Successful root canal treatment is based on diagnosis, treatment planning, knowledge of tooth anatomy, and the traditional concepts of debridement, sterilization, an obturation. Several obturation techniques are available for root canal treatment. The choice depends on the canal anatomy and the unique objectives of treatment in each case. The two basic obturation procedures are lateral condensation and warm vertical condensation. The advent of new devices and techniques, such as those utilize heat, and vibration for warm lateral and warm vertical condensation, are revolutionizing the practice of endodontics and making obturation procedures more predictable. The aim of this library dissertation is to have comprehensive overview of the obturation techniques available and also emphasize on recent advances in obturation techniques.

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OBTURATION TECHNIQUES

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INTRODUCTION

INTRODUCTION

During the last two decades, the science and practice of endodontic therapy has advanced dramatically with the introduction of evidence-based and validated protocol as well as modern techniques and materials.[9]

The success of root canal treatment depends upon proper diagnosis and treatment planning, knowledge of canal anatomy and morphology, canal debridement, sterilization of canal and obturation. Endodontic treatment plays an important role in providing patients with high quality comprehensive dental care.[11,12]

Root canal obturation involves the three-dimensional filling of the entire root canal system and is a critical step in endodontic therapy. There are two purposes to obturation; the elimination of all avenues of leakage from the oral cavity or the periradicular tissues into root canal system of any irritants that remain after appropriate cleaning and shaping of the canals.[13]

The classic ‘Washington study’ observed that 58.66% of endodontic failures are caused by incomplete obturation and the other established text books concluded that lack of adequate seal is the cause of endodontic failures.[7]

Several obturation techniques has been evolved from past, like heat or chemically-softened gutta percha to injection techniques, ultrasonics, vibration and carriers based.[12]

Cold lateral condensation technique is the gold standard technique used for almost all clinical situations. It provides length control and thus prevent overfilling. However, it does not produce a homogenous mass thereby creating spaces between the cones and may also not fill the canal irregularities .[11,12]

Tailor made gutta percha prepared by joining multiple gutta percha cones from butt to tip until a roll is formed which is used for complete obturation of blunder bus canals. The technique is time consuming and increased sealer :gutta percha ratio tends to create voids throughout the canal [11,12]

Vertical compaction technique is based on Schilder's concept of cleaning and shaping root canals in a conical shape, and then obturating the space 'three-dimensionally' with gutta-percha, warmed in the canal and compacted vertically with pluggers. It seals the canal apically and laterally. Disadvantages include vertical root fracture, overfilling and time consuming. [11,12]

Sectional obturation technique has advantage of sealing the canals apically and laterally, and is indicated in post core cases. The technique is time consuming and difficult to remove the sections of gutta percha in cases of overfilling. [11,12]

Thermafil obturation technique is specially designed flexible steel, titanium or plastic carriers coated with alpha phase gutta percha. It has the advantages of three dimensional obturation and fills the canal irregularities like fins, anastomoses and lateral canals. Less strain is exerted during obturation. Extrusion of gutta percha filling material beyond the apex is common. [11,12]

The aim of this library dissertation is to have comprehensive overview of the obturation techniques available and also emphasize on recent advances in obturation techniques. [11,12]

DEFINITION

Definition:

According to the American Association of Endodontists " Obturation is the method used to fill and seal a cleaned and shaped root canal using a root canal sealer and core filling material".

OR

Root canal obturation is defined as "The three- dimensional filling of the entire root canal system as close to the cement-dentinal junction as possible

-American Association of Endodontics, 1994.

OBJECTIVES

Objectives:

1. Achieve total obliteration of the root canal spaces so as to prevent ingress of bacteria's and body fluids into root canal space as well as egress of bacteria's which are left in canal.
2. Attain fluid tight seal so as to prevent bacterial microleakage.
3. Replace the empty root canal space with an inert filling material so as to prevent recurrent infection.
4. Seal the root canal space as well as to have coronal seal for long term success of root canal therapy.
5. Prevent nutritional elements from accessing the pulpal space along any entrance to the root canal, including apical foramina, accessory canals and the oral access cavity.
6. Eliminate space for further growth of micro-organisms that may have survived the biomechanical preparation.

WHEN TO OBTURATE?

When to obturate:

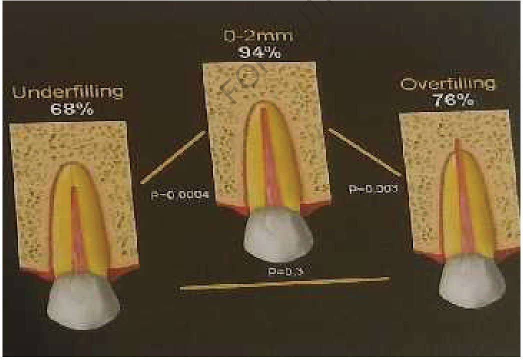
Radicular space obturation is ideally accomplished after cleaning and shaping has been completed to an optimum size. Regardless of the material used, established criteria must be met before the canal is considered ready for filling. Obviously the canal must be completely prepared to the acceptable depth and width prior to even considering readiness for filling.[4] For many years most authorities agreed that four conditions must be satisfied:

1. Negative culture test.
2. No excessive exudates from the canal i.e the canal should be completely dry, with no "weeping" of fluids in the form of bleeding or discharge of serous fluids.
3. Absence of foul odour.
4. Lack of periapical sensitivity (i.e Asymptomatic).[6]

Fig 1. Persistent exudation from canal

Apical limit of Obturation

- There seems to be a consensus among the huge majority of authors and clinicians that the best chances of success are observed when the filling material is restricted to the intraradicular space.
- Ideally, the apical limit of the Obturation should coincide with the apical limit of preparation. Thus, the core filling material should be well-fitted to the working length, while the very apical part of the canal, between the apical end of the core material and the apical foramen, may or may not be filled with sealer.
- One group of investigators observed the highest success rate (94%) in teeth with a root canal filling ending 0 to 2 mm short of the radiographic apex, a 76% success rate after overfilling and a 68% success rate in teeth with underfilling of more than 2 mm.



- A cross-sectional study confirmed that canals filled to 0 to 2 mm from the apex exhibited the best periradicular status, followed by overfilling and underfilling.

- It has been suggested that 0.5mm short of the radiographic apex is the length that provides the best outcome and that the success rate can be expected to decrease by 14% for every mm short of this length.
- In vital case, the apical extent of filling is not expected to significantly influence the outcome since bacteria is not present, provided that the clinician has maintained the aseptic chain during treatment. In previously infected cases, on the other hand, it is of paramount importance that the root canal procedures, including obturation, reach the very apical part of the canal close to its terminus.[6]
    a) Underfilled canals have a higher probability of failure than overfilled canals, especially if the segment apical to the obturation terminus was not instrumented, because bacteria located there are highly likely to be unaffected by the chemomechanical procedure. Because bacteria present in the apical canal are presumably directly involved in the causation and/ or maintenance of apical periodontitis, they can maintain a level of tissue injury that is sufficient to sustain disease if not eliminated by instrumentation that is too short of the apex.
    b) Overfilling can negatively influence the treatment outcome when associated with concomitant infection. This is related to lack of an adequate apical seal or previous extrusion of infected debris during over-instrumentation.
    c) However, one must realize that failure may occur even when apical segment was instrumented but not filled. Even if the bacterial counts have been reduced in this region, the empty space could be conducive to the accumulation of periradicular tissue fluids or exudates rich in

proteins and glycoproteins, which can provide a substrate for residual bacteria to grow and recolonize this unfilled apical segment.

d) Because most of contemporary root canal filling materials no longer exhibit significant toxicity after setting, they are usually unable to cause persistent inflammation that can cause or sustain an apical periodontitis lesion. When extruded through the apical foramen, sealers may be either solubilised in tissue fluids, phagocytosed or encapsulated by fibrous connective tissue, depending on the physico-chemical properties of the material.[6]

Obturation at the apical part of canal at its terminus

Under filling

Overfilling

WHY TO OBTURATE?

Why to Obturate?

- A canal should be obturated after preparation to block all the portal of entries into the root canal system through which microorganisms and their irritants enter the canal and cause re-infection.
- To seal the irritants left out in the canal, which cannot be removed by cleaning and shaping procedure.[3]

CLASSIFICATIONS

Classifications:

According to Dr. Louis I.Grossman:

1.Cold Lateral compaction

2. Warm compaction (warm gutta-percha)

(a) Vertical

(b) Lateral

3. Continuous wave compaction technique

4. Thermoplasticized gutta-percha injection

5. Carrier-based gutta-percha

(a) Thermafill thermoplasticized

(b)Simplifill sectional Obturation

6. McSpadden thermomechanical compaction

7. Chemically plasticized gutta-percha

8. Custom cone

According to John Ide Ingle:

1) Solid-Core Gutta-Percha with Sealants

A) Cold Gutta-Percha Points

a) Lateral Compaction

b) Variation of Lateral Compaction

B) Chemically Plasticized Cold Gutta-Percha

a) Essential Oils

i) Eucalyptol

ii) Chloroform

iii) Halothane

C) Canal Warmed Gutta-Percha

a) Vertical Compaction

b) Sectional Gutta-percha

c) Lateral Vertical Compaction

i) Endo-Tec

ii) Thermopact

d) Thermomechanical Compaction

i) Microflow, TLC, Engine Plugger & Maillefer Condenser

ii) J. S. Quick-Fill

iii) Canal Finder

iv) Ultrasonic

D) Thermoplasticized Gutta-Percha

a) Syringe Insertion

i) Obtura

ii) Ultrafil

b) Solid-Core Carrier Insertion

i) Thermafil

ii) Successfil

i) Silver Points

2) Apical Third Filling

a) Dentin Chips

b) Calcium Hydroxide

3) Injection or "Spiral" Filling

a) Cements

b) Pastes

c) Plastics

d) Calcium Phosphate

According to Stephen Cohen:

<u>Canal Obturation with a semi-solid material: Gutta-Percha</u>

1) Single-Cone Method

2) Lateral Condensation Method

3) Lateral and Vertical Condensation Method

4) Warm Lateral Condensation Technique

5) Sectional Method

6) Vertical Condensation Method with Warm Gutta-percha

7) Chloropercha Method

8) Modified Chloropercha Method

a) Johnston-Callahan Diffusion Technique

b) Nygaard-Ostby Technique

9) Gutta-percha-Eucapercha Method

10) Thermoplasticized Condensation Method

11) Thermoplasticized Gutta-percha Injection-molded Method

II) Canal Obturation with Pastes

1) Hydron, a hydrophilic plastic root canal filling

2) Pressure syringe Injection technique

3) N-2 and Related Pastes

III) Canal Obturation with Solid Materials

1) Silver Cones

a) Split/ Sectional Cone Technique

b) Technique with Improved Silver Cones

c) Technique with Apical Silver Cones

2) Stainless Steel files

3) Rigid Cones

a) Rigid Vitallium Cones

b) Rigid Chromium-Cobalt Cones

IV) Miscellaneous

1) Lee Endo-Fill

2) Dentin-Chips Apical-Plug Filling Technique

3) Calcium Hydroxide Pastes as Sealers and Apical Plugs

According to Bergenholtz

Solid core techniques

- Single cone
  - Simple
  - Quick
  - Good length control
  - Round standard preparation required

- Lateral compaction
  - Good length control
  - Not one compact mass of gutta-percha
  - Time-consuming technique
  - Supposed risk of root fracture

Softened core techniques

- Warm lateral compaction
  - Moderate length control
  - Time-consuming technique
  - Heat may damage periodontium
- Warm vertical compaction
  - Poor length control

- Sealer extrusion
- Heat may damage periodontium

- Injection – molded gutta-percha
  - Quick technique
  - Poor length control
  - Heat may damage periodontium
- Thermomechanical compaction
  - Quick technique
  - Poor length control
  - Heat may damage Periodontium
  - Instrument fracture risk
- Cone carrier
  - Quick technique
  - Sealer extrusion
  - Gutta-percha may be stripped off carrier in curvation
  - Difficult to remove for retreatment
  - In combination with posts, inconvenient technique
- Chloroform-resin
  - Quick technique
  - Potential health hazard effects on dental personnel with long-term use

According to Gutmann and Whitherspoon:

I. Solid core Gutta-percha with sealants

A. Cold gutta-percha points

- Lateral compaction
- Variations of lateral compaction

B. Chemically plasticized cold gutta-percha essential oils and solvents.

- Eucalyptol
- Chloroform
- Halothane

C. Canal warmed gutta-percha vertical compaction

- System B compaction
- Sectional compaction
- Lateral / Vertical compaction
    - Endotec II
- Thermo-mechanical compaction
    - Microseal System, Engine-plugger, Maillefer Condenser
    - Hybrid technique
    - J.S. Quick-Fill
    - Ultrasonic plasticizing

D. Thermoplasticized gutta-percha

- Syringe insertion
    - Obtura
    - Injection R-fill, back-fill
- Solid-core carrier insertion
    - Thermafil and Densfil

- Soft core and Three Dee GP
- Ultrafil

II. Apical third filling

- Light speed Simplifill
- Dentin – chip
- Calcium hydroxide

III. Injection or "Spiral" filling

- Cements
- Pastes
- Plastics
- Calcium phosphate

ARMAMENTARIUM FOR OBTURATION

ARMAMENTARIUM FOR OBTURATION

Main armamentarium for obturation consists of:

1. Absorbent paper points for drying the prepared root canal before applying sealer.
2. Endo organizer for arranging gutta-percha and accessory points of various sizes.
3. Endoblock for measuring gutta-percha points.
4. Lentulospirals for placing sealer.
5. Primary and accessory gutta-percha points.
6. Spreaders and pluggers for compaction of gutta-percha.
7. Endodontic locking tweezers.
8. Scissors for cutting gutta-percha.

