Endodontic Treatment 2011: Proven or Still Evolving?

Gordon and Paul’s Clinical Bottom Line: Most endodontic treatment is accomplished by general practitioners. Unfortunately, predictable success with current endodontic procedures has been shown to be elusive. What are the most adequate materials, devices, and techniques? What makes endodontic procedures most predictable, easiest, and most efficient? In this update report, CR has evaluated the currently popular endodontic concepts and materials and made conclusions that will help you to increase success in your endodontic procedures.

• Endodontic treatment has saved millions of teeth
• Revenue produced from endodontic treatment comprises a significant portion of overall general practitioner income
• Increased indication for endodontic treatment: aging population, bisphosphonates, multiple dry mouth medications, poor diet, etc.
• Some endodontic treatment could be more successful: recent study reports only about 80% success nationwide; however, reports from endodontists show 95% success
• Clinical challenges are blocked canals, breakage/separation of instruments, perforation, lingering pain or sensitivity, or outright failure
• More teeth are being extracted and implants placed instead of endodontics
• Endodontics can be simple and easy or complicated, unpredictable, and painful
• New endodontic concepts are present, but some are relatively controversial
• Additional new concepts under development appear promising

This report discusses and critiques current endodontic concepts including: diagnosis, instrumentation, irrigants, obturation and sealers, and treatments leading up to final restoration. Frequently asked questions are answered, useful products identified, clinical tips presented, and a CR survey on endodontics reported.

Provisional Cements: The Optimal One for Your Clinical Needs

Gordon and Paul’s Clinical Bottom Line: Fixed prosthodontic procedures remain as the single most revenue producing part of general dental practice. Cemntation of provisional restorations can or may not provide a comfortable, relatively esthetic, interim procedure until the final restorations are completed. CR scientists and clinicians have developed a concise and practical report for you on the differences among provisional cements, including their physical characteristics as well as a predictable clinical technique.

Provisional/temporary cements find widespread use in dentistry for cementing provisional restorations such as inlays, onlays, crowns, fixed partial dentures, and implant restorations. Selecting the best provisional cement can prevent the occurrence of provisional restoration dislodgment and subsequent emergency appointment. The characteristics of an ideal provisional cement are:

• Easy to use (dispensing, mixing, applying and clean-up)
• Excellent retention and marginal sealing for the duration desired (weeks to months)
• Elimination of sensitivity
• Acceptable flavor and odor
• Biocompatibility and compatibility with a wide range of provisional materials and final cementation materials
• Low solubility in oral environment

• Sufficient working time and reasonable set time
• Ease of removal of provisional restoration without damage to oral tissues
• Ease of cement removal from the surface of the preparation

Provisional cements can be broadly classified into: 1) ZOE (zinc oxide with eugenol, abundant), 2) Non-ZOE (zinc oxide without eugenol), 3) resin-based cements including implant cements, and 4) other cements including polycarboxylate, zinc phosphate, and glass ionomers.

This CR report includes the results of an extensive in-vitro study to characterize 28 brands of provisional cements and guides the clinician in material selection and technique. This report also evaluates the influence of the use of eugenol-based and non-eugenol-based provisional cements on the shear bond strength of final cements.

Products Highly Rated in CR Clinical Trials

Harmony Dual-Arch Tray: Unique anterior dual arch tray that captures prepared teeth, opposing arch, bite registration, and facial midlines in one simple step, and posterior impression trays, both made with biodegradable corn starch. (Page 6)

Total Solutions Implant Maintenance Starter Kit: COLORVUE probes with vivid yellow and black markings provide superior visualization of depth gauge introraally. Three IMPLACARE scaler tip designs also included. Both provide safe care of implant surfaces. (Page 6)

Locator Implant Attachment System: Overdenture stabilization with implants is a simple and easy way to improve patient satisfaction with dentures. Locator Implant Attachments are a popular and successful attachment for parallel and divergent implants. (Page 6)
Endodontic Challenges in 2011

- Many contradictory conclusions are present in the literature when observing meta analyses on methods for instrumentation (hand, rotary, reciproc), obturation type (gutta percha, resin, glass ionomer), and materials (irrigants, amount of irrigant necessary (5-2 mm), and use of posts or not.

