ROOT CANAL SYSTEM OBTURATION
Primary causes of failure of RCT

“Apical percolation of fluids & potentially micro-organisms into a poorly obturated root canal system”

Dow & Ingle, 1955
วัตถุประสงค์ เพื่อให้นักศึกษาทราบถึง

- เหตุผลในการอุดคลองรากฟัน
- ระยะเวลาที่เหมาะสมในการอุดคลองรากฟัน
- วัสดุอุดคลองรากฟันชนิดต่างๆ
- เทคนิคในการอุดคลองรากฟัน
The overall function of a root filling is to occupy the instrumented root canal space to allow proper healing of the periapical tissue. Specifically it attempts:

1. Stops coronal leakage
2. Entombs surviving bacteria
3. Stops influx of periapical tissue fluid and release of bacterial elements
4. To hold back any surviving bacteria in dentinal tubules and uninstrumented parts of the root canal space.
5. To prevent release of bacterial elements in the other direction, i.e. from the root canal to the apical environment (apical leakage).
6. To prevent leakage of nutritional factors from the periapical tissue to the canal space.
Which is more important, apical or coronal seal?

Contemporary documentation emphasize the need to address the thorough seal of the root canal system, both apical & coronally.
Appropriateness of Care & Quality Assurance Guidelines (AAE)

- **Three-dimensional filling** of the entire root canal system as close to the CDJ as possible
- **Minimal amounts of sealers** are used in conjunction with the core filling material to establish an adequate seal
Appropriateness of Care & Quality Assurance Guidelines

- **Use of paraformaldehyde-containing materials** for root canal obturation is **below** the standard for endo therapy.

- **Radiographic appearance** of a dense, 3-dimensional filling which extends as close as possible to the CDJ.
Voids in Root Canal Filling

- The prime source of voids in obturation is the lack of skill, technique chosen for a particular canal anatomy & improper canal shaping.

- Unclear how important of voids is to the success or failure but the fillings should be as dense as possible.
Apical position of the obturation material?

• Obturation to the radiographic apex or beyond, which confirmed by a PUFF of material.
• No long-term studies have supported this position, it tends to cause post-op discomfort

• Support obturation within the confines of the canal system in all cases
Obturation

- Timing
- **Filling materials**
- Techniques
Timing of obturation

- Signs & symptoms?
- Infection beyond the tooth?
- Canal prepared to the optimal size & shape?
- Canal clean & dry?
- Patient tolerate additional treatment time?
Probably the most crucial & contemporary issue in the timing of obturation is the prevention of further canal contamination after cleaning & shaping.

Gutmann & Witherspoon, 1998
Guideline for one-visit endodontics

• Should not be undertaken by inexperienced clinician

• +ve patient acceptance

• Sufficient available time (complete <60 mins)

• Absence of clinical signs & symptoms

• No infection beyond the tooth
Ideal root canal filling material

- Easily introduced into root canal
- Seal the canal laterally & apically
- Dimensionally stable
- Imprevious to moisture
- Bactericidal/bacteriostatic
Ideal root canal filling material

• **Not stain** tooth
• **Not irritate** periapical tissues
• **Easily removed**
• **Sterilizable**
• **Radiopaque**
Root canal filling materials

• Cones
  — Solid
  — Semi-solid: Gutta-percha, RealSeal™
  — Pastes

• Sealers
GP exists in 2 crystalline forms

• Alpha & Beta

• Interchangeable depends on temperature
GP exists in 2 crystalline forms

• Heating **beta** (37°C) changes to **alpha** (42-44°C) & **amorphous melt** (56-64°C)

• Commercially available forms are **beta structure**

• **Alpha phase** for thermosoftening obturation
Approximate composition of GP cones

- **66%** zinc oxide (filler)
- **20%** gutta-percha (matrix)
- **11%** heavy metal sulphate (radiopacifier)
- **3%** waxes or resins (plasticizer)
Composition of RealSeal

• **Resilon™**: thermoplastic resin
  • Bioactive glass
  • Bismuth oxychloride
  • Barium sulfate
Advantages of GP as a filling material

- compatibility
- **become plastic when warmed**
- inertness
- **dimensional stability**
Advantages of GP

- tissue tolerant
- non-discoloration of tooth structure
- radiopacity
- be easily removed from the canal
Disadvantages of GP as a filling material

• lack of **rigidity**
• lack of **adhesive quality**
• lack of **length control**
Advantages of RealSeal as a filling material

MONOBLOCK

• Canal condition:
  
  Self-etching RealSeal primer

• RealSeal Sealer

• RealSeal point
Resilon

Fig. 26. (A) Resilon, a biodegradable polycaprolactone with (B) matching sealer.
Table 17.2 Dimensions of gutta-percha cones.