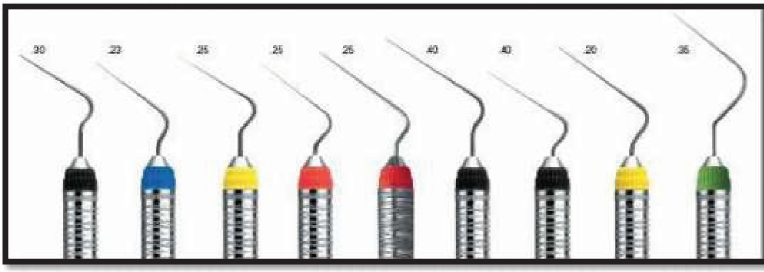
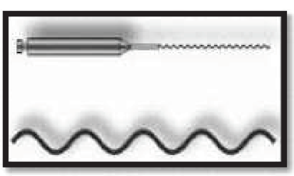
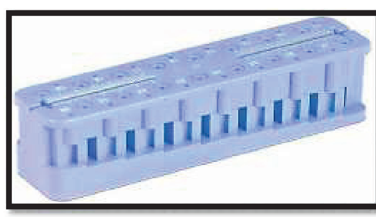


Fig 1. Standardized finger and hand spreaders, sized and color coded to match ISO instrument sizes

Endodontic locking tweezers





Lentulospirals for placing sealer   Endoblock for measuring Gp

points

Absorbent paper points for drying the prepared root canal before applying sealer

Fig 1.

METHODS OF OBTURATION

METHODS OF OBTURATION

Today, most root canals are being filled with gutta-percha and sealers. There are the two basic procedures: lateral compaction of cold gutta-percha or vertical compaction of warmed gutta-percha. Other methods are variations of warmed gutta-percha.

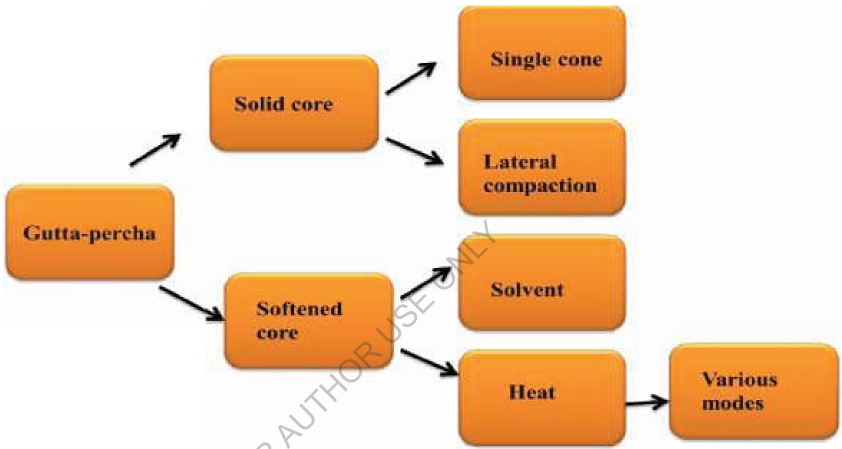


Fig 2. Outline of techniques to fill root canals with gutta-percha

Techniques of Obturation:

COLD LATERAL COMPACTION:

The lateral compaction of cold gutta percha points with sealer is the technique most commonly used by the practitioners and has long been the standard against which other methods of canal Obturation have been judged.

Indication:

1. Straight canals
2. Post- space preparation.

This technique encompasses first placing a sealer lining in the canal, followed by a measured primary point, that in turn is compacted laterally by a plugger-like tapering spreader used with vertical pressure, to make room for additional accessory points.

The final mass of points is severed at the canal's coronal orifice with a hot instrument, and final vertical compaction is done with a larger plugger. If executed correctly, solid canal Obturation will totally reflect the shape and diversions of the properly prepared canal network.

Lateral condensation can only be achieved if certain clinical criteria are fulfilled in canal preparation and instrument selection.[2]

Clinical criteria are as follows:

1. Sealer application on the canal walls can also be performed using lentulo-spiral or with the master gutta-percha cone itself.
2. The final canal shape should be a continuous taper, approaching parallel in the apical area, that matches the taper of spreader or plugger.
3. The spreader must reach within 1.0 to 2.0mm of the working length, an apical stop must be created to resist apically directed condensations.
4. The accessory gutta-percha cones must be smaller in diameter than the spreader/plugger.
5. Selection of master cone should be similar to the master apical file size.[1,2]

Lateral condensation is not the technique of choice in preparations that cannot meet these criteria and not all canals can be shaped to meet these criteria.[2]

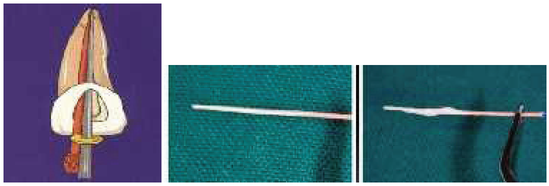
Technique:

Choose a spreader that can reach to working length or within 0.5mm (mark the length with rubber stopper) - fit in the canal. Isolate and dry the canal with paper points. A master cone or master gutta percha point (MGP) is selected fitted to the working length; snug fit at apical 3mm (TUG-BACK). A radiograph is obtained to verify the position of the master cone.

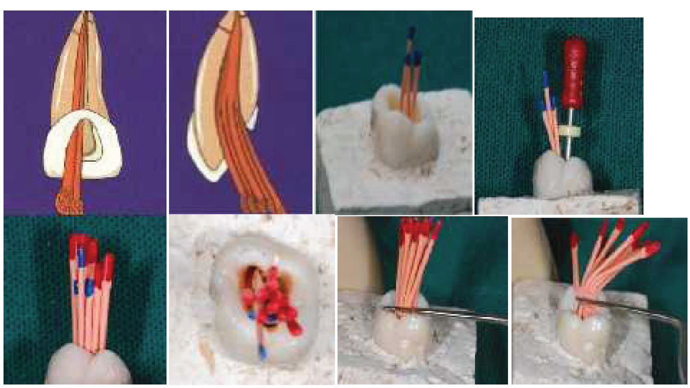
Coat the canal with sealer using master cone or lentulo-spiral and seat the master cone upto the working length. Place the hand or finger spreader alongside the master cone to a level 1mm short of working length and compacting the cone apically and laterally; and at the same time creating the space for the accessory cone.

The spreader is disengaged from the cone by rotating it between the fingertips or by rotating the handle in an arc. A sequential accessory cone is placed in the space created by the spreader. This procedure is continued until the spreader cannot penetrate into coronal 1/3rd of the canal.

A radiograph is obtained to verify that atleast the apical 2/3rd of the canal is adequately obturated (no voids). Excess coronal GP is seared off at the orifice & the coronally softened GP is compacted apically with a large plugger that can fit in the orifice. A final post-obturation radiograph is taken after placement of coronal restoration.



Thin coat of sealer



Accessory GP & Spreader selection

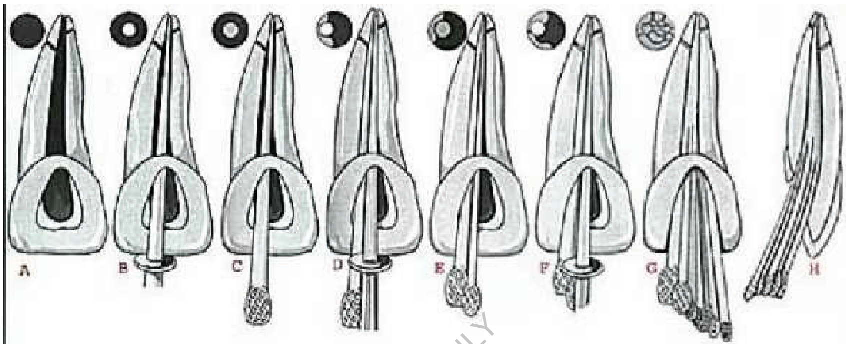


Fig.3 Summary of cold lateral compaction

Advantages:

1. Simple, relatively uncomplicated technique – requires simple armamentarium.
2. Length control
3. Provides good apical and lateral seal.
4. Can be performed in most clinical situations
5. Dimensional stability of the gutta-percha remains unaffected.

Disadvantages:

1. Time consuming.
2. Resultant Obturation is a series of sealer-welded cones and thus not a homogenous mass

3. Poor seal in irregular canals, open apex and those with internal resorption.
4. Presence of voids in the filling as the master cone and accessory points remain discrete.

VARIATIONS OF LATERAL COMPACTION

Modifications of the technique have been applied for filling the curved canals, immature apices or tubular canals.[2]

Curved Canals:

Virtually all canals exhibit some curvature. Over 40% of maxillary lateral incisors have a “breaking curve” in the apical third. Over 50% of the palatal roots of maxillary first molars curve back to the buccal. These are examples of the apical curves. General root curvature is apparent radiographically in most of the posterior teeth. Many “hidden” curves to the buccal or lingual cannot be seen radiographically in anterior teeth. Lateral compaction of curved canals can be very effective in most cases. It may be difficult, if not impossible, in severely curved, dilacerated, or bayonet canals.

If smaller, more flexible spreaders cannot reach within the apical 1 mm, or the taper of the preparation is less than that of the spreader, then lateral condensation is not the technique of choice. Teasing a flexible primary point smaller than size 30 to place at the apex, or expecting a stiff spreader to reach within 1 mm of the working length, precludes the use of proper lateral compaction.

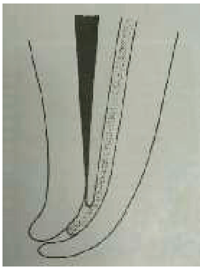


Fig. 4 lateral compaction of primary GP point in curved canals.spreader catches into point, forcing it apically

The other techniques that use warmed or thermoplasticized gutta percha are more applicable. In the vast majority of curved canals, where lateral compaction is applicable, the routine is exactly the same: sealer placement and primary point placement, followed by spreaders and auxiliary points.

Consequently, the master point should be placed 2 mm short of the apical terminus to be pushed into place by vertical as well as lateral force of the spreader. Small flexible spreaders should be used in case they have to follow the curve.[2]

Immature Canals and apices

The immature canal is complicated by a gaping foramen. The apical opening is either a non-constrictive terminus of a tubular canal or a flaring foramen of a blunderbuss shape.

Every effort should be made to attain the apical closure by “Apexification”. In case apexification fails or is inappropriate, special methods must be employed to obturate the canals without benefit of the constrictive foramen serving as a confining matrix against which to condense.[2]

Tubular Canals

The large tubular canal with little constriction at the foramen may best be filled with a ‘coarse’ primary gutta-percha cone that has been blunted by cutting off the tip.

Sometimes the canal is such that a large "tailor-made" point must be used. In either case, the 'trial point' should pass the tests of proper fit. The objective of the primary point is to block the foramen, as far as possible; while auxiliary points are condensed to complete the filling. The length of tooth must be marked on the spreader so that it will not be forced out of the apex. With care, a well compacted filling may be placed without gross overfilling of either cement or gutta-percha. Warm gutta-percha techniques should be considered in larger canals after the apical seal has been achieved by customizing or lateral compaction.[2]

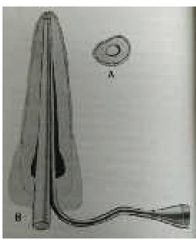


Fig.5

A. Cross section of tubular canal in young tooth, ovoid in shape.
B. Blunted , "coarse"GP or tailor-made cone used as primary point, followed by spreader and additional points

INVERTED CONE TECHNIQUE

The particular type of canal for which this method of filling is most applicable is the tubular canal found in the tooth that has suffered early death of the pulp, or one that has been re-corrected by apexification.

As a primary point, a coarse gutta-percha cone is selected and the serrated butt end of the point is carefully removed with a scalpel. The point is inverted and tried in the canal, it should visibly go to the full depth, but stop dead just short of the apex. It should exhibit "tugback" when an attempt is made to remove it. Finally, it should appear in the radiograph to be in optimum position to obliterate the foramen area of the canal.

If the inverted point is thought to fill correctly the requirements of a primary point, the canal is liberally coated with the sealer, and the coated point is slowly pushed to full position. This point may act as a plunger because of the shape of the canal and the tight fit of the point. The patient may complain of discomfort of air evacuation; however, if the point is placed slowly, relatively little cement will be forced into the periradicular tissue.

When the primary inverted point is in place, additional gutta percha points should be carefully added by lateral condensation with the spreader. It is most important at this time to mark the length of the tooth on the spreader, so that the instrument does not penetrate into the periradicular tissue. The spreader is used repeatedly, followed by auxiliary gutta-percha points until the canal is totally obliterated.

The common error in this technique is an outgrowth of fear of overfilling. Insufficient pressure applied during lateral condensation, results in poorly condensed filling, which in turn allows subsequent leakage and invites failure.[2]

TAILOR MADE GUTTA PERCHA ROLL

If the tubular canal is so large that the largest inverted gutta percha point is still loose in the canal, a tailor made gutta-percha point must be used as a primary point. This point may be prepared by warming a number of gutta-percha points and combining them, “butt to tip” pressing and twisting them together to form a bundle.