- Consensus agreement...Factors influencing outcomes

- Periapical lesion or no lesion perioperatively. Reduced success when lesion is symptomatic present.
- Root canal obturation extending to 2 mm from the radiographic apex not extending filling for increased success.
- Quality of the subsequent restorative treatment. High quality, well fiting restorative treatment for increased success.
- With the need to reduce success.
- Estimated pooled success rates completed at least one year previously ranged from 68% to 85% (see picture at right).
- Properly accomplished endodontics on vital teeth can be 95% successful if all internal root canal anatomy is identified, but 3-5 times more failure on infected teeth in 3 to 10 years if excellent treatment is not accomplished.
- Highly suspect or symptomatic teeth should probably be treated endodontically rather than waiting until they are infected with the possible exceptions of those with apparent reversible pulps, primary occlusal trauma, avulsed or non-vital, lesions, or cracks.
- Reported endodontic success has not improved over 40 to 50 years, but more difficult cases are being treated.

Clinical Trials

- Use single, well-accomplished appointments for most cases unless infected and/or symptomatic.
- When encountering a "lot tooth," opening and placing a temporary restoration is a viable alternative.
- Create straight line access and don't over cut canals. Leave optimum canal size structure with minimal but sufficient: flaring for adequate tooth build-up and sizing if needed especially to correct to re-treatment.
- Use care to avoid perforations.
- Irrigation systems reduce risk of irrigant going beyond apex. EndoVac (Dentsply), EndoActivator (Dentsply Tulsa), and P File (Plastic File) are popular. Use of the EndoActivator, BioPulm MTAD (Dentsply Tulsa), and Q Mix (Dentsply Tulsa) have been shown to inhibit the growth of the most bacteria associated with endodontics.
- Don't over extend the root canal filling. Slight under filling is better (within 2 mm of apex) than over extension of underfilled canal.
- Consider using Tylenol (325-1000 mg) or ibuprofen (400-600 mg) instead of codeine. May also consider combining ibuprofen with acetaminophen.
- Radiographic identification of an optimum endodontic result. No apical lesion at one year, narrow void-free canal within 2 mm of apex, and obturation material interface with restorative material at bone level (assuming post not needed).

Useful Products and Concepts for Endodontics: Mandatory, Desirable, and Elective

Mandatory

- Apex locator. Currex devices are accurate at the time, but must be combined with other methods. Root ZX II (J. Morita) and the Extracurricular 1-10 (Prober) are popular devices.
- Magnification using loupes. Oracultics, Designs for Vision, and Surgitek are most used. 2.0x to 4.0x are most used with 2.5x most popular.
- Rubber dam. From both clinical and legal perspective, rubber dam use is mandatory. Lates and non-lates (Coltene Whiteleader) are most used.
- Adequate final restoration to eliminate coronal leakage. Onlays or crowns are most adequate. If not financially feasible, a direct resin-based composite only is acceptable for an interim period.

Desirable

- Continuing education. If you feel your endodontic procedures are out-of-date, enroll in a CE course. Drs. Stephen Bachman, Gary Carr, Harry Muskat, Cliff Ruddle, and John West are examples of well recognized CE instructors. (Go to Google for information.)
- Clinical microscopes. Many endodontists now consider use of a clinical microscope to be the current level of care. Global and Zeiss are used most.
- SAF System from Redent Nova (available from Henry Schein). This recently introduced, evolving system uses an elastomeric composite file that has been shown to closely adapt to canal anatomy removing significantly more debris than conventional techniques.
- File holder. Often, when it appears the canal is blocked, bending the file will allow it to find the canal. EndoReader (SybronEndo) or a simple metal plier.
- Post File. These are desirable when rotary files will not negotiate a sharp curvature. If hand file cannot negotiate canal, don't use rotary.
- Endo Guide bars. Conical carbide endo guide bars assist the dentist to enter the canal at the correct angle. Tapered side bars (55/65).
- Removal instruments. Obtura III Max (Obtura Sparta) for gutta percha removal and PS Neuton (Recrot) assist in root polishing and post removal.
- Torque control clip. Example: X Smart Eas (Dentsply Tulsa) or Endo DTIC (Dentsply) torque control mouns.
- Reciprocating instrumentation systems. Proven simple technique to rotary instrumentation with less file breakage. Desirable for those experiencing file breakage with rotary instruments. SafeSerts (Essential Dental Systems) or Foredent (Ultradent).