<table>
<thead>
<tr>
<th>Type of cone</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standardized cones</td>
<td>Corresponds in diameter and taper (2%) to root canal shaping instruments according to ISO 6877. The sizes of the gutta-percha cones range from ISO 10 to ISO 140 (Fig. 17.8)</td>
</tr>
<tr>
<td>Accessory cones</td>
<td>Larger taper, descriptive size, may be used for lateral compaction</td>
</tr>
<tr>
<td>Greater taper cones</td>
<td>Cones with a 4% or 6% (and up to 12%) taper used together with special engine-driven root canal shaping instruments (see Chapter 16)</td>
</tr>
<tr>
<td>Compaction cones</td>
<td>Taper corresponds to the taper of finger-spreaders</td>
</tr>
<tr>
<td>Normal size designation</td>
<td>Diameter $D_3$ (3 mm from tip) (mm)</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>XF (extra-fine)</td>
<td>0.20</td>
</tr>
<tr>
<td>FF (fine-fine)</td>
<td>0.24</td>
</tr>
<tr>
<td>MF (medium-fine)</td>
<td>0.27</td>
</tr>
<tr>
<td>F (fine)</td>
<td>0.31</td>
</tr>
<tr>
<td>FM (fine-medium)</td>
<td>0.35</td>
</tr>
<tr>
<td>M (medium)</td>
<td>0.40</td>
</tr>
<tr>
<td>ML (medium-large)</td>
<td>0.43</td>
</tr>
<tr>
<td>L (large)</td>
<td>0.49</td>
</tr>
<tr>
<td>XL (extra-large)</td>
<td>0.52</td>
</tr>
</tbody>
</table>
Roles of root canal sealer

- **Binding agent** to cement the primary cone into a canal
- **Filler** for the discrepancies between the cone & canal walls
- **Lubricant** to facilitate sealing of the cone into the canal
Requirements of a good root canal sealer

• provide an **excellent seal** when set
• produce **adequate adhesion**
• **radipacity**
• **nonstaining**
• **dimensionally stable**
Requirements of a good root canal sealer

- easily mixed & introduced into canals
- easily removed
- insoluble in tissue fluids
- bacterticidal
- nonirritating to periradicular tissue
- slow setting
Highly Radiopaque Sealers

• Barium sulfate or silver particles

• Detract from the quality of compaction
give a false sense of obturation

Sealers do not have to be highly radiopaque
Root canal sealer may be divided into

- **Zinc oxide-eugenol based**
- **Resin-based**
- **Dentin adhesive materials (GI)**
- **Calcium hydroxide**
- **Combination**
ZOE sealer

42% zinc oxide reagent
27% staybelite resin
15% bismuth subcarbonate
15% barium sulphate
100% eugenol

Core concept 18.2 Properties of different sealers

Zinc oxide–eugenol-based sealers
- Reasonable seal
- Dissolve in fluids
- Long-lasting cytotoxicity
- Sensibilization

เพิ่มความไวต่อการแทรก
ZOE sealer

Most commonly used:

• Pulp Canal Sealer

• Grossman-type sealer (Roth sealer, Procosal, Tubliseal, Tubliseal EWT)
Resin-based sealers

- AH-plus, AH-26

  - 60% bismuth trioxide
  - 25% hexamethylene tetramine
  - 10% silver powder *(stain tooth)*
  - 100% bisphenol diglycidyl ether
Dentine-adhesive sealers

- **Ketac-Endo**

Dentine-adhesive sealers

- Good seal
- Set very quickly
- Good biocompatibility
- Difficult to remove
Calcium hydroxide