The slightly warmed gutta-percha cones are rolled between two sterile glass slabs held at an angle to make a cone with a diameter approximately the size of the canal. If the angle of the slab is too large for the canal, the cone is re-warmed and re-rolled to a small diameter. Care has to be taken so that no voids exist in the mass. After the cone is allowed to cool and harden or is chilled with a spray of ethyl chloride, the apical end of the stiffened point is softened superficially by flash dipping the point in chloroform, eucalyptol or halothane. The softened cone is inserted with a few gentle pumping motions until it reaches the working length. A mark is made on the buccal aspect of the cone, and it is dipped in alcohol to stop the action of this solvent. Alcohol can also be used to assist in drying the canal prior to filling. The customized cone is a replica of the internal shape of the canal and should be inserted in the same path and position when cemented.[2,10]

The rolled gutta-percha should be tested for tugback and by means of the radiograph. The gutta-percha protruding from the crown should then be severed at the base of the pulp chamber with a hot spoon excavator, so the spreader can be introduced. The spreader should be marked just short of the working length of the tooth. Lateral compaction is necessary in conjunction with the customized or tailor-made gutta-percha roll, to ensure complete obliteration of the canal space. [2,10]

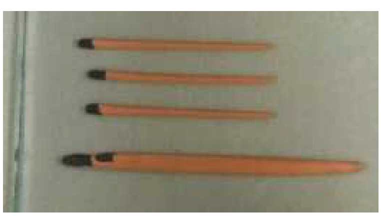


Fig6. Several GP points heated and rolled together, using a spatula or two glass slab

Simpson and Natkin have suggested a specialized filling technique for those teeth with tubular canals but closed apices. The canal is initially filled with a warmed and softened tailor made gutta-percha roll cemented to place, and severed at the canal orifice with a hot spoon excavator. Using a heavy plugger, the gutta-percha is forced to the apex and compacted to place. Pressure with the plugger will leave a void in the center of the mass, when the plugger is removed with a twisting motion. The plugger is dipped in oxyphosphate of zinc powder to prevent sticking, and then used to collapse the gutta-percha into the space created by the initial plugging. If the gutta-percha begins to set, the plugger is heated to better compact the filling. With heavy vertical pressure, the entire root canal is obturated and the excess gutta-percha seared off at the gingival level.[2,26]

Advantages:

1. Deep spreader penetration minimizes apical leakage and percolation.
2. Positive dimensional stability of the root canal filling.
3. Less likelihood of carrying filling material beyond the root apex.

Disadvantages:

1. Presence of voids.
2. An Increased sealer : gutta-percha ratio when compared to the thermoplasticized techniques.
3. Voids in intracanal defects and lateral canals.
4. Less homogenous mass.
5. Time consuming.

A number of measures have been reported to enhance gutta percha adaptation and density in lateral condensation.

Examples include:

- Warming spreaders before each use in a hot bead sterilizer.
- Softening gutta percha with heat before insertion of the cold spreader.
- Mechanical activation of finger spreaders in an endodontic reciprocating handpiece.
- Application of an ultrasonically energized spreader.
- Application of an engine-driven thermomechanical compactor which creates frictional heat and advances the material apically within the canal.[7]


Fig 7.

Figure shows a complex canal system filled by lateral condensation, supplemented with ultrasound.

CHEMICALLY PLASTICIZED GUTTA PERCHA

A modification of the lateral compaction technique involves the use of a solvent to soften the primary gutta-percha point in an effort to ensure that it will better conform to the aberrations in apical canal anatomy.

Indications:

1. Lack of apical stop
2. Large or irregular apical portion of the canal

Gutta-percha solvents used:

Chloropercha

Kloropercha-gutta-percha+Canada-balsam+resin+zinc oxide eugenol

Eucapercha

Chloropercha Method:

Chloropercha is gutta percha in chloroform. The chloropercha paste has been used by some clinicians as the sole root canal filling material. As such, the technique is unsound because of the excessive shrinkage of the filling after evaporation of chloroform. However, if used as a sealer with a well fitted primary cone, chloropercha can fill accessory canals and the root canal space successfully. The technique is useful in cases of perforations and in filling unusually curved canals that cannot be negotiated, or in canals with ledge formations. [8]

MODIFIED CHLOROPERCHA METHODS:

Johnston-Callahan Method:

Johnston modified the Callahan chloropercha technique to develop the Johnston-Callahan diffusion technique. In this method, the canal is repeatedly flooded with

95% alcohol and then dried with absorbent points. It is then flooded with Callahan's 'rosin chloroform' solution for 2-3 minutes.

More chloroform is added, if the paste becomes too thick by diffusion or evaporation. A suitable gutta percha cone is inserted and compressed laterally and apically with a stirring motion of the plugger until the gutta-percha is entirely dissolved in chloroform rosin solution in the canal.[4]

Additional points are inserted, one at a time, and dissolved in the same way. A plugger is used to apply lateral and vertical pressure to force the chloropercha into the accessory canals and multiple foramina. Care must be exercised to prevent overfilling, because freshly prepared chloropercha is toxic before evaporation.

The problem with this technique is use of too much of solvent. As chloroform evaporates from the chloropercha, it causes a significant dimensional change of the filling, and a possible loss of apical seal. [2,23,24]

Nygaard-Ostby Method:

This is a modified chloropercha method made by adding a preparation of finely ground gutta-percha, Canada balsam, colophonium and zinc oxide powder mixed with chloroform in a dappen dish/ water glass.

After the canals are coated with Kloroperka, the primary cone dipped in the sealer is forcefully inserted apically, pushing the partially dissolved tip of the cone to its apical seat. Additional cones dipped in the sealer are packed into the canal to obtain a satisfactory filling.

Nygaard-Ostby suggested that to avoid overfilling, additional lateral condensation with the use of spreader is delayed till a subsequent appointment.[2,10]

Gutta-percha-Eucapercha Method:

At one time there was a concern that chloroform was carcinogenic, but later it was cleared for clinical use in dentistry by the FDA, OSHA and ADA. In any event, other solvents, eucalyptol and halothane became popular as substitutes for chloroform.

Eucalyptol is derived from eucalyptus trees, and is the main constituent of eucalyptus oil. It has much less local tissue toxicity than does chloroform, and is used in medicine as a decongestant and rubefacient. Drawbacks to the use of eucalyptol are slower action, the requirement of heating for use and higher expense (Wourms et al,1991). Eucalyptol can be heated up to about 30°C (86°F) in a dappen dish, and it dissolves gutta-percha into eucapercha in about a minute. Eucalyptol is reported to have antibacterial and anti-inflammatory properties.[8]

Technique:

The endodontic cavity preparation is done as usual, to obtain a smooth tapered preparation. Since the gutta-percha-eucapercha can be diffused and made to flow into narrow and curved canals, the endodontic preparation does not have to be very extensive apically. The apical preparation is done with a 25 or 30 # File. Preparation should present a definite apical preparation, to prevent an undue amount of eucapercha from being forced beyond the confines of the root canal system.

The primary cone should be fitted very tight to about 1.0 to 1.5 mm short of the radiographic apex; it should possess a definite "tugback". The canal patency is evaluated. The large well of the dappen dish is filled about 2/3[rds] full with eucalyptol. The gutta-percha segments are placed in the eucalyptol. The dappen dish is held with pliers over the flame of an alcohol lamp or Bunsen burner for 20-30 seconds. The contents are stirred with a plastic instrument until gutta percha segments are dissolved, the eucapercha mixture turns into a cloudy mass. The apical 1/2 of the prefitted primary cone is dipped into the warm eucapercha mix and rotated for 30-45 seconds. A primary cone can be dipped in warm eucapercha for about a minute without losing its basic shape. The eucapercha cone is inserted into the canal until the mark on the gutta-percha coincides with the operating landmark on the incisal or occlusal surface.

Fig 8.

Vertical and lateral condensation is then done to complete the filling procedure. On occasion, a few drops of warm eucalyptol can be added to the pulp chamber to help soften the filling mass and move the gutta-percha-eucapercha apically. Prefitted and premeasured pluggers are used for vertical condensation. Additional accessory cones are added and fused to the gutta-percha-eucapercha mass to fill the entire canal system three dimensionally.

The gutta-percha-eucapercha technique, if carried out properly, can effectively fill the lateral and accessory canals. However, the fine canals will not appear as radiopaque as when the gutta-percha is used in conjunction with root canal cement sealer containing barium sulfate.[8]

Disadvantages of chemically plasticized gutta-percha obturation technique:

1. Shrinkage of the apical portion of the gutta-percha, which leads to microleakage (due to solvent evaporation)
2. Could cause apical tissue irritation
3. Gutta-percha might extrude beyond the apex.

II WARM COMPACTION METHOD

A. WARM VERTICAL COMPACTION:

Its origins are diverse with initial codification of its essentials by Berg in 1953, and technique popularized by Schilder in 1967. It is also called a Warm sectional technique, Vertical compaction with warmed gutta-percha, or the Schilder technique and multiple wave obturation technique.

Schilder introduced the concept of cleaning and shaping root canals in a conical shape, and then obturating the space 'three-dimensionally' with gutta-percha, warmed in the canal and compacted vertically with pluggers. It was his contention that all the "portals of exit" were clinically significant and would be obturated with a maximum amount of gutta-percha and a minimum amount of sealer.[2]

Indications:

1. As an alternative to cold lateral compaction technique.
2. When the fitting of a conventional master cone to the apical portion of a canal is impossible.
3. Ledge formation, perforation or unusual canal curvatures or large lateral

canals.

4. Internal resorption.
5. Root end induction.

Schilder's Objective:

- A continuous tapering funnel should be present from the root canal orifice to the root apex.
- The root canal should be prepared so that it flows with the shapes of the original canal.
- The shape of the apical foramen should not be changed or moved.
- The apical foramen should be kept as small as is practical so that excess gutta-percha will not be forced through it during vertical compaction.[1]

Fitting the Master Cone:

Following the preparation of a thoroughly cleansed and continuously tapering canal, the critical step of fitting the master cone is the next important feature of this technique. For this, the conventional cone-shaped gutta-percha points are used, not the standardized numbered points. The cone-shaped gutta-percha more closely mirrors the tapered canal shape.

The cone is placed to reach the radiographic terminus and then cut back slightly short (0.5–1.0 mm) of this length. This allows heat molding of the round cone into the non-round portal of exit.

Cleaning, shaping and obturation are clinically inseparable. When the gutta-percha is subsequently warmed and compacted, it fills not only the critical parts of the canal, but the cleaned portals of exit as well.

When compacted, the primary cone provides the body of the warm “wave of compaction” moving apically and then a warm wave of compaction moving coronally. The cone must fit tightly in the apical third, that is, have “tugback,” and have diminished taper toward the middle and coronal thirds as well. It is typical of vertical compaction that more than one portal of exit per canal will be filled.

Although gutta-percha is a poor conductor of heat, it can be softened by heat over a range of 4-6 mm and vertically condensed till the root canal system. The apical extent to which the gutta-percha can be compacted is dependent on the quantity and depth of heat transmitted and the force of condensation.

The thermo softening of gutta-percha is governed by the amount of heat used. This varies in direct proportion to the proximity and intensity of the heat source, the frequency of the heating cycle and the volume of the gutta-percha in the canal. There is virtually no risk of packing too short or too long, if the first cone fits properly. The thermo-softened gutta-percha as used in this technique has been shown to expand 1-2%.

A recent study showed that the warm gutta-percha shrinkage upon cooling is on the order of 0.45%. To counterbalance the effect of dimensional changes, when the gutta percha is softened, a continuous condensation force must be exerted during cooling.[2,25]

Prefitting the Vertical Pluggers

A set of pluggers designed by Schilder (Dentsply/Maillefer; Tulsa, Okla.), a wider plugger for the coronal third of the canal, a narrower plugger for the middle third, and the narrowest plugger for the apical third of the canal are used in the process.

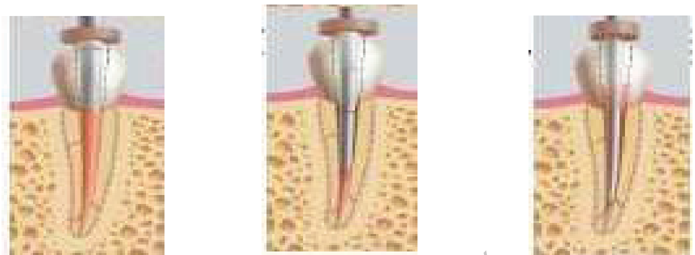


Fig. 9

The objective is that the widest appropriate plugger capture the maximum cushion of warm gutta-percha as the heat wave is carried apically. Only one or two pluggers may be needed for shorter teeth, whereas three or four are used in longer canals. Most cases require three graduated sizes. Schilder pluggers are marked with serrations every 5 mm, so that the depth which each instrument penetrates should be recorded. The pluggers are then set aside for immediate use.[2,26]

Heat Transfer Instrument:

Initially, an instrument designed much like a spreader was used to transfer heat from a bunsen burner to the gutta-percha. It was heated "cherry-red," immediately carried into the canal, submerged into the mass of gutta-percha, and drawn through the gutta-percha for 2 or 3 seconds to allow the heat to transfer from the heat carrier. It was then withdrawn in a slightly circular wiping motion, freezing some of the gutta-percha onto the heat carrier. Successive waves of vertical compaction immediately followed the previous carrier.[2]

The Schilder heat carrier has been essentially superseded by the Touch 'n Heat 5004 (SybronEndo/Analytic; Irvine, Calif.), an electronic device specially developed for the warm gutta-percha technique. It exhibits the same thermal profile as the original heat carrier but has the advantage of generating heat automatically at the tip of the instrument. [2]

In addition to selecting pluggers for vertical compaction, a heat transfer instrument (0 or 00 Caulk/ Dentsply, Milford, Del.; Hu-Friedy Co., Chicago, III.) or a heating instrument (Touch n' Heat, EIE/Analytic technology, San Diego Calif.) is chosen to remove segments of the gutta percha during the compaction apically or to heat and add segments of gutta percha during the compaction of the coronal portion of the canal.