Elective

- Carrier-based obturation systems. Plastic or metal carrier coated with gutta percha, heated, and placed to length. Thermafil (Dentsply Tulsa) is most popular; without metal or plastic carrier: gutta core.
- Non-gutta percha obturation systems. Research supported alternatives for gutta percha. RealSeal (SybronEndo).
- Glide path rotary files. Fragile, ultra small rotary files that allow a transition from a P10 file to the smallest conventional rotary file. PathFile (Dentsply Tulsa).

Questions and Answers (Continued from page 1)

In order of instrumentation, irrigations, obturation, and scaling as based on available research literature and observations of CR staff and Endodontists

1. Should antibiotics be used routinely during endodontic treatment for asymptomatic teeth? Controversial. Not warranted based on best evidence currently available. However, antibiotics may be useful for infected teeth.

2. Are all canal instrumentation techniques comparable (hand, reciproc, or rotary file)? Yes, controversial, depends on personal preference, all types used properly are successful.

3. Which instrumentation type is most popular? Rotary.

4. Which instrumentation technique has the most reported file breakage? Rotary has the most, but done properly, canal debridement and shaping is more consistent. Reciproc has less breakage making it an alternative for those experiencing significant file breakage.

5. Are lasers effective in removing smear layer and vaporize tissues in canals? Results are inconclusive and commercial.

6. Is use of clinical microscope mandatory? Most endodontic treatment is done with loops, but microscopes can be desirable and used by many endodontists.

7. Is cone-beam radiography useful in endodontically? Infrapently and usefully, but can show reasons for some painful or failing treatments that would otherwise be missed.

8. Which irrigant is best? Sodium hypochlorite, chelating glutaraldehyde, LLTA (Leyden turaninutrient acid), and MTAD (EndoTrac rinse, citric acid, and detergent) are used. Sodium hypochlorite is very hot with well know significant problems if injected beyond apex. Use of BioPulm MTAD (Dentsply Tulsa) or Q Mix (Dentsply Tulsa) to remove smear layer and necrotic tissue caused by instrumentation is promising. Comparative studies are inconclusive.

9. Should hydrogen peroxide be used? Use is based on antiobacterial and cleaning properties. Research questions value. Some prefer effective property when mixed with sodium hypochlorite. Use declining.

10. Should intracanal medications be used? Many potent antimicrobial medications have been used historically. Current research shows that intracanal medications do not prevent pain. Ca(OH)2 occasionally used for bactericidal activity.

11. Which obturation concept is best? Gutta percha, resin, glass ionomer, or others? Success is reported with each. Comparative research is inconclusive. Gutta percha is most used.

12. Are ZOE-based, calcium hydroxide, or resin sealers best? Both research and observations are mixed. Most use ZOE-based sealers.

13. Is the Sargenti technique effective? The Sargenti technique can be effective, but has been controversial in the U.S. and FDA approval is still pending.
Endodontic Survey Results (n = 1171 respondents)

- Specialty: 55% CR, 2% Prosthodontist, 2% Pediatric, 1% Endodontist
- Root Canal Therapy: 76% accomplished endo, average 7.5 teeth/month
- Referral to Endodontist: Posterior teeth 59%, anterior teeth 41%
- Magnification Use: 82% liners 2.0-3.0x, 27% liners 3.0-3.5x, 15% liners >4.0x, 12% no magnification, and 2% microscope
- Apex Locator Use: 47% all the time, 22% never, and 31% sometimes. Root ZX (J Morita) most popular
- Type of File Used: more than one choice: 79% rotary, 70% hand files, and 10% reciprocating. Conventional tubes and Buischere most popular manufacturer
- Irrigation Use: more than one choice: 94% sodium hypochlorite, 22% chlorhexidine gluconate, 9% hydrogen peroxide, and 20% others (see recall, local anesthetic, later, etc): 18% no active irrigation such as ultrasonic. Enzyme Activator (Dentsply Tulsa), etc.
- Obturation Type: 68% master cone and 27% carrier based
- Gutta Percha Placement: 41% lateral condensation, 27% warm vertical condensation, and 23% carrier based
- Sealer Type: 3% zinc oxide eugenol base, 25% resin base, 22% calcium hydroxide base, and 9% glass ionomer
- Post and Core Build-up at Same Appointment: 66% sometimes, 25% never, and 9% always
- Opinions on Reasons for Failures: 51% inadequate canal debridement, 50% inadequate seal, 11% inadequate obturation, and 8% other. Bacterial infection, canal preparation, accessory sealer, etc.
- Appointments: 69% 1 appointment and 30% 2 appointments
- Partial or Complete Failure at 2 years: 59% report up to 10% failure; indicated by occasional unscheduled pain, sensitivity to pain, or overnight failure
- Extraction of Teeth Due to Availability of Implants: 59% extracting more teeth than previously would have been treated endodontically.

