief burst of heat to separate the plugger from the gutta-percha, the plugger is removed from the canal. It is usually found to bring with it the coronal portion of the gutta-percha as well.
8. The apical part may now be further compacted with conventional hand pluggers.
9. The coronal part of the canal may now be obturated with either injectable gutta-percha, described later, or further use of the System-B as follows.
10. A small length of gutta-percha, about 7 mm, is cut from a further accessory point, coated with sealer and inserted into the canal.
11. With the heat source turned down to 100°C, otherwise this gutta-percha will not stay in the canal, a short burst of heat is applied, the gutta-percha compacted, and the plugger removed as before. Hand pluggers may be used to further compact this and any subsequent increments required.
12. A layer of resin-modified glass-ionomer cement is applied over the obturation, and a post-operative radiograph is exposed as normal.

INJECTABLE GUTTA-PERCHA

Devices for injecting softened gutta-percha have been available for some time, but in the past have suffered from techniques which led to difficulty in accurate apical placement. The latest of these, the Obtura-II, has recently gained acceptance by endodontists. The machine resembles a glue-gun. Pellets of alpha-phase gutta-percha are softened at about 200°C in the handpiece, and extruded through a heated silver needle (Fig. 11). A wide, well-prepared canal is a prerequisite. Although the manufacturers describe a procedure for total obturation of a root canal, apical control can be difficult. The machine has become accepted for two specific procedures.

CORONAL BACK-FILLING

The previously described System-B achieves an excellent and controlled obturation of the apical 5–7 mm of the root canal. At this point the canal is quite wide, and can accept the tip of the Obtura's needle. A film of sealer is applied to the canal wall. The machine is heated to 200°C. A small amount of the warm gutta-percha should be extruded to warm the needle and discarded. The needle is then quickly introduced to the canal. If this part of the protocol is not followed, a void may result between the two parts of the filling. The trigger is activated and thermoplasticised gutta-percha extruded into the canal, gently pushing the needle out. Once the canal is filled conventional pluggers may be used to compact the gutta-percha, which is finally sealed with glass ionomer as usual.

OPEN APICES

The open apex, particularly in paediatric endodontics, can present a problem if it is too wide to permit the creation of a custom-fitted cone. A method of using the Obtura-II has been described whereby an increment of gutta-percha is applied to the canal close to the apex, and gently compacted with pluggers. A rapid-developing radiograph is exposed to verify the position of the apical seal, and further compaction carried out if required. Once the apical seal is intact the remainder of the canal may be filled with the Obtura-II in the normal way.

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