Step By Step Procedure:

Dry the canal with paper points and confirm the patency of the foramen with an instrument smaller than the last size instrument used to develop the apical preparation.

Fit the appropriate gutta-percha cone to the patent radiographic terminus to exhibit tug-back. Confirm the position radiographically. Cut off the butt end of the cone at the incisal or occlusal reference point.

Remove the cone and cut back 0.5 to 1.0 mm of the tip, reinsert, and check the length and tugback. The cone's apical diameter should be the same diameter as the last apical instrument. Remove the cone, curve if necessary and set it aside.

Prefit the three pluggers to the canal preparation: first the widest plugger to a 10 mm depth; next, the middle plugger to a 15 mm depth; finally, the narrowest plugger to within 3 to 4 mm of the terminus. Record the lengths of the desired plugger depth.

Lightly coat all of the walls with root canal sealer. Coat the apical third of the gutta-percha cone with a thin film of sealer. Grasp the butt-end of the cone with cotton pliers and slide the cone approximately halfway down the canal. Then gently follow it fully into place with the closed tip of the cotton pliers .In a curved canal, the cone will rotate as it responds to the curvature.

Using a hot spoon excavator or the Touch n' Heat 5004 Heat carrier, sear off the cone surplus in the pulp chamber down to the cervical level. This transfers heat to the coronal third of the gutta-percha cone.

Using the widest vertical plugger that has previously been coated with cement powder as a separating medium, the gutta-percha is folded into a mass and compacted in an apical direction with sustained 5 to 10 second pressure.

This is the first heat wave. The temperature of the gutta-percha has been raised 5 to 8°C above body temperature, which allows deformation from compaction. At this temperature (42 to 45°C), the gutta-percha retains its same crystalline beta form with minimal shrinkage as it cools back to body temperature.

The second heat wave begins by introducing the heat carrier back into the gutta-percha, where it remains for 2 to 3 seconds, and when retrieved, carries with it the first selective gutta-percha removal.

Immediately, the midsized coated plugger is submerged into the warm gutta-percha. The vertical pressure also exerts lateral pressure. This filling mass is shepherded apically in 3 to 4 mm waves created by repeated heat and compaction cycles.

The second heating of the heat carrier warms the next 3 to 4 mm of gutta-percha and again an amount is removed on the end of the heat carrier.

The narrowest plugger is immediately inserted in the canal and the surplus material along the walls is folded centrally into the apical mass so that the heat wave begins from a flat plateau. The warmed gutta-percha is then compacted vertically, and the material flows into and seals the apical portals of exit.

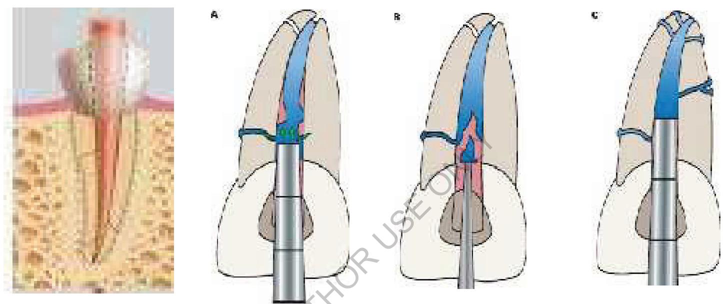
After completing the apical "down-pack", if a post is to be placed at this depth, no more gutta-percha is added.

"Backpacking" the remainder of the canal completes the obturation. The classic method of backpacking consists of placing 5 mm precut segments of gutta-percha in the canal, cold welding them with the appropriate plugger to the apical material, warming them with the heat-carrier, and then compacting. It should be noted that no selective removal of gutta-percha is attempted in the backpacking. This sectional procedure is continued with heat and the next wider plugger until the entire canal is obturated.

An alternative method of backpacking may be done by injecting plasticized gutta-percha from one of the syringes, such as Obtura II (Obtura/Spartan, USA). In any event, the plasticized gutta-percha must be compacted with vertical pluggers to ensure its flow against canal walls, to weld it to the apical materials, and to minimize shrinkage.

The final act involves the thorough cleansing of the pulp chamber below the CEJ, placement of an appropriate barrier and permanent restoration.

In molar teeth, extra sealer should be placed in the chamber area, warm gutta-percha is syringed into the chamber floor, and the gutta-percha is compacted with large amalgam pluggers to ensure that any furcal portals of exit will be filled prior to final restoration.[2]



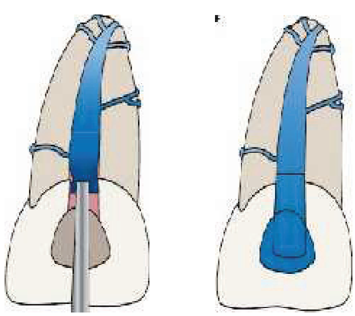


Fig 10. Summary of Warm Vertical Compaction

Advantages:

1. Excellent seal of the canal apically and laterally.
2. Dense obturation
3. Obturation of the larger lateral and accessory canals.

Disadvantages:

1. Time consuming
2. Difficulty of length control.
3. Risk of vertical root fracture resulting from undue force
4. Periodic overfilling with gutta-percha or sealer that cannot be retrieved from the periradicular tissues.
5. Somewhat larger canal preparation is necessary to allow manipulation of instrument.
6. Heated instrument may burn soft tissues.

SYSTEM B: CONTINUOUS WAVE OF OBTUATION:

Buchanan has developed a variation of warm gutta-percha vertical compaction technique, a variation of that he perceives as

faster and more accurate. Concerned with the complexity and time consumed in completing an obturation, he retained the principles of vertical compaction but improved the methodology.

Working with Analytic Technology, which had developed the Touch ’n Heat device for warming gutta-percha in the canal, Buchanan and Analytic perfected the System-B Heat Source and associated pluggers (SybronEndo/Analytic; Irvine, Calif.). This new heat source monitors the temperature at the tip of the heat-carrier pluggers, thus "delivering a precise amount of heat for an indefinite time."

System B obturation is predicated on a precise preparation, perfectly tapered to match as closely as possible the shape of the non-standardized gutta-percha cones-fine, fine-medium, medium, and medium-large (F, FM, M, and ML). Another Buchanan/Analytic development is gutta-percha cones that match the shape produced during canal preparation using Greater Taper instruments.[2]

Advantages:

1. System uses thermostat where temperature can be controlled.
2. Dense Obturation.
3. Gutta percha flows three dimensionally into accessory canal and canal irregularities.

Disadvantages:

1. Increased risk for extrusion
2. Temperature to which gutta-percha is heated may be detrimental to the periodontium.

Downpack Technique :

"ContinuousWave Technique requires good canal shape and meticulous gutta-percha cone fitting. The cone must fit in its last 1 mm, and fit to full length before minimal cutback (less than 0.5 mm)." The cone is then removed and the corresponding plugger is tried for size in the canal. It should stop at its "binding-point," about 5 to 7 mm short of the working length. The stop attachment is then adjusted at the coronal reference point and the plugger is removed and attached to the Heat Source. The canal is dried.

The primary point is coated with sealer and pushed into place, all the way to the apical stop. The Heat Source is activated, set for “use” and “touch,” and the temperature is set for 200°C and the power dial at 10.

The cone is then seared at the orifice with the preheated plugger tip, and the preheated plugger is then “driven” smoothly through the gutta-percha to within 3 to 4 mm of its binding point in the canal. This will take about 2 seconds. Maintaining apical pressure, the plugger will continue to move apically, and at this time the heat switch is released.

The plugger is held there, cold, under sustained pressure, for an additional 10 seconds. It is during this period the gutta-percha flows to the apical matrix and into accessory canals. The pressure also compensates for the shrinkage that might occur as the mass cools. To remove the plugger while still maintaining apical pressure, the heat switch is activated for only 1 second

followed by a 1-second pause. The “cold” plugger is then quickly withdrawn. Following radiographic confirmation, the remainder of the canal is now ready for backfill. [2,27]

Backfill Technique:

Using the same size gutta-percha cone and plugger, the cone is coated with sealer and positioned in the backfill space in the canal. The System B temperature is now set at 100°C.

Preheat the plugger out of the canal for only 1⁄4 second, cut the heat, but immediately plunge the plugger into the backfill cone and hold it in place for 3 to 5 seconds as the gutta-percha cools. Another cone is added in the backfill space and heat is again applied. The final plugging is done with a large cold regular plugger.

Another method of backfilling is to use the Obtura II gutta-percha gun. To date there have been few reports on the success of the System B Technique. On the other hand, concern has been expressed about the 200°C heated plugger so near the thin root at the apex. The short period of time this high heat is delivered, however, seems to preclude any periodontal damage.

It is claimed by the manufacturer that the system B heat source allows sufficient heat for the apical gutta percha to be softened and adapted to the irregularities of the intracanal anatomy. However, previous studies have found poor adaptation of gutta percha to the canal walls in the important apical part of the canal (Villegas et al.) and negligible increase in the temperature of the gutta percha at the apical end of the canal (Goodman et al, 1981, Blum et al, 1997, Sweatman et al, 2001) when Sysem B was used following the manufacturer's instruction.[2]

J.C. Villages, T Yoshioka, Ch. Kobayashi & H Suda determined intracanal temperature rise 2 and 4 from the working length (WL) accessory to obtain good replication of intracanal anatomy when the system B heat source was used to fill a split-tooth model. Positioning the plugger close to WL and a temperature rise of 6 degree Celsius were necessary to obtain replication of intracanal anatomy.[16]

Chris J, Bowman and J. Craig Baumgartner evaluated the movement of gutta percha into lateral grooves and depressions in the apical 7mm of root canal by using system B heat source for the continuous wave of condensation and the Obtura II for the backfill. A split tooth model was constructed with lateral grooves and dentin depressions prepared at 1, 3, 5, ND 7mm from the working length. The study included three experimental groups with 10 obturations in each group. Group A – System B fine heat plugger used at 5mm from WL, group B - System B fine plugger used at 4mm from WL: and group C- System B fine plugger used at 3mm from WL. Group C had statistically better movement of gutta percha into the 1mm dentin depression than either group A (P=0.0005) or group B (P=0.0025) and better movement of gutta percha into the 3mm dentin depression that group A. A significant difference in gutta percha flow into the lateral grooves was seen at 3mm from WL with group C (P<0.0001). Group C demonstrated gutta percha in the grooves, whereas both groups A and B had no gutta percha in the grooves.[17]

P. R Cathro & R.M. Love compared the proportion of gutta percha , sealer and voids following the filling of simulated root canals in plastic blocks using two warm gutta percha techniques, Microseal and System B/ Obtura II Obturation techniques. The Microseal technique produced a heterogenous consisting of the Microseal Master cone and gutta percha from the Microflow Catridge mixed with sealer . The system B/ Obtura II technique produced a homogenous at all levels.[18]

Fig 11. Device used for continuous wave of Obturation : System B, Touch n Heat

MODIFICATION OF WARM VERTICAL COMPACTION:

WARM/SECIONAL GUTTA PERCHA OBTURATION:

The use of small warmed pieces of gutta-percha, the so-called sectional obturation technique, is one of the earliest modifications of the vertical compaction method described earlier. Webster might well have been describing this procedure in 1911 when he spoke about filling "with gutta-percha, using points heated and well packed in with hot instruments." Eventually this became known as the "Chicago" technique since it was widely promoted by Coolidge, Blayney, and Lundquist, all of Chicago. It was also the favourite technique of Berg of Boston.[2]

The method begins like other methods-fitting the plugger to the prepared tapered canal. It should fit loosely and extend to within 3 mm of the working length. A silicone stop is then set on the shaft marking this length.

Next, the primary gutta-percha point is blunted and carried to place. It should be fitted 1 mm short of the working length and confirmed radiographically. Upon removal, 3 mm of the tip of the point is cleanly excised with a scalpel, and this small piece is then luted to the end of the warmed plugger.

Sealer is placed lining the canal, the gutta-percha tip is warmed by passing it through an alcohol flame, and it is then carried to place. Under apical pressure, the plugger is rotated to separate the gutta-percha and it is thoroughly packed in place. At this point, it is best to expose a radiograph to be sure the initial piece is in position.

If so, the remainder of the canal is filled in a like manner, compacting additional pieces of warmed gutta-percha until the canal is filled to the coronal orifice. If a post is planned, the compaction can stop after the second piece, leaving 5 to 6 mm of apical canal filled.

Another variation of heat-softening the gutta-percha is to soften each piece in chloroform or halothane in a 'quick dip'. Rather than laboriously adding sections of gutta-percha, backfilling may be done with thermoplasticized gutta-percha from one of the gutta-percha guns.

This technique is useful in filling tube-type canals or severely curved canals, but requires a very precise length control by the clinician. If too much pressure is used, the apical section of gutta percha may be forced into the periapical space or vertical root fracture may result.[2,28]

Advantages:

1. It provides good lateral and apical seal.

Disadvantages:

1. Time consuming and difficult technique.
2. Presence of voids between sections.
3. May result in overfilling.

LATERAL/VERTICAL COMPACTION OF GUTTA PERCHA:

Martin developed a device in which he incorporated the best qualities of both, lateral compaction and vertical compaction of warm gutta percha techniques. The device called Endotec II (Medidenta Inc; Woodside, N.Y) is battery- powered, heat controlled spreader/ plugger that ensures complete thermo-softening of any type of gutta percha. The quick-change, heated tips are sized equivalent to a No. 30 instrument, are autoclavable, and may be adjusted to any access angulation. Martin claims that the "Endotec combines the best of the two most popular obturation techniques: warm/vertical and the relative simplicity of lateral compaction" (H. Martin, personal communication, December 1999).[2]

Canal cleaning and shaping for this technique is a continuous taper design with a definite apical stop. After the primary point is fitted to full working length, the hand spreader and the Endotec plugger/spreader are fitted as well. At this point, silicone stops are placed to mark the length of canal. After drying of the canal, a limited amount of sealer is applied.