- **Apexit**
- **CRCS (Calciobiotic)**

**Calcium-hydroxide-containing sealers**

- Release calcium hydroxide, which may result in disintegration
- Once set and integrity is maintained, no calcium hydroxide leaches out and no effect can be expected
- Initial antibacterial effect
- Risk of dissolution over time
<table>
<thead>
<tr>
<th>Base</th>
<th>Catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>32% Calcium hydroxide</td>
<td>36% Disalicylates</td>
</tr>
<tr>
<td>32% Colophony</td>
<td>18% Bismuth carbonate</td>
</tr>
<tr>
<td>8% Silicon dioxide</td>
<td>15% Silicon dioxide</td>
</tr>
</tbody>
</table>
Combination

- **Sealapex**

**ZOE+Ca(OH)$_2$**
<table>
<thead>
<tr>
<th>Name</th>
<th>Manufacturer</th>
<th>Form</th>
<th>ZOE</th>
<th>Ca(OH)_2</th>
<th>Resin</th>
<th>Gl</th>
<th>Silicone</th>
<th>Work</th>
<th>Set</th>
<th>Specific Indications: Usage Concerns</th>
</tr>
</thead>
<tbody>
<tr>
<td>AH-26 (Thermoseal)</td>
<td>Dentsply, USA/Maillefer, Switzerland</td>
<td>P/L</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>L</td>
<td>Allergic/mutagenic potential; adhesive; formaldehyde release (?); silver containing</td>
</tr>
<tr>
<td>AH-Plus®(Topseal)</td>
<td>Dentsply, USA/Maillefer, Switzerland</td>
<td>P/P</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>L</td>
<td>Nonmutagenic; no release of formaldehyde; radiopaque; all techniques; low solubility</td>
</tr>
<tr>
<td>Sealapex</td>
<td>Kerr Sybron, USA</td>
<td>P/P</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>L</td>
<td>Osteogenic (?); possible dissolution; expands on setting</td>
</tr>
<tr>
<td>Apexit</td>
<td>Ivoclar-Vivadent, Liechtenstein</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRCs (Caleiobiotic)</td>
<td>Hygienic, USA</td>
<td>P/L</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>L</td>
<td>Softens gutta-percha; good for lateral compaction; viscous; adhesive</td>
</tr>
<tr>
<td>Pulp Canal Sealer</td>
<td>Kerr Sybron, USA</td>
<td>P/L</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S/M</td>
<td>M/S</td>
<td>Silver containing, radiopaque; all techniques</td>
</tr>
<tr>
<td>Wach’s Sealex-Extra</td>
<td>Balas Dental Supply</td>
<td>P/L</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S/M</td>
<td>M</td>
<td>Adhesive; good for lateral compaction especially in small canals; softens gutta-percha; good if overextension possible</td>
</tr>
<tr>
<td>Grossman-type Stainless</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roth 801</td>
<td>Roth International, USA</td>
<td>P/L</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>L</td>
<td>All techniques; expansion</td>
</tr>
<tr>
<td>Roth 811</td>
<td>Roth International, USA</td>
<td>P/L</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M</td>
<td>M</td>
<td>All techniques</td>
</tr>
<tr>
<td>Roth 601</td>
<td>Roth International, USA</td>
<td>P/L</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S</td>
<td>S</td>
<td>No vertical compaction</td>
</tr>
<tr>
<td>Procosal</td>
<td>Procosal Chemical, USA</td>
<td>P/L</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L/M</td>
<td>L/M</td>
<td>All techniques</td>
</tr>
<tr>
<td>Endoseal</td>
<td>Centric Inc, USA</td>
<td>P/L</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L/M</td>
<td>L/M</td>
<td>All techniques</td>
</tr>
<tr>
<td>Tubiseal</td>
<td>Kerr Sybron, USA</td>
<td>P/P</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S</td>
<td>S</td>
<td>No vertical compaction</td>
</tr>
<tr>
<td>Tubiseal-EWT</td>
<td>Kerr Sybron, USA</td>
<td>P/P</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M</td>
<td>M</td>
<td>All techniques</td>
</tr>
<tr>
<td>Grossman-Type Silver</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roth 511</td>
<td>Roth International, USA</td>
<td>P/L</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>L</td>
<td>All techniques</td>
</tr>
<tr>
<td>Roth 515</td>
<td>Roth International, USA</td>
<td>P/L</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M</td>
<td>M</td>
<td>Avoid anterior teeth</td>
</tr>
<tr>
<td>Ketac-Endo</td>
<td>ESPE-Premier, Germany/USA</td>
<td>Cap</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S/M</td>
<td>M/S</td>
<td>No compaction; releases fluoride; tubule penetration; bond to dentin?</td>
</tr>
<tr>
<td>Lee Endo Fill</td>
<td>Lee Pharmaceuticals, USA</td>
<td>P/L</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Strengthen root (?); polymerization shrinkage</td>
</tr>
</tbody>
</table>