CR Conclusions: The reported success rate of a typical general practitioner endodontic treatment could be better, but can be very effective if accomplished adequately. Norins in the US are rotary canal instrumentation, sodium hypochlorite irrigant, and gutta percha obturation. Successful endo requires excellent diagnosis, canal debridement, disinfection, filling, and restoration. Practitioners are advised to update their endodontic knowledge and concentrate on producing excellent successful results. There exists a wide divergence of opinion and many controversies on techniques with most claiming clinical success. New endodontic concepts are under investigation, and CR will report on them at that later time.

Provisional Cements: The Optimal One for Your Clinical Needs (Continued from page 1)

CR Clinical Techniques and Tips for Using Provisional Cements

- Retentive strength: Medium to high strength is desired to avoid dislodgment of provisional and return of patient to practice for re-erecement. This problem plagues practices worldwide, irritates patients, and adds to overhead expenses.
  - Tooth preparation: For teeth with parallel walls (6-18 degrees) and adequate proximal wall height (>4 mm), a low to medium strength provisional cement is sufficient. However, most teeth lack adequate retentive features; therefore, add grooves and boxes to increase retention.
  - Eugenol, non-eugenol, or resin? Eugenol is a known obturant and can help reduce sensitivity of a tooth during the provisionalization stage. Its continued use, although contrary to the current trend, is encouraged by CR (see graph on page 4).
  - Clean preparation: Use a flour pumice (such as Prepasive by WhipMix) on a flexible rubber cup to remove all provisional cement and debris before final cementation. Use a 5% glutaraldehyde 35% HPMA disinfectant (GluMax by Leneu, MicroPrime G by Danville, etc.) can help disinfect and decrease sensitivity during provisionalization. Other additives like triclosan, potassium nitrate, and chlorhexidine may also provide relief.
  - Moisten preparation: Use a water-soluble lubricant (such as glycerin by Ultradent, KY jelly by Jelf, etc.) on adequately prepared teeth for easy removal of the provisional crown. Some clinicians add Vaseline to final cements (such as ZOE by 3M ESPE) for long-term provisionalization or when added strength is required.
  - Potential endodontic therapy: A tooth preparation with an indirect pulp restorations (e.g., build-up or crown prep) or a tooth that may require future endodontic therapy is best treated by long-term provisionalization (>1 month) to avoid endodontic access through the new crown. Use ZOE based provisional cement for its obturation effect.
  - Single implant restorations: Most implant restorations are single units with a highly retentive abutment and are cemented with a provisional cement. For single units, a medium strength cement is desired to allow for future removal if necessary.
  - Multiple-unit fixed implant restorations: A provisional cement with a long working and setting time and low to medium strength that allows for future removal if necessary is desired.

Provisional Cement Survey Results (n = 965)

- Eugenol based provisional cement: Decreased use over past 20 years primarily due to the false belief that eugenol interferes with setting of final cement (see graph on page 4).
- Non-eugenol based provisional cement: 75% use when final restoration is all-ceramic, zinc oxide, or fiberglass composite. Overall, non-eugenol based provisional cement is used more frequently than ZOE based provisional cement regardless of final restoration.
- Top five most common provisional cements:
  1. TempBond ZOE (Kerr) .................. 38%
  2. TempBond NR (Kerr) .................. 26%
  3. TempBond Clear (Kerr) .................. 13%
  4. ZOE (DCM) .................. 12%
  5. Reli-X NF (3M ESPE) .................. 9%
- Final cement used as a provisional cement: 53% use final cement as a provisional cement with the most common technique using polyalkenoate cement (Durelon) with or without additions of Vetelin.
- Added strength desired: Polycarboxylate, zinc phosphate, glass ionomer, or resin-based non-eugenol cements are most common for increased strength.
- Dissolution of final crowns: 85% have non-eugenol cements for dissolution or use a final crown cemented directly using a eugenol based provisional cement.
- Setting time: 60% state setting time does not make a difference in choice of provisional cement.
- Long-term provisionalization (>6 weeks, e.g., full arch or full-mouth rehabilitation): Non-eugenol-based provisional cement is most preferred cement (29%) followed by eugenol based (22%), polyalkenoate (17%), resin-based (12%), and IRM (11%).
- veneer provisionalizations: Flasable composite (30%) and bonding agent (27%) are most common.
Provisional Cements: The Optimal One for Your Clinical Needs (Continued from page 3)