The primary point is then firmly positioned and gently adapted with a hand or finger spreader. It has also been recommended that one or two additional gutta-percha points be placed to reduce the possibility that the warm plugger will loosen the point when the tip is retracted. At this juncture the Endotec plugger is placed in the canal to full depth. The activator button is pressed and the heating plugger is moved in a clockwise motion.

The heat button is then released and the plugger cools immediately. It is now removed from the gutta-percha with a counter-clockwise motion. This lateral compaction has formed a space for an additional point to be added, after which the plugger is again placed, heated, moved clockwise for 10 to 15 seconds, cooled, and retracted counterclockwise. Now the plugger can be used cold to compact the softened gutta-percha, followed again by warming and lateral space preparation for additional points.

The Endotec can also be used to soften and remove gutta-percha for post preparation or in the event of retreatment. An Air Force group also found they could measurably improve compaction while obturating a mandibular molar with a C-shaped canal by using the EndoTec in what they termed a "zap and tap" maneuver: preheating the Endotec plugger for 4 to 5 seconds before insertion (zap) and then moving the hot instrument in and out in short continuous strokes (taps) 10 to 15 times. The plugger was removed while still hot, followed by a "cold spreader with insertion of additional accessory points."[2,29]

Fig 12. Endotec device

Procedure:

Thorough canal cleaning and shaping with continuous taper design and a definite apical stop is attained. After the primary point is fitted to full working length, the hand spreader and the Endotec plugger/ spreader are fitted as well. At this point, silicone stops are placed to mark the length of the canal.

After drying the canal, a limited amount of sealer is applied. The primary point is then firmly positioned and gently adapted with a hand / finger spreader. One or two additional gutta-percha points are placed alongside the primary points, to reduce the possibility of loosening the point on retraction of the tip of the warm condenser.

At this juncture, the Endotec plugger is placed in the canal to full depth. The activator button is pressed, and the heating plugger is moved in a clockwise motion. The heat button is then released and the plugger cools immediately. It is now removed from the gutta percha with a counterclockwise motion.

This lateral compaction forms a space for an additional gutta percha point; after which the plugger is placed again, heated moved clockwise for 10-15 seconds, cooled and retracted counterclockwise. The same procedure is repeated - adding, spreading and condensing several gutta-percha points until the canal is compactly filled.[15]

The Endotec can also be used to soften and remove gutta-percha for post preparation or in the event of retreatment.

Liewehr F. R. et al (1993) observed improved compaction while obturating a mandibular molar with a C-shaped canal by using Endotec in a "zap and tap" maneuver - preheating the Endotec plugger for 4-5 seconds before insertion (zap) and then moving the hot instrument in- and -out in short continuous strokes (tap) 10-15 times. The plugger was removed while still hot, followed by a "cold spreader with insertion of additional accessory points."

A significant advantage of Endotec warm lateral condensation technique is its ability to soften and coalesce several gutta-percha points in the canal. In the traditional lateral condensation technique, the gutta-percha points are merely laminated together, leaving possible voids for potential leakage. With the Endotec warm lateral condensation technique, the gutta-percha is fused and compacted into a denser, more homogenous mass creating a three dimensional obturation of the root canal space.

The Down Pak- 3D Obturation with heat and vibration:

The Down Pak is an innovative device recently introduced and this allows three dimensional obturation with heat and vibration. The Down Pak is cordless and designed with a multifunctional, endodontic heating and vibrating spreader device and can be used for both warm vertical and lateral condensation techniques.

It is suitable for use with Gutta-percha, Resilon, and current Hybrid resin filing materials. It is versatile device. Down Pak offers a wide selection of tips in nickel titanium and ultrasoft stainless steel. The heat carrying instruments are consistent with tapered root canal preparations.

The system also offers two tips for cautery or removal of plastic obturator handles. Vibration has been shown to increase gutta-percha fill density.

Studies have shown that Down Pak's combination of heat and vibration resulted in a denser more compact filling of the root canal space. It is claimed that the system works with all warm condensation techniques and may even benefit cold lateral techniques when using the only vibration feature.

THERMOMECHANICAL GUTTA-PERCHA OBTURATION:

McSpadden introduced an automatic technique using thermatic condensation of gutta-percha in 1979.

Initially called the McSpadden Compactor, the device resembled a reverse Hedstroem file, or a reverse screw design. It fit into a latch-type handpiece and was spun in the canal at speeds between 8,000 and 20,000 rpm. At these speeds, the heat generated by friction softened the gutta-percha and the design of the blades forced the material apically. In experienced hands, canals could be filled in seconds.

Fragility and fracture of the instruments, along with overfilling because of the difficulty in mastering the technique, led to its failure. [2]

Later in Europe, Maillefer modified the Hedstroem-type instrument as the Gutta-Condenser, and Zipperer (Germany) called its modification as the Engine Plugger. The latter more closely resembled an inverted K-file. [2]

McSpadden, in the meantime, modified his original patent and brought out a newer, gentler, slower-speed model. It is now supplied as an engine-driven instrument made of nickel titanium and presented as part of the Microseal System (Analytic/ Quantec, USA). Because of their flexibility, the NiTi condensers may be used in curved canals.[2,30]

The Microseal Condenser is used in conjunction with heat-softened, alpha phase-like gutta-percha as well as regular gutta-percha points. Of course, sealer is always used. To obturate a canal, the clinician is advised to place the primary gutta-percha point, followed by the appropriate size Condenser (one that will reach near the working length), which has been coated with the heat-softened gutta-percha.

The Condenser is spun in the canal with a controlled speed handpiece at 1,000 to 4,000 rpm to form a firmer core. This “flings” the gutta-percha laterally and vertically.

McSpadden has developed a technique to fill open-apex cases as well by initially depositing a bolus of low-heat gutta-percha at the apex with a large condenser. This is allowed to cool and harden to form an apical plug against which the remaining canal is obturated with gutta-percha points and additional heat-softened gutta-percha. To date, this particular technique-combining the reverse screw-type condenser with warmed alpha gutta-percha-has not been widely reported in US literature; however, the technique is popular in europe, with some reporting from there.[2,31]

Technique:

The canal, thoroughly cleaned and shaped, is irrigated and dried with absorbent points, and is then thinly coated with very small amount of sealer.

Selection of the Gutta-Percha Point:

It is important to choose the proper size of gutta-percha point so that the tip cannot pass through the apical foramen. Upon insertion, the point should bind in the canal approximately 1.5mm from the apical terminus. If the diameter of the Gutta Percha tip is smaller than the apical foramen, the tip will be pushed through the apex when the compactor is activated.

Selection of the Compactor:

The initial compactor should be the same size as the largest file used within 1 to 1.5mm of the apical terminus. A 2nd and larger compactor may be required to condense the flared coronal portion of the canal.

Steps in Compaction:

Following are the steps in technique:

The selected compactor is inserted into the canal beside the gutta percha cone until resistance is met with. The canal should have enough flare to allow the straight insertion of the compactor to a depth of approximately 4mm before resistance is encountered. The compactor should feel slightly wedged between the cone and the canal wall at this point.

If the initial gutta-percha cone completely obstructs the coronal portion of the canal, preventing the insertion of the compactor to an adequate depth, the excess cone will be clipped off without being fed in the canal when the engine is turned on. The compactor's direction of rotation should be checked to ensure the displacement of gutta-percha in an apical vector.

The compactor must be activated full speed at start, without any apical pressure. The frictional heat will plasticize the gutta percha and the resistance will be minimized.

After approximate 1 second, while rotating at maximum speed, the compactor is carried in one-third motion apically to a level not to exceed the predetermined depth of the prepared canal. The most important experience is the feel of the instrument backing itself out. This sensation usually indicates that the canal is completely filled. This is called as hybrid technique.

While rotating at full speed, the compactor is gradually withdrawn. If the compactor is withdrawn faster than the gutta percha is being fed into the canal system, voids may develop in the body of gutta-percha mass. Staying too long in the canal can cause the formation of air cavitations (evident by a "popcorn" appearance of the gutta-percha on the radiograph).

A 2nd and larger compactor is required to condense the flared coronal portion of the canal. For the compactor to function effectively, it must be in contact with the gutta-percha and the canal walls. As the compactor is brought out of the orifice, it is moved side to side, against the funneled walls to allow the gutta-percha to feed more smoothly.

When filling curved canals, it is important to clean and shape the canal to the widest possible dimension. The compaction is done by introducing the gutta-percha and the compactor to the depth of curvature, and activating the compactor to plasticize the gutta-percha.

The compactor is removed while the engine is turning; when the rotation stops, the softened material is immediately packed twice apically.

In most cases, the filling material will move to the extent of prepared canal. If necessary, the engine is rotated again and the compactor pumped 2-4 times apically while rotating at full speed.[2]

Advantages:

1. Ease of selection and insertion of gutta-percha cones.
2. Economy of time.

3. Rapid filling of canals apically and laterally, including irregular spaces within the canal if one uses a sealer comparable to lateral compaction.

Disadvantages:

1. Inability to use the techniques in narrow canals.
2. Frequent breakage of compactor blades.
3. Possibility of overfilling of canals.
4. The generated heat, may damage periodontal tissues.
5. Technique is difficult to master.

THERMOMECHANICAL SOLID-CORE GUTTA-PERCHA OBTURATION:

J.S. QUICKFILL

One other innovation using the thermomechanical principle to compact the gutta percha in the root canal has been introduced as J.S. Quickfill [J.S. Dental Mfg. Inc. (Sweden and USA)].

This system consists of titanium core devices, resembling the latch-type endodontic drills, and coated with α-phase Gutta Percha. Quick-Fill is designed to be used in a standard, slow-speed handpiece with a speed of 3,000-6,000 rpm.

Designed as an inverted 'K' type file, it is available in 21mm and 25mm, in sizes 15-60. It works with frictional heat, and hence requires no heating units or open flame.[2]

The Technique:

Prepare the canal using the preferred method. Choose a Quick-Fill two sizes smaller than the last file used to prepare apex. Set endostop on the Quick-Fill to 1 mm short of the apex. The millimetre markings on the Quick-Fill correspond to 18mm, 19mm, 20mm and 24mm.

Lightly coat or dip Quick-Fill in sealer of choice. Before starting, place Quick-Fill at the orifice until a light resistance is felt. Do not apply any pressure or force. Start handpiece, in clockwise rotation between 3000-6000 rpm, and apply light pressure.

The gutta-percha will give a tactile sense of plasticizing. The Quick-Fill must be used in clockwise rotation only. Precede apically using constant light pressure until working length is reached (use endostop).

After compaction, there are two choices: either the compactor may be removed while it is spinning and final compaction completed with a hand plugger or the titanium solid core may be left in place and separated in the coronal cavity with an inverted cone bur.[2]

- Pallares A, Faus V, from Valencia, Spain, conducted an apical leakage dye study comparing J.S Quick- Fill against lateral condensation, They found no significant difference in efficacy; however, they did find with the J.S. Quick – Fill that the sealer (AH26) adapted more peripherally against the dentin walls and the gutta-percha was more centrally located. The cement has also penetrated the dentinal tubules and the lateral and accessory canals.[2]

  Canalda- Sahli and his co-workers, also from Spain, found that J.S Quick- Fill should be used successfully to seal root canals in teeth with large straight canals.[20]

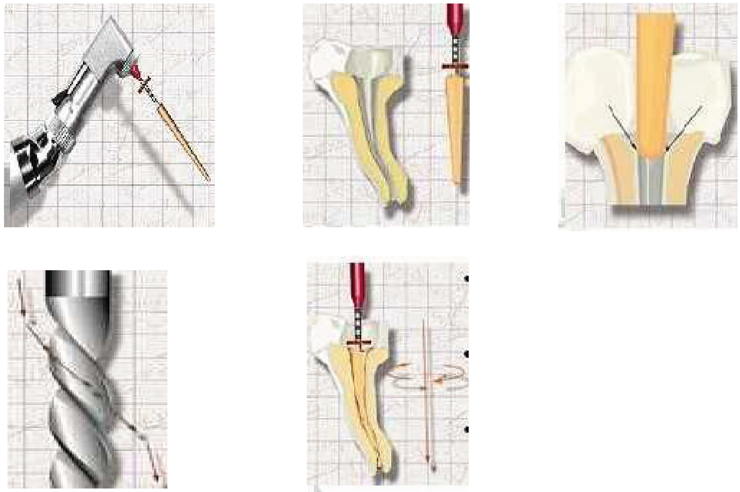


Fig 13. J.S Quickfill Obturation technique

ULTRASONIC PLASTICIZING:

The technique of plasticizing gutta-percha in the canal with an ultrasonic instrument was first suggested by Moreno from Mexico.

He used a Cavitron ultrasonic scaler (Dentsply/Caulk;Milford, Dela.) with a PR30 insert, but because of its design it could be used only in the anterior mouth.

Moreno placed gutta-percha points to virtually fill the canal. He then inserted the attached endodontic instrument into the mass, activated the ultrasonic instrument (without the liquid coolant), and as it plasticized the gutta-percha by friction, advanced it to the measured root length. Final vertical compaction was done with hand or finger pluggers.

THERMOPLASTICIZED INJECTABLE GUTTA-PERCHA OBTURATION TECHNIQUE:

An innovative device, introduced to the profession in 1977, immediately caught the fancy of dentists interested in the compaction of warm gutta-percha. Developed by a group at Harvard/Forsyth Institute, gutta-percha was ejected out of a prototype pressure syringe that had warmed it to 160°C. At this temperature, the gutta-percha would flow through an 18-gauge needle. From this early model, a more efficient system was developed and patented.