P/L: Powder/Liquid, P/P: Paste/Paste, S: Short, M: Moderate, L: Long
Techniques of obturation

• Solid core
  • Single cone
  • Lateral compaction
• Softened Core
Techniques of obturation

Softened Core

- Warm lateral compaction

Softened core techniques

Warm lateral compaction

- Moderate length control
- Time-consuming technique
- Heat may damage periodontium
Techniques of obturation

Softened Core

• Warm vertical compaction
  Poor length control
  Sealer extrusion
  Heat may damage periodontium
Techniques of obturation

Softened Core

• Injection-molded gp

• Thermomechanical compaction

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
Techniques of obturation

Softened Core

- Core carrier
- Chloroform resin

Core carrier
- Quick technique
- Sealer extrusion
- Gutta-percha may be stripped off carrier in curvature
- Difficult to remove for retreatment
- In combination with posts, inconvenient technique

Chloroform-resin
- Quick technique
- Potential health hazard effects on dental personnel over long time use
Compaction Vs Condensation

- **Condense**: to make more dense, compression or reduction of liquid or gas
- **Compact**: to put firmly together

AAE emphasized the use of “compaction” on obturation technique
Cold compaction

- **Lateral compaction of GP**
- **Spreader (size, length & curvature)**, compact both in a lateral & vertical direction
- **Anatomic considerations** (C-/S-shaped)
“Tug back”
**FIG. 9-15** A, Gutta-percha cone extending beyond the apex. B, Cone shortened a corresponding amount to improve its fit.

**FIG. 9-16** Gutta-percha cone binding in the coronal half (arrow) but loosely fitted in the apical half, giving a false sense of a tight fit (tug-back).
Modification of the master cone

• **Chemical softening**

Slightly oversized MC is placed in a solvent for 3-5 S

Canal is *wet*, X-ray check

MC is dry for 1-2 mins to remove residual solvent
Modification of the master cone

- Cones are softened with heat or GP softener ex: chloroform
• Cones are rolled & fused between 2 glass slabs or with spatula
Mixing root canal cement

FIG. 9-21 Mixing Grossman’s cement to a thick and creamy consistency. A, Drop test. The cement should drop off the spatula edge in 10 to 15 seconds. B, String-out test. The cement should string out for at least 1 inch when the spatula is raised slowly from the glass slab.
Master cone placement