CR Laboratory Tests and Results

The following chart is a comparison of the characteristics of 28 provisional cements. Grading is based on the most common restoration: single crown (provisional fabricated with resin-based material). Please refer to Clinical Tips (on page 3) for implant or fixed prostheses with three or more units.

<table>
<thead>
<tr>
<th>Brand (Company)</th>
<th>Cost/Unit ($)</th>
<th>Cost of Material Wasted ($)</th>
<th>Working Time (minutes)</th>
<th>Intralinear Set Time (Self Cure) (minutes)</th>
<th>Dual Cure</th>
<th>Retentive Strength Rating</th>
<th>Available Mix Types (boxed in bold)</th>
<th>Overall Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>TempBond (Kerr)</td>
<td>$7.20</td>
<td>*</td>
<td>3.9</td>
<td>3.0</td>
<td>No</td>
<td>Low</td>
<td>auto, manual, uni-dose</td>
<td>Excellent</td>
</tr>
<tr>
<td>Belux Temp E (3M ESPE)</td>
<td>$1.20</td>
<td>*</td>
<td>3.7</td>
<td>5.7</td>
<td>No</td>
<td>Low</td>
<td>manual</td>
<td>Excellent</td>
</tr>
<tr>
<td>TempCore 70 (Bettis)</td>
<td>$3.50</td>
<td>*</td>
<td>&gt;5</td>
<td>4.0</td>
<td>No</td>
<td>Low</td>
<td>manual</td>
<td>Excellent</td>
</tr>
<tr>
<td>Fyndel** (Denpuy Castle)</td>
<td>$5.80</td>
<td>*</td>
<td>&gt;5</td>
<td>8.1</td>
<td>No</td>
<td>Moderate High</td>
<td>auto, manual</td>
<td>Excellent</td>
</tr>
<tr>
<td>TempCore 70 (Henry Schein)</td>
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<td>*</td>
<td>3.2</td>
<td>5.0</td>
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<td>auto</td>
<td>Excellent</td>
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<tr>
<td>CR Plus (Ivoclar)</td>
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<td>$2.20</td>
<td>2.9</td>
<td>8.2</td>
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<td>Low</td>
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<td>TempCore EM (DMG America)</td>
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<td>Low</td>
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<td>8.1</td>
<td>No</td>
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<td>auto</td>
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<td>4.5</td>
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<td>Integrity TempGrip (Dentsply Caulk)</td>
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<td>Protemp Cac (Parkell)</td>
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<td>Xemp Temp Resin (Dentsply HealthCare)</td>
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<td>Premier implant crown (Premier)</td>
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<td>$3.20</td>
<td>3.6</td>
<td>2.6</td>
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<td>No</td>
<td>auto</td>
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<td>TeleC CS Link (Vivadent)</td>
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<td>IMProv (Ivoclar)</td>
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<td>$2.20</td>
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<td>HMT (Dentsply Caulk)</td>
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<td>&gt;5</td>
<td>12.3</td>
<td>No</td>
<td>Moderate High</td>
<td>manual, uni-dose</td>
<td>Excellent</td>
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<tr>
<td>Duradon*** — universal, universal (3M ESPE)</td>
<td>$7.10</td>
<td>*</td>
<td>&gt;5</td>
<td>6.7</td>
<td>No</td>
<td>No</td>
<td>manual, uni-dose, manual</td>
<td>Excellent</td>
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<td>Fleck** (Melloy/Keystone)</td>
<td>$2.50</td>
<td>*</td>
<td>&gt;5</td>
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<td>No</td>
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<td>manual, uni-dose</td>
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<td>Fuji TFMPT LC (GC America)</td>
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<td>2.5</td>
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<td></td>
<td></td>
<td>auto</td>
<td>Good</td>
</tr>
</tbody>
</table>

*Variables: depends on amount of material dispensed or type of mix used. ** $25 \text{ C}^{-1}$ ** $25 \text{ C}^{-1}$ with water. **None of these being used as provisional. **Not indicated as a prosthetic cement.