Today, through further improvements, the device is marketed as the Obtura II Heated Gutta-Percha System (Obtura-Spartan Corp., Fulton;Mo.),with digitally controlled temperatures ranging from 160°C to 200°C while the needle size has been reduced to either 20 gauge (equal to a size 60 file) or 23 gauge (equal to a size 40 file).

Although regular beta-phase gutta-percha is still used, the clinician can now choose a less viscous, higher flow form of gutta-percha known as Easy Flow

(Charles B. Schwed Co.; Kew Gardens, N.Y.). [2,15]




Fig 14. Obtura II and Obtura III

This technique has also been referred as 'High Heat Technique', mainly because of the temperature required to soften the gutta percha for delivery into the canal.[15]

The obtura system consists of a control unit and a pistol-grip syringe designed to accept gutta-percha pellets formulated for use with the system. The gutta percha is heated in the barrel of the syringe to 160-200^{0}C.

The molten gutta-percha is extruded through silver needles that are supplied in 20, 23 and 25 gauge sizes. As the gutta percha leaves the tip of the needle, its temperature drops to 62-65^{0}C. The heating barrel reaches full operating temperature in less than two minutes, thereby eliminating the need to preheat the gutta-percha.

The Technique:

Canals to be obturated must have a continuously tapering funnel, from the apical matrix to the canal orifice.

Of significance is a properly shaped canal in the apical to middle transitional area, particularly in the curved canals, for the flow of the softened material. Also a definite apical matrix is essential to confine and retain the gutta percha in the canal system.

The pellet form of the gutta percha is inserted into the heated delivery system. The gutta percha is heated to approximately 365-392^{0}F (185-200^{0}C). A needle or applicator tip (gauges 20, 23, 25) designed to deliver the softened material, is inserted into the canal at the junction of middle & apical thirds.

The applicator tip and the pluggers should be prefit to determine the depth of placement, and also to ensure that it does not bind against the canal walls. If necessary, the pluggers can be curved or the newer Ni-Ti pluggers can be used.

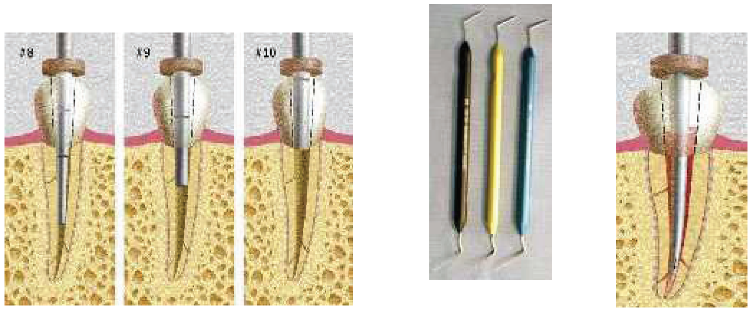


Fig 15. Plugger Selection Sequence for Downpak

The injecting needle and pluggers must be tried for size in the root canal. They must, both, reach within 3.5mm to 5mm of the apical terminus and fit loosely at that point. Silicone stops are placed on the pluggers of adequate diameter to ensure that they will move the softened gutta-percha and not just punch through it.

Into the dried canal, 1-2 drops of sealer are placed at the pre-chosen depth, short of the apex. This is followed by the Obtura needle, and a deposit of gutta-percha is made. The canal may be totally filled as the needle is withdrawn, or a small deposit may be made and compacted in the canal segmentally.

Note that the gutta-percha has to be passively injected into the root canal, avoiding apical pressure on the needle and keeping sufficient space around the needle to avoid air entrapment. Once the deposit is placed, the premeasured plugger is rapidly used to move the Gutta Percha apically and laterally.

A drop of sealer on the tip of the plugger will prevent its adherence to the gutta-percha. If the filling is short, gutta-percha, if now firm, may be warmed with a hot instrument and then further compacted; or the bolus may be completely removed and the canal refilled.

Another, popular obturation method, is to initially place a fitted master point to the apical terminus and follow this with the Obtura needle-tip, depositing a bolus of warm gutta-percha around the point. This is immediately compacted vertically and laterally. More plasticized gutta-percha is then added and compacted. This technique will ensure apical closure without overfilling.[2, 15]

Advantages:

1. Rapid technique requiring minimum chairside time.
2. Three dimensional Obturation is achieved as the gutta-percha flows into the lateral canals and irregularities such as webs , fins, cul-de- sacs and internal resorption defects.

Disadvantages:

1. Possibility of extrusion beyond the apex.
2. Risk of thermal damage to the Periodontium.

The Ultrafil System:

The Ultrafil System (Hygenic Corporation, Akron, OH) is a 'Low Heat' (70° C) system, with a sterilizable injection syringe, 3 different types of disposable gutta--percha cannules with attached needles, and a portable heating chamber with preset temperature. The low heat Ultrafil system heats cannules containing gutta-percha to 70^0C in a heating unit.[14]

Depending on the consistency desired, the clinician can choose one of three types of gutta-percha.

1. **Regular Set** - Gutta-percha, in a white cannule, requires no condensation because of its low viscosity. In this instance, the Ultrafil would serve as both a delivery and filling system. It reaches a full set after 30 minutes.
2. **Firm Set** - In a blue cannule, condensation is possible, but not required. It sets in 4 minutes.
3. **Endoset** - is delivered in a green cannule and requires condensation; completely sets in 2 minutes.[4]

The cannules must be placed in the heater at least 15 minutes before use, and must be discarded after 4 hours of heating. The gutta percha is contained within the cannule with a nylon plastic plug at one end and a pre-attached 22-gauge stainless steel needle at the other. The diameter of the needle is .028" (.69mm), with a length measuring .85" (21.3mm).[14]

The ULTRAFIL 3D cannule needle may be precurved for easy access into the canal. The Ultrafil 3D dispenser is a precise, well balanced, ratchet type dispenser that has been specially designed to accommodate the ULTRAFIL 3D cannules. Once loaded with the cannules, the trigger is squeezed gently and released, and the gutta-percha is allowed to flow out at its own rate.

It is important to avoid excessive pressure in order to prevent extrusion of the material from other channels. The temperature of the thermoplasticized gutta-percha as it is extruded through the needle tip ranges from 38° to 44° C.[15]

Method of Use:

According to Michanowicz, continuous tapered canal should be prepared that is large enough, 8 to 10 mm from the apex, to receive a 22 gauge needle, about the size of a #50 file. It is also imperative to develop a perfect apical stop. If the apex is open, Ultrafil will extrude into the soft tissue.

After the canal is dried, it is lightly coated with sealer, and the needle of the cannule is placed in the canal. It must fit closely, without binding, 8-10 mm from the apex. The working time is 60-70 seconds. The syringe trigger is squeezed and released, and after a wait of 3 seconds, squeezed and released again.

This sends a bolus of gutta-percha towards the apex. The needle is not withdrawn but left in place until a 'lift' is felt as the material flows to the apex, and backflow tends to displace the needle.

Injection is then continued, not forcing the deposit, but allowing the gutta-percha to displace the needle from the canal. The regular set Ultrafil (White Cannule) gutta-percha cannot be compacted because of its soft consistency / low viscosity. Pluggers just punch through the material without displacing it. It reaches a full set after 30 minutes.

Because of low viscosity, the extrusion of the material is of a major concern. As it cannot be compacted, the possibility for shrinkage must be considered and this cannot be compensated by increased amount of sealer. [14]

Fig 16. Sumarry of Ultrafil Obturation tecnique

INJECT-R FILL-BACKFILLING TECHNIQUE:

Another method of backfilling has been developed by Roane at the University of Oklahoma and is marketed as Inject- R Fill (Moyco-Union Broach; Bethpage, N.Y.). Inject-R Fill, a miniature-sized metal tube containing conventional gutta-percha and plunger, simplifies warmed vertical compaction by altering the backfilling process. The technique allows for delivery of a single backfill injection of gutta-percha once the apical segment of a canal has been obturated. According to Roane, the technique is rapid and produces a result similar to that of warm vertical compaction.[2]

Technique:

The Inject-R Fill must first be heated in a flame or an electronic heater, and the coronal surface of the gutta-percha already in the canal should be warmed using a heated instrument. When a burner is used, the stainless steel gutta-percha filled sleeve is waved through the flame, until gutta-percha begins to extrude from the open end.

The warmed unit is then placed into the orifice of the canal. For the device to fit, the canal orifice must be at least 2 mm in diameter. A push of the handle towards the canal injects the heated gutta-percha into the canal. The carrier is then rotated to break it free from the access.

Pre-fitted hand or finger pluggers are subsequently used to compact the gutta-percha and push the injected mass into contact with the apical segment. The plugger must be positioned in the center of the mass and pressed firmly toward the apex.

Pressure is sustained for a few seconds before the plugger is rocked from side to side and rotated to break it free. As the plugger is removed, a small void is left in the center of the mass. The void is closed by folding over remaining gutta-percha from the sides and packing it apically. This process is repeated until a larger plugger can be used without creating a void and the gutta-percha mass is firm.[2]

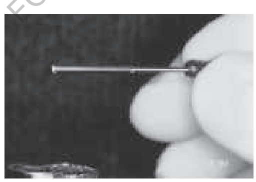


Fig 17. Inject-R-Fill

Solid Core Carrier

Pre-coated carriers:

- ThermaFil (Dentsply/Tulsa)
- Densfil (Dentsply/Maillefer),

- Soft-Core (Soft-Core System, Inc.), and
- Three Dee GP (Deproco UK Ltd.)
- One-step obturations

Operator coated carriers:

- Alpha seal
- Successfil

In 1978, Johnson described a unique yet simple method of canal obturation with thermoplasticized α-phase gutta-percha carried into the canal on an endodontic file. What was a curiosity in 1978, has become today a popular and respected technique of canal obturation. ThermaFil is considered the major core-carrier technique, and through a licensing agreement with Dentsply, a duplicate product, Densfil was created. Recently, two similar products were introduced: Soft-Core, and its European version, Three Dee GP.[2]

THERMAFIL ENDODONTIC OBTURATOR

The Thermafil Obturation Technique was derived from an original idea by Dr. W.B. Johnson who first described it in an article published in the Journal of Endodontics in 1978. [2]

"ThermaFil is a patented endodontic obturator consisting of a flexible central carrier, sized and tapered to match variable tapered files (.04/.06) endodontic files. The central carrier is uniformly coated with a layer of refined and tested alpha-phase gutta-percha.".

Likewise, the ThermaFil system now comes with metallic size verifiers that are used to determine, with greater precision, the size and shape of the prepared canal prior to choosing the correct ThermaFil carrier. [2]

Initially, the central carrier was a newly designed stainless steel device. Contemporary carriers are made of radiopaque plastic that is grooved along 60 degrees of their circumference. While the gutta-percha covering the original carriers was heated in a flame, the new plastic core carriers are heated in a controlled oven environment called the ThermaPrep Plus heating system (Dentsply/Tulsa; Tulsa, Okla.). The heating time is well delineated and is dependent on the size of the core carrier. The use of the oven, according to the manufacturer's directions, is essential for success with this technique.[2]

Fig 18. Thermafill obturator and Thermafill core

Technique:

Careful cleaning and shaping of canal is necessary to obtain a continuous tapering preparation. After the canal is dried, a very light coat of sealer is applied to all of the walls. Immediately after the sealer is applied, the warm obturator is removed from the ThermaPrep Plus heater and carried to full working length in the canal.

The carrier is not twisted during placement, and attempts to reposition the carrier should be avoided to prevent disruption of the gutta-percha that was initially positioned through the compacting action of the core carrier.

Once it is ensured radiographically, the shaft is severed in the coronal cavity. While the handle is firmly held aside, a No. 37 inverted cone bur is used to trim off the shaft 2 mm above the coronal orifice. [2]

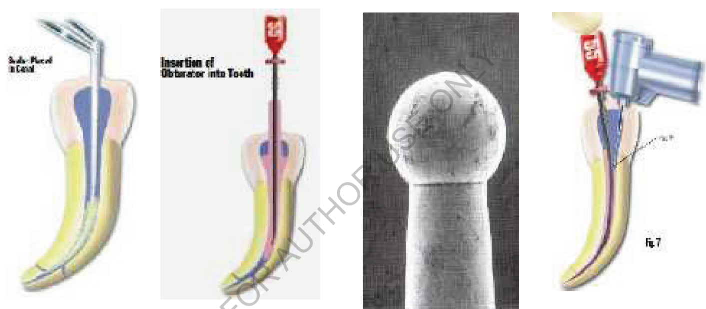


Fig 19. Sumarry of Thermafill obturation

Densfil:

Densfil endodontic obturators are quite similar to Thermafil. These Plastic core obturators (Dense Heat-oven heated) are made from biocompatible, nontoxic, radiopaque medical grade plastic. The Densfil plastic carrier are available in sizes #20-140, and the titanium obturators are available in sizes #20-60.

The DensHeat oven offers predictable, stable controlled heat for obturator preparation and allows heating up of six obturators at a time.

Fig 20. Densfil size verifier, Densfil ovenIII, Plastic obturators

Soft Core & Three De Gutta-percha:

Soft-Core, or its counterpart, Three Dee Gutta-percha, is similar to ThermaFil; however, it contains a biopolymer compound and a tungsten core that is radiopaque. It has an easily detachable handle, referred to as a metallic insertion pin, which is removed with a slight twisting action. This leaves the coronal portion of the plastic core hollow, thus facilitating post space preparation.

