PathFiles

- Directions for use
  - loose size #10 to WL
  - passive action, following the canal path
  - 300rpm

No. 1 = #13
No. 2 = #16
No. 3 = #19 Not needed here

Supplemental Instruments

- Orifice relocation with Sx

- Hand files
  - various sizes
  - initial scouting and patency, WL
  - canal gauging

Shaping:
X1  017 / .04
X2  025 / .06

Optional:
X3  030 / .07
X4  040 / .06
X5  050 / .06

Gauge after X2
My First Impression

- Passive hand movements
  - seems less "direct" than PT Universal
  - higher fatigue resistance allows this

- Coronal flaring
  - still like the Sx
  - overall shape similar to PT Universal

- Safe usage
  - no preparation errors
  - no breakage

Routine Root Canals (SB, 13)

Key Evidence

- Classics
  - canal preparation needed, not sufficient
  - overall tapered shape is recommended

- In vitro studies
  - several thousands of papers
  - CAVE: "biologic plausibility"
  - many clinical outcomes inferred

- Clinical
  - few prospective studies
  - good analyses from retrospective studies

**Aim**
- to investigate factors influencing the periapical status after RCT

**Methods**
- more than 1000 patients and 2200 roots were followed for 2-4 years
- data was obtained prospectively for pre- and perioperative factors such as
  - initial presence of p.a. lesion, presence of sinus tract, achieving patency,
  - using EDTA, CHX, root filling extrusion, satisfactory coronal restoration
- the proportion of roots with complete periapical healing was determined
- robust statistical methods were used to determine odds ratios for each factor taking clustering into account

**Results**
- based on review of ~1500 teeth & ~2500 roots overall success was ~80-83%
- almost all lesions that ultimately healed did so within two years
- these pre-operative factors were significantly associated with success:
  - pulpal status, absence (and small size) of p.a. lesion and of sinus tracts
- some perioperative factors were significantly associated with success:
  - patency (+), long fill (-), use of CHX (-), use of EDTA (+)
- several well-established clinical strategies not associated (e.g. 5.25% NaOCl)

**Discussion**
- very large and well controlled prospective study of resident treatments
- author acknowledges bias brought in by the specific setting
- more research is required to more directly establish best practices, however common sense and classic studies continue to inform clinical endodontics
Key 2b: **Cleaning & Shaping**

- Select an adequate irrigant (-sequence)
  - NaOCl is essential
  - interactions exist among irrigants; substrate

- Deliver the irrigant to the site
  - shape adequately, remove debris successfully
  - provide irrigant flow

- Evidence
  - clinical outcomes studies are sparse
  - perhaps different cases require specific strategies

**Biofilms Visualized**

- Conventional microscopy
  - Brown Brenn stain

**Presence and Removal**

- Biofilms are present in root canals
  - standard methods are effective...but not completely
  - activated irrigation recommended

- Biofilms may be present extraradicularly
  - possible but not frequent
  - may be associated with refractory lesions: surgery

- Biofilms may be present in retreatment
  - typical strategy: enlargement, irrigation, medication
  - inaccessible canal spaces
  - development of resistant strains, persisters
Sodium Hypochlorite Facts

- Excellent disinfection capacity
  - household bleach (in fact app. 6-7%, ref. Chlorox)
  - available chlorine determines efficacy

- Tissue dissolving properties
  - depend on temperature
  - are self limiting depending on concentration

- Significant toxicity
  - solution expressed into tissue leads to necrosis
  - DO NOT LOCK needle in canal

NaOCl Incidents

Removing Smear Layer
EDTA Facts

- Minimal disinfection capacity
  - insignificantly better than saline
  - believed to allow access beyond smear layer

- Tissue dissolving properties
  - dissolves dentin by chelation
  - effect greatest at neutral pH, typically 17% conc.