**Summary**

- **Cost/Unit Range:** TempBond to TempBond Clear and Zone.
- **Cost of Waste in Delivery System:** Up to $4.50 for single crown restoration compared to $0.00 for mix-based.
- **Working Time:** TempBond NE (Kerr) is the fastest (8 minutes).<br>**Intralinear Set Time:** TempBond NE (Kerr) is the longest (15 minutes).<br>**Dual Cure Materials:** Most cements are dual cure. TempBond NE is single cure only.<br>**Crown pull-off (retention) strength:** Protemp Plus (3M ESPE) has the highest strength, followed by TempBond NE and NeXtemp Temporary Crown (Premier).<br>**Other cements:** NeXtemp Temporary Crown (Premier) and TempBond NE have the lowest pull-off strength.<br>**Overall Grade:** Excellent to Good.

**Effect of Eugenol on Final Concretion**

- **Shear Bond Strength (MT)**: Eugenol-based cements have higher bond strength compared to non-eugenol-based cements.

**CR Conclusions:** Clinicians should select provisional cements based on reducing sensitivity, the degree of retention desired, the duration of provisionalization, and cost. TempBond, E.T.C., and NeXtemp Temporary Crown were the best performing provisional cements tested in this study. Further studies are recommended to determine the long-term effects of using eugenol-based provisional cements.
Anterior and Posterior Dual-Arch Impression Trays with Additional Features

This unique anterior dual-arch tray with facial midline positioning and posterior dual-arch tray have additional desirable features including: rigid and solid design; fully attached thin inter-occlusal mesh; and low sidewalls. Anterior trays allow accurate impression of prepared teeth, opposing arch, bite registration, and facial midline record all in one impression. Posterior trays have wide arch and metal distal bar to prevent distortion of impression. Both are constructed with biodegradable corn starch and posterior trays are made metal portion for added rigidity.

Advantages:
- Rigid and solid metal/biodegradable corn starch design
- Provides accurate impressions and inter-occlusal record
- Easy to use
- Low sides for no soft tissue or occlusal interferences
- Thin, non-soring, inter-occlusal mesh
- Cost

Limitation:
- CR Evaluators recommend use of dual-arch trays for one or two units and full-arch trays for three or more units (see Clinicians Report June 2008).

Implant Scaler and Easily-Identifiable Probe Do Not Alter Implant Surfaces

Many clinicians have sought metal-free scalers and probes for safe maintenance of implants, but have discovered many drawbacks on use. While titanium scalers have provided more durability and better access for implant maintenance, most can alter implant surfaces. Total Solutions Kit contains three durable unfilled resin scaler tip designs and choice of 4 vivid yellow and black perio probes, all of which are compatible with the popular Satin Steel handles. All instrument tips will not significantly alter implant surfaces and are safe to use on all dental implants.

Advantages:
- Durable metal-free scaler tips do not alter implant surfaces
- Easily identifiable depth gauges on perio probes
- Light weight and ergonomic handles
- Tips are removable and interchangeable

Limitation:
- Scaler tips are bulkier than metal tipped instruments

Long-Term Use Validates Popular Overdenture Attachments for all Major Implant Systems

Many CR Evaluators use the Locator Implant Attachment System because of its ease of use and availability for and success with many implant brands. This system provides a way to predictably engage cadaverous implants in the mandible or maxilla and retain overdentures. Not indicated for multiple implants with a divergence of greater than 40 degrees between implants.

Advantages:
- Easy to use and place
- Provides multiple levels of retentive strength
- Easily cleaned
- Unique pivoting technology provides for some correction of non-parallel implants (no more than 20 degrees of divergence per implant)
- Less expensive than other systems
- Various tissue heights available including short

Limitation:
- Non-sterile packaging

CR Conclusions: 95% of 19 CR Evaluators rated Locator Implant Attachments as excellent and used them in their practices. 100% rated it excellent or good and worthy of trial by colleagues.