The presence of the metallic insertion pin also allows a curving of the coronal portion of the carrier, thus facilitating the angle of core insertion. It is supplied in a sterile blister pack that also contains a matching size verifier. The carriers are thinner in taper than the Thermafil carriers, but are ISO sized at the apex. This facilitates their use in small canals which are difficult to shape.

Heating of the gutta-percha on the Soft-Core carrier is done in a halogen oven that is thermostatically controlled.[2,41]

Fig 21. Softcore Oven, Softcore obturators

ALPHA SEAL:

Alpha Seal (The Cutting Edge, Chattanooga, TN) is one of the newest additions to methods of obturation. Similar in concept to Thermafil, this system uses K-files as the carriers for the Alpha Seal (α-phase) gutta-percha but in contrast, the clinician does the 'coating' of the carrier.

The rationale for using the master apical file or similarly sized titanium carrier is the presumption that this instrument is more effective in resisting slippage and displacement of the gutta-percha than the precoated carriers such as Thermafil.

The Technique:

A sterile master apical file is inserted into the Alpha Seal syringe containing the heated gutta-percha. Upon removal, the working portion of the instrument becomes coated with the gutta-percha and the carrier file is inserted subsequently in the canal in the same manner as the Thermafil.

As with other warm gutta-percha techniques, a slow-setting $Ca(OH)_2$ sealer should be used in conjunction with the carrier. The main advantages of this method over the Thermafil are the ability to try in the carrier prior to obturation and to precurve the carrier prior to coating.[2, 21]

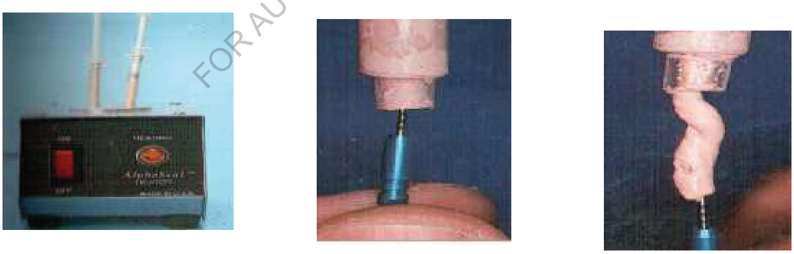


Fig 22. Alpha Seal obturation Technique

SUCCESSFIL:

SuccessFil is almost identical in concept to Alpha Seal. One of the key differences, however, is that SuccessFil uses its own titanium cores that have been sized according to ISO standards.

A secondary, perhaps insignificant difference arises in how each company processes its gutta-percha to α phase. With the Alpha Seal, the molecular weight is lowered by heat fractionization to form a tackier, more fluid material. With the SuccessFil, however, the molecular weight is reduced through extensive milling. As with the Thermafil and Alpha Seal methods, a special heater is provided to ensure proper heating of the gutta-percha.

Made of titanium alloy, the SuccessFil cores have non-cutting tips and are highly flexible for use in curved as well as straight canals. The core is, however, not used as a cutting instrument to enlarge or cleanse the root canal space. These are available in 25mm lengths with color-coded handles in ISO sizes 20-80.[2, 21]

The Technique:

Before coating the pre-fit core in the SuccessFil Syringe, the core must be sterilized. The number of coatings a syringe will provide varies and is dependent upon the thickness, shape and length of coating. The coating may be applied to form a tapered cone shape or a cylindrical shape.

Warm the SuccessFil Syringe in the heater for a minimum of 3 minutes. Insert a sterile SuccessFil Core into the syringe tip to the desired length of coating. Extrude the core by depressing the plunger while gradually pulling the core out, using the core handle.

The faster the core is pulled, the more tapered (less gutta-percha volume loaded) the coating. For a cylindrical shape, one the syringe is heated for a minimum of 3 minutes; Hold the syringe, tip down, and completely extrude the gutta-percha and core, without pulling the core.

The core is pulled away from the syringe as it exits the tip. After each use, during the procedure, the SuccessFil Syringe should be returned to the heater for rewarming.

<u>Method of Use:</u>

A SuccessFil core, the same number as the last apical file, is selected and tested for size in the canal. It should go fully to length without binding. It is withdrawn and set aside while the dried canal is lightly coated with a sealer.

The carrier is then coated with gutta-percha and is immediately inserted to full depth without twisting. With a vertical plugger dipped in alcohol, the gutta-percha is better compacted around the carrier. After radiographic confirmation, the core is separated by holding the handle and severing the core shaft 2mm above the orifice.

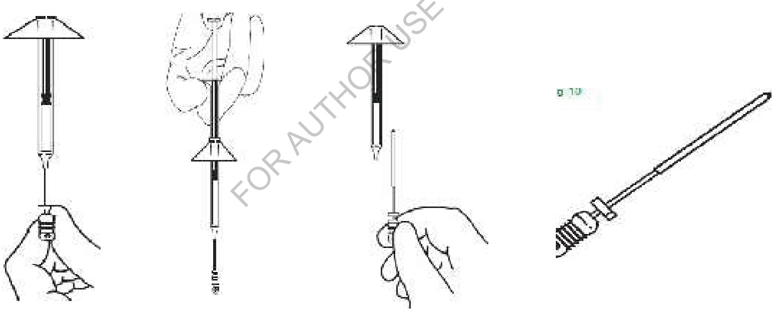


Fig 23. Successfil obturation technique

Combination techniques (core with syringe insertion):

Trifecta system: Utilization of apical 3-5 mm plug of Successfil high viscosity gutta-percha and rest of the canal space is obturated either with Ultrafil, or by Obtura II.

Modified Trifecta System: Utilization of apical 3-5 mm plug of Successfil high viscosity gutta-percha and rest of the canal space is obturated by lateral condensation.

APICAL THIRD FILLING OBTURATION:

SIMPLIFILL OBTURATION TECHNIQUE:

SimpliFill was originally developed by Senia at Lightspeed Technology to complement the canal shape created using Lightspeed instruments. The Apical GP Plug size is the same ISO size as the Lightspeed "Master Apical Rotary" (MAR). It is a relatively new, two-phased Obturation method that advocates the use of a stainless steel carrier to place and compact a 5 mm segment of gutta-percha into the apical portion of a canal.

SimpliFill is the only carrier system where the carrier is not left in the canal. This facilitates post placement and also in cases of retreatment.[2]

It is available in apical sizes 35-130, in 25, 30 and 50 mm lengths. Once the carrier is removed and the Simplifill Apical Plug has been placed, the backfilling can be done using virtually any technique.

The Technique:

Following the completion of canal preparation using rotary Lightspeed, the specially designed Apical GP plug Carrier corresponding to the MAR is trial fitted without sealer into the dry canal.

Before insertion, however, the rubber stopper on the carrier, with its attached gutta-percha, is set 2 mm short of the working length. The carrier is then inserted into the canal and slowly advanced, until it should start to bind at the length indicated by the rubber stop (i.e: 2 mm short of the working length).

Once the fit has been verified, the Apical Plug carrier is removed and the canal is coated with an appropriate sealer using the MAR or a sealer saturated paper point. The rubber stopper on the carrier is now advanced 2 mm to the working length.

The GP Plug is subsequently coated with sealer, inserted in the canal, and advanced until resistance is felt, about 2 mm short of the working length. Using the carrier, the GP Plug is now vertically compacted to the working length with firm apical pressure. The carrier must not be rotated during insertion or compaction. Once the GP Plug is snugly fit, the GP Plug is released by rotating the carrier handle counter-clockwise. During this rotation, the carrier must not be pushed or pulled.

If the GP Plug does not release, the carrier sleeve is grasped with cotton pliers and, while pushing apically on the sleeve, the handle of the carrier is rotated counter-clockwise and withdrawn. Phase two consists of backfilling the remaining canal if no post is desired.[2]

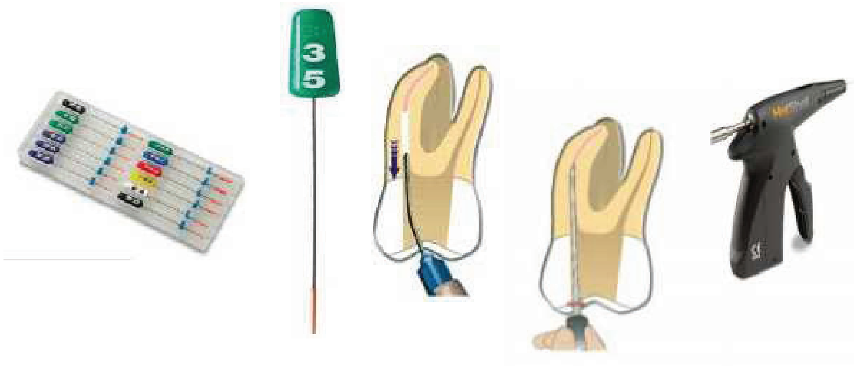


Fig 24. Simplifill obturation technique

Advantages:

1. It conserves dentin because of the Lightspeed instrumentation technique (less flaring).
2. It eliminates additional internal forces since no spreader or plugger is used to compact the apical plug.
3. It is simple to master; and, in contrast to other core-carrier systems, no carrier is left in the canal.
4. Excellent sealing and apical control
5. Ensures a perfect fit
6. Predictable backfill can be done with virtually any technique
7. Time saving

Fibrefill Obturators:

This Obturation technique is a combination of post and gutta-percha available as a single unit. Apical 5-8 mm is made up of gutta-percha and coronal two-thirds is a resin core post. This apical gutta-percha is attached with a thin flexible filament to be used in moderately curved canals. Its advantage includes less coronal microleakage.[10]

Fig 25. Fibrefill obturators

DENTIN CHIP APICAL FILLING:

A method finding increasing favour, and one that inadvertently happens more often than not, is the apical dentin chip plug, against which other materials are then compacted.

Quite probably, some of the so-called “miraculous cures” occur apically, to prepared but unfilled canals, because the apical foramens have actually been obturated by dentin chips from the preparation.[2]

Method of use:

After the canal is totally débrided and shaped and the dentin no longer contaminated, a Gates-Glidden drill or Hedstroem file is used to produce dentin powder in the central position of the canal (Fig 25. A). These dentin chips may then be pushed apically with the butt end (Fig 25. B) and then the blunted tip of a paper point (Fig 25. C).

They are finally packed into place at the apex using a premeasured file one size larger than the last apical enlarging instrument (Fig 25. D). One to 2 mm of chips should block the foramen. Completeness of density is tested by resistance to perforation by a No. 15 or 20 file. The final gutta-percha Obturation is then compacted against the plug (Fig. 26).

Japanese researchers found they could totally prevent apical micro-leakage when they injected 0.02 ml of Clearfil New Bond dentin adhesive (J. Morita, Japan) into the coronal half of the dentinal apical plug.

A study done on monkeys at Lorna Linda University indicated it is evidently the inorganic component of dentin, hydroxyapatite, that is the principal stimulant in providing more hard tissue foramen and less inflammation than fresh dentin chips or demineralized dentin.[2]

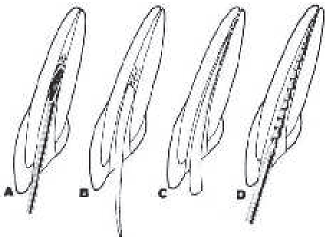


Fig 26. Dentin chip apical filling technique

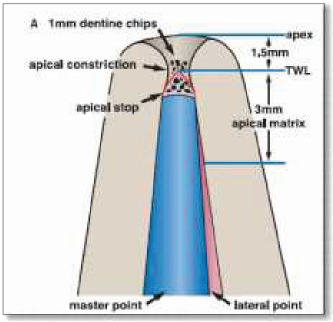


Fig 27. Final gutta percha obturation compacted against dentin plug

CALCIUM HYDROXIDE APICAL FILLING:

Cementogenesis, stimulated by dentin fillings appears to be replicated as well by calcium hydroxide.

Method of use:

Calcium hydroxide can be placed as an apical plug in either a dry or moist state. Dry calcium hydroxide powder may be deposited in the coronal orifice from a sterilized amalgam carrier. The bolus may then be forced apically with a premeasured plugger and tapped to place with the last size apical file that was used.

One to 2 mm must be well condensed to block the foramen. Blockage should be tested with a file that is one size smaller. Moist calcium hydroxide can be placed in a number of ways: with amalgam carrier and plugger, with a Lentulo spiral, or by injection from one of the commercial syringes loaded with calcium hydroxide: Calasept or TempCanal.

In the latter method, the calcium hydroxide paste is deposited directly at the apical foramen from a 27-gauge needle and is then "tamped" to place with a premeasured plugger.

In comparison of techniques for filling the entire small curved canals with calcium hydroxide, the North Carolina group found Lentulospiral to be most effective, followed by the injection system; counterclockwise rotation of a #25 file was the least effective. It was inferred that if the calcium hydroxide deposit is thick enough and well condensed, it serves not only as a stimulant to cemental growth, but also as a barrier for extrusion of well compacted Gutta-percha.

NEWER OBTURATION TECHNIQUES:NON-INSTRUMENTATION TECHNOLOGY

NEWER OBTURATION TECHNIQUES

NON-INSTRUMENTATION TECHNOLOGY

The previous section has described the delivery of sealer cements by rotary instruments, injection, or carriage on points of core material. A highly innovative approach was found in non-instrumentation technology (NIT), where the controlled development of a vacuum within the tooth allows fluid sealer to be drawn into the complexities of the canal system. This technology has been subjected to one clinical trial in which the radiographic quality of root fillings with AH 26 was comparable to that of conventional techniques.[7]

SINGLE-CONE OBTURATION TECHNIQUE:

Single-cone Obturation came to the fore in the 1960s with the development of ISO standardization for endodontic instruments and filling points. After reaming a circular, stop preparation in the apical 2mm of the canal, a single gutta-percha, silver, sectional silver or titanium point was selected to fit with 'tugback' to demonstrate inlay-like snugness of fit.