- Slow insertion:
  - Thorough sealer distribution
  - Dissipation of trapped air
  - Coronal movement of sealer
Lateral compaction
<table>
<thead>
<tr>
<th>Root Canal Spreader (RCS) Code</th>
<th>Diameter 1 mm from the Tip (mm)</th>
<th>Diameter 16 mm from the Tip (mm)</th>
<th>Distance from the Tip to the Bend (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCS3*</td>
<td>0.35</td>
<td>0.88</td>
<td>24.43</td>
</tr>
<tr>
<td>RCSD11*</td>
<td>0.50</td>
<td>1.01</td>
<td>22.46</td>
</tr>
<tr>
<td>RCSD11S*</td>
<td>0.28</td>
<td>0.80</td>
<td>23.18</td>
</tr>
<tr>
<td>RCSD11T*</td>
<td>0.34</td>
<td>1.01</td>
<td>21.50</td>
</tr>
<tr>
<td>RCSD11TS*</td>
<td>0.25</td>
<td>1.01</td>
<td>20.40</td>
</tr>
<tr>
<td>RCSGP1*</td>
<td>0.24</td>
<td>0.75</td>
<td>20.86\</td>
</tr>
<tr>
<td>RCSGP2*</td>
<td>0.24</td>
<td>0.82</td>
<td>23.69</td>
</tr>
<tr>
<td>RCSGP3*</td>
<td>0.30</td>
<td>0.68</td>
<td>28.35</td>
</tr>
<tr>
<td>RCSMA57*</td>
<td>0.22</td>
<td>0.79</td>
<td>26.25</td>
</tr>
<tr>
<td>RCSW1S*</td>
<td>0.36</td>
<td>0.91</td>
<td>19.85</td>
</tr>
<tr>
<td>RCSW2S*</td>
<td>0.39</td>
<td>0.97</td>
<td>18.92</td>
</tr>
<tr>
<td>RCS30*</td>
<td>0.30</td>
<td>0.70</td>
<td>28.10</td>
</tr>
<tr>
<td>RCS40*</td>
<td>0.45</td>
<td>0.77</td>
<td>28.10</td>
</tr>
<tr>
<td>RCS50*</td>
<td>0.50</td>
<td>0.85</td>
<td>28.10</td>
</tr>
<tr>
<td>RCS60*</td>
<td>0.55</td>
<td>0.92</td>
<td>28.10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spreader</th>
<th>Recommended Accessory Cones</th>
</tr>
</thead>
<tbody>
<tr>
<td>D11TS, GP1 and GP2, S20  S20</td>
<td>Extra fine or size No. 20</td>
</tr>
<tr>
<td>MA57</td>
<td></td>
</tr>
<tr>
<td>D11TS, D11T, GP3, S25</td>
<td>Fine or sizes No. 20 or 25</td>
</tr>
<tr>
<td>D11T, S3, W1S, W2S, S30</td>
<td>Fine or size No. 25</td>
</tr>
<tr>
<td>D11, S40, S50</td>
<td>Medium fine</td>
</tr>
</tbody>
</table>
Depth of Instrument Placement During Obturation

- **Important of placing spreader within 1-2 mm of the prepared canal**

- **Failure to place spreader to the full WL results in the lack of adaptation & compaction of MC in apical portion**

- **MC surrounds by a sea of sealer that looks acceptable on the radiograph but does not seal!!**
Warm vertical compaction

- Schilder technique
- Nonstandardized cone, fit 1-2 mm of constriction
Warm vertical compaction

- **Plugger (length, size & curvature)**

  “Fitting & selection of the compactors is crucial to the success of this technique”
Warm vertical compaction

A heated instrument is used to sear off & transfer heat to the main portion of master cone.
Warm vertical compaction

A cold plugger is used to compact the softened portion apically & laterally
Warm vertical compaction

• Continued until soften GP is delivered into apical 1-2 mm of the prepared canal

• Pluggers 2-3 sizes are necessary to match the taper

• GP should not be overheated (Touch n heat, System B)
Warm vertical compaction
Thermoplasticized GP

• **Introduced by Yee et al. (1977)**

• **Injectable techniques**
  
  • **Obtura II (high-heat)**

  • **Ultrafil (low-heat)**
Obtura II

• GP pellets are heated to 185°-200°C
• GP in the needle (60°C) is injected into canal
• Slow-setting sealer
• Compaction of GP to adapt to the walls
• Cul-de-sacs, internal resorption, C-shaped
• Better than lateral compaction
Ultrafil System

• GP pellets are heated to 70°C
• GP in the needle (40°C) is injected into canal
• Slow-setting sealer
Thermomechanical Compaction

• Introduced in 1979 by McSpadden

• McSpadden compactor, Condenser, Engine Plugger, JS Quick-fill, Multi-Phase II Pac

Mac Compactor

• Resemble inverted hedstroem or K-file
Thermomechanical Compaction

- Friction heat soften GP
- Rapid but problems: cutting dentine, breakage of compactors, heat etc.
- Compactor rotates at 4000-5000 rpm
Core carrier techniques

- ThermaFil
ThermaFil

- Introduced by Johnson in 1978
- The core is placed in a specific oven (ThermaPrep)
- Placed into canal to the predetermined depth marked with a stop
- Top of the carrier is cut off 1-2 mm above orifice
ThermaFil

• Add accessory cones with lateral & vertical compaction

• Both ThermaFil & System B in the absence of smear layer showed no sig diff in leakage up to 24 d but leakage at 64 d was greater in ThermaFil (Kytridov et al., 1999)

• Post space Prep: Prepi burs, ThermaCuts
Core carrier techniques

• Soft core
Non-instrumented technique
Problem Solving in Endodontics, 3rd edn
Pathways of the Pulp, 8th edn
Endodontics, 4th edn
CAI “Obturation”