- Side effects
  - may lead to exaggerated demineralisation
  - has potential to greatly suppress NaOCl action

Chlorhexidine Facts

- Disinfection capacity beyond NaOCl
  - seen as beneficial in retreatment
  - may not provide any clinical benefit

- Concentration and galenics
  - reports available from 0.12 to 2% (-5%)
  - gel vs liquid vs impregnated gutta percha points

- Side effects
  - NaOCl and CHX give rise to reddish precipitate
  - this material may be toxic or even carcinogenic

Activated Irrigation (PUI)

- Effect of ultrasonically activated irrigation I
  - no effect: no more bacterial reduction
  - no effect: incomplete smear layer removal

- Effect of ultrasonically activated irrigation II
  - positive effect: bacterial reduction
  - positive effect: removal of smear layer

- Preparation errors
  - use of cutting ultrasonically activated instruments may lead to undesirable canal shapes
**Exotic Systems**

- Laser-assisted irrigant activation (PIPS)
  - mechanical and streaming effect of pulsed laser to distribute common or novel irrigation solution
  - no thermal effect
  - currently under investigation

- Pulsed plasma probe
  - plasma: gas mixture (99% He & O₂) flows through a nozzle connected to a high voltage generator (10kV)
  - short pulses (100ns) of reactive gas eliminate biofilm
  - currently under investigation

**Activation of Irrigants**

- “Photon-initiated photoacoustic streaming”
  - uses pulsed laser to activate deposited irrigant
  - no thermal effect
  - may be efficient against biofilms
**Key Evidence**

- **In vitro**
  - many studies addressing bacterial killing and soft tissue digestion, recently anti-biofilm effects
  
  Byström 1981

- **In situ**
  - several groups use teeth in patients that will be extracted or sampled
  
  e.g. Nusstein group

- **Clinical**
  - little specific evidence for a particular irrigant over another, still a good rationale for NaOCl and EDTA
  
  Ng 2011

**What About “Single-Visit”?**

- Initially...
  - was taught Scandinavian strategy and Ca(OH)$_2$
  - evidence appeared to be acceptable

- In California:
  - patients clearly prefer single-visit

- Currently....
  - yes if pulpitis and enough time
  - no for Re-RCT and infected canals & symptoms

- In Italy:
  - yes with optimal disinfection to avoid leakage

**Legend**

- Sathorn C *Int Endod J* (2005)
Clinical Research
One- versus Two-visit Endodontic Treatment of Teeth with Apical Periodontitis: A Histobacteriologic Study
Jorge Vene Jr, DDS, Jose E. Siqueira Jr, DDS, MSc, PhD, and Domenico Ricucci, MD, DDS
Sirma Loghin, DDS, Nancy Fernández, DDS, Belina Flores, DDS, and Alvaro G. Cruz, DDS, MSc

Table 3: Microbiological Status and Location of Residual Microorganisms in the Middle and Apical Root Canal System of Teeth with Apical Periodontitis after Treatment in 1 or 2 Visits

<table>
<thead>
<tr>
<th>Specimen</th>
<th>MBC</th>
<th>MLC</th>
<th>IST</th>
<th>DT</th>
<th>AR</th>
<th>Overall</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Visit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Extraradicular biofilm</td>
</tr>
<tr>
<td>2 Visits</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Introduction
Strategies
Discussion

Key 3: Obturation
- Benefit vs harm
  - is an obvious way to demonstrate proficiency
The effect of canal preparation on periapical disease. *Int Endod J, 16:68-75*

**Aim**
- to compare outcomes in cases with and without root canal obturation

**Methods**
- 86 and 336 teeth were treated as experimental and control groups
- the control teeth were chemo-mechanically prepared and obturated
- no obturation was done in the experimental group, both were temporized
- obturation was only done after negative culture
- radiographic follow-up was done over 2 yrs, using a 6-step scale
- groups were compared using chi-square tests

**Results**
- experimental group: number of Rx-negative cases increased significantly, cases with large lesions were significantly reduced, rarely positive cultures during the course of the treatment
- control group: also significant reduction of Rx positive cases, different situation (better) initially than in the experimental group
- success was better in short-filled than in "long" or "flush" cases

**Discussion**
- in spite of no obturation, healing occurred in many cases
- there was recontamination in 15% of the unfilled cases

**My conclusion**
- obturation, and its quality, are important but no prerequisites for healing
Fate of the Tissue in Lateral Canals and Apical Ramifications in Response to Pathologic Conditions and Treatment Procedures

Domenico Ricucci, MD, DDS, and José E. Siqueira Jr., DDS, MSc, PhD

- Material & Methods
  - narrative review of literature
  - case review of 493 specimens obtained by extraction or surgery
  - routine H&E stains as well as Brown Brenn was done
  - special attention was paid to tissue and substances in lateral canals and apical ramifications (LC/AR)

J Endod 2010