The cone was then cemented in place with a (theoretically) thin and uniform layer of traditional sealer, at least in the apical part of the canal. In a retrospective clinical study, Smith et al. demonstrated 84% success following cementation of an apical silver cone with sealer, and 81% with a full-length silver cone and sealer. Equally, all those who accept endodontic referrals are very familiar with single-cone removal from canals in which a large volume of surrounding sealer has leached away or dissolved under the action of tissue or oral fluids.[7]

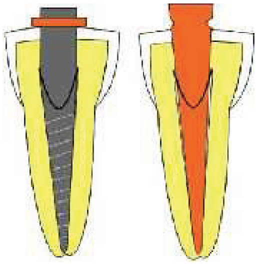
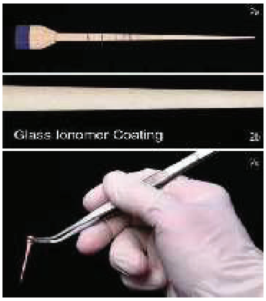


Fig. 28 Single cone Obturation

The Active GPTM precision Obturation system utilizes Glass ionomer technology, extending the working time of the Glass ionomer sealer by modifying its particle size to the nanoparticle level. The gutta-percha cones are coated with Glass ionomer particles at a thickness of 2 micron meters. The cones can be bent up to 1800 without showing any signs or symptoms of delamination of the coating, and are matched in size to the preparations created by the files. Matching of the primary cone to the preparation is very important with any single cone technique, because the accurate fit of the cone to the preparation minimizes the amount of sealer used, as well as minimizing any potential shrinkage.



MTA OBTURATION

MTA Obturation can be considered in the following cases:

1. For the **entire canal Obturation**, especially in previously endodontically treated teeth that have been subjected to long term microleakage and bacterial contamination.
2. In cases of **surgical root resection**- MTA is placed in the canal and allowed to cure before surgical endodontics can give operators the flexibility where root end management might be challenging due to anatomic barriers, patient concerns, and hemostatic considerations, or if surgical access is compromised. Conversely, in cases that exhibit apical perforations, canal transportations or stripping, MTA can provide a predictable seal that can promote biore- mineralization and healing without post-treatment surgical intervention.
3. As an **alternative to gutta-percha** due to its superior sealibility against bacterial microleakage, while demonstrating antibacterial and bioinductive properties that can improve treatment outcomes, also the material is sterile, resistant to moisture, and non-shrinking, and stimulates mechanisms responsible for the resolution of periapical disease.
4. Can be used in **apexification and perforation** repair due to its cementogenic properties, and its ability to induce apexogenesis by the stimulation of mesenchymal cells from the aical papilla.
5. In endodontic **retreatment cases**, MTA can offer an alternative method, which can possibly reduce the indications for endodontic surgery.
6. A variety of circumstances can either prevent healing or promote periapical bone loss after conventional endodontic treatment. These factors can be

iatrogenic, anatomic, or microbial (biofilms or extraradicular bacteria) and can often include restorative or apical microleakage. In such cases, prior to surgery, MTA Obturation is an option that can have important advantages. Although one study showed lower incidence of cementum formation, when compared to freshly placed MTA, but no significant difference in osseous healing/ cementum formation was observed during a 4 months period in canine models (Shabahang, Torabinejad et al, JOE, 2004). This protocol might be beneficial when surgical access is compromised by anatomic structures, to lessen technical demands on the operator, or address patient management concerns.

7. **Complete or partial Obturation** of the root canal system by using MTA is a viable option for teeth that exhibit extensive internal root resorption,open apices, and selected cases that show anatomic variations that include dens evaginatus, dens invaginatus, "C" shaped canals, fusion or gemination.[33,43]

Obturation technique:

Requires the same preparation executed for gutta-percha placement. In non surgical Root canal therapy - the main canal apical preparation should be done till #30 (minimum); #35 or 40 master apical file is more desirable.

White MTA has better handling characteristics and compactibility, attributed to smaller particle sizes, when compared with its counterpart, but gray MTA appears to have superior sealing properties when the material is examined in vitro. Clinicians should judge which type to use on the basis of an assessment of tooth location, esthetics and surgical indications.

After drying the canal, the mixed MTA is placed in the canal with a carrier gun and advanced apically with an endodontic plugger, or a Glick instrument. MTA can be mixed with 0.12% CHX rather than sterile water, to increase its antibacterial properties.

A stainless steel K-file, 1 or 2 sizes smaller than the master apical file, is used to compact the apical 3-5mm of MTA. If the last master apical file is #35, then a size 25/30# is used to advance and push the wet MTA to working length.

Some clinicians advocate removing the pilot tip to create a flat end before using the instrument for compaction. The initial delivery coats the canal walls & radial lands of the plugging K-file.

The file is then directed off the walls circumferentially, and pushed with light to moderate pressure.

Hand pluggers can also be used for compaction, but may be difficult to handle in curved canals. The WL gradually shortens as the compaction proceeds.

Ultrasonic energy placed against the plugger can be used to further compress the material by using a low-range setting for the unit.

A radiograph is taken to access the presence of visible voids. If the compaction density is adequate, then fresh MTA can be placed in the canal, and compacted from the apical to coronal area by using larger hand files and pluggers.

If the density is inadequate, then MTA can be recompacted by using a smaller K-file (20#), until an acceptable result is achieved. If visible voids are present, MTA can be flushed out with anesthetic or sterile water by using a 27-or-30 gauge needle.

Backfilling can be done with gutta-percha or a resin based material. After placing a MTA plug, canal irrigation can be done by a side venting needle.

During condensation, minimal force will prevent the extrusion of large amounts of MTA, in an immature apex or in cases of apical root resorption. Extruded MTA will not affect periapical healing in most cases.

With large open apices, the MTA can be pushed down by using the back end of an extra coarse paper point or Glick instrument. Endodontic pluggers can be used with ultrasonic energy, but caution should be exercised with ultrasonics, which can cause large amounts of MTA to extrude apically when open apices are present. Although extruded MTA does not affect the outcome, the esthetics of placement might be a concern for the clinicians who are attempting to achieve an ideal result. [33,43]

Lawaty technique:

The Lawaty technique was introduced by Dr.Ingrid Lawaty, Santa Barbara, CA.

After cleaning & shaping is done, the mixed MTA is transferred to the pulpal floor with a Glick instrument. The MTA is placed to half fill the access cavity, over the prepared dry canals.

The access cavity serves as an MTA reservoir during the compaction process, and can be remoistened as needed to maintain a workable consistency of the cement. An apex locator is then attached to a K-file, 1 size smaller than the MAF. This technique can help locate the canal terminus and helps prevent extrusion of the material. The K-file is moved circumferentially along the canal glide path, with an apical pumping motion by using the coronal portion of the canal as a funnel, which allows the MTA to flow from the access cavity reservoir to the canal terminus.

The apex locator can be removed as the depth of the canal glide path is reduced, and the apical MTA plug is formed. The MTA can thereafter be circumferentially funneled and pumped more aggressively without substantial risk of extrusion. A progression of K-files are then used after the formation of apical MTA plug, sizing upward incrementally to a size 60 K-file. No sizes should be skipped to prevent the potential for void formation. [33,43]

Fig 29. MTA obturation instruments

Disadvantages:

MTA does present some disadvantages when used in canal Obturation.

1. Gray MTA can discolour teeth if the material is placed in the coronal structure, or near the CEJ, in anterior teeth. This can be attributed to the reduction of ferrous ions into the dentinal tubules, which might increase over time. This is important in cases where ceramic crowns and veneers are to be placed. White MTA can be used as an alternative in such cases.
2. Another potential problem with the material can be elective removal after placement and curing. MTA removal can pose a dilemma, hence it should be considered as a

permanent filling, and treated by surgical resection of the root end, in case of failure. The patients should be informed regarding the alternative material used for obturation, in case of future referrals.

3. Although current techniques show dense radiographic obturations with MTA; micro-computed tomography of extracted teeth reveals small voids present in most experimental specimens. Though, these voids can be detected when current delivery protocols are used, and they appear not to affect biologic mechanisms necessary for favourable healing.

4. Another minor drawback is the slow setting time, the material takes 2.5-4 hours for an initial set, but it requires 21 days for complete curing. However, in case of single step apexification, the top of the MTA can be dried with paper points, and a flowable compomer can be placed over the exposed MTA.

5. It has been documented that teeth obturated with MTA might not only increase their fracture resistance with time, but bacteria might be effectively entombed and neutralized in severely infected teeth. Moreover, if a filling material can substantially improve endodontic outcomes and provide a wide range of treatment options, which prolong the retention of the natural dentition and avoid implant placement. Hence, some disadvantages might be overlooked in favour of the superior physiochemical properties. Although MTA might not exhibit all the characteristics necessary for the ideal filling material, patients requiring complex endodontic treatment might benefit from its bioinductive properties in conventional and surgical therapies. [33,43]

DISCUSSION

DISCUSSION:

Root canal obturation involves the three-dimensional filling of the entire root canal system as close to cemento-dentinal junction as possible and is a critical step in endodontic therapy.

Many root canal filling techniques have been developed in the hope of achieving total root canal Obturation.[34] The choice depends on the canal anatomy and the unique objectives of treatment in each case. Lateral and warm vertical condensation techniques are most common and have passed the test of time.[22]

Newer methods include the use of injectable, thermoplasticized gutta percha systems, carrier coated with alpha phase gutta percha, cold flowable obturation materials that combine gutta percha and sealer in one product and glass ionomer embedded gutta percha cones. [22]

Cold lateral condensation has been the gold standard technique to which other techniques have been compared. It has the advantages of excellent length control, low cost and can be accomplished with any of the acceptable sealers. [22]

The disadvantage is that, filling consists of a large number of separate gutta percha cones tightly pressed together and joined by frictional grip and the cementing substance, rather than a homogeneous mass of gutta percha. Voids can be seen with poor root canal preparation, curved canals, inadequate lateral pressure during condensation, or mismatch between gutta percha cones and the prepared root canal. The resulting fill in such cases have to rely on sealer to fill the voids, and thus has poorer prognosis.[22,35]

De Moor & De Boever, achieved a better apical sealing with cold lateral condensation and a hybrid gutta percha condensation technique than with techniques using thermoplasticized gutta percha. However, Gordon et al, compared the area filled by gutta percha, sealer and the voids in standardized simulated curved canals and in mesio-buccal canals of extracted maxillary first molars filled with a 0.06 taper single cone technique or with cold lateral condensation of multiple 0.02 gutta percha points and found no differences between the techniques in the amount of gutta percha occupying a prepared 0.06 tapered canal. Lea CS et al showed that warm vertical compaction using the continuous wave of condensation technique in acrylic blocks resulted in greater gutta percha fill by weight compared with standard cold lateral compaction.[35]

Warm vertical condensation of gutta percha forms the basis for many techniques, such as the master cone sectional, warm gutta percha, and thermoplasticized techniques. It has been found that a higher percentage of the canal area is filled with gutta percha in oval canals using the warm vertical condensation technique.[22]

It uses heat to produce a homogenous mass that adapts well to the canal walls. Advantage of warm vertical compaction technique include movement of the plasticized gutta percha and filling in canal irregularities and accessory canals. Disadvantage are difficulty in obturating curved canals, risk of vertical root fracture and extrusion of material into the periradicular tissues.[22,37]

Liewehr et al compared the increase in density of obturation between the standard cold lateral compaction and warm lateral compaction using endotec thermal endodontic condenser. The blocks were weighed after instrumentation, and after cold or warm lateral compaction techniques. An increase in the final weight of the filling material in the same volume implied an increase in density of obturation. He found increase in density of obturation with warm lateral compaction .[37]

Nelson et al, found that spaces between the cones in lateral compaction group were obvious throughout the entire canal length, even after the spreader was unable to penetrate no more than 3 mm apically as compared to the continuous wave of condensation. Continuous wave of condensation technique produced an obturation with greater density than conventional cold lateral compaction. [37]

The second most frequently used obturation method after warm vertical compaction among general dentists is core-carrier based obturtion. Technique utilizes heated alpha phase gutta percha on a metal carrier prior to obturate the root canal. The materials of the core-carrier obturator continued to evolve from stainless steel, to titanium, plastic and crosslinked gutta percha obturator.[37]

Advantages of core-carrier obturation include filling of canal irregularities, isthmus, C-shaped morphologies, resorptive defects and accessory canals. Difficulty in root canal filling with in the root canal space is the drawback.[37]

Gencoglu et al and Garip et al found that core-carrier obturation had less sealer and more gutta percha and facilitated adaptation of the filling material along the root canal spaces.[38]

Schrenker et al and Zupanc et al reported that obturation by crosslinked gutta percha core obturator consistently produced homogenous obturation with lower incidences of voids compared with cold lateral condensation. Schafer et al demonstrated the improvement on retrievability in endodontic re-treatment by crosslinked gutta percha obturation than plastic core one. Some clinicians suggested that core-carrier obturation enabled gutta percha tag formation inside dentinal tubules, especially when the smear layer was removed by combined irrigations.[38,39]

Core-carrier obturation might induce less vertical forces on the root canal and thus reduced the chance of root fracture after obturation.[39,40]

De- Deus et al evaluated the gutta percha filled area in the teeth obturated with Thermafil, System B and lateral condensation. He found that in between thermafil system and both System B and lateral condensation, significant differences were obtained while comparing the mean gutta percha filled area. From the results, he concluded that significantly higher gutta percha filled area occurs with Thermafil technique of Obturation.[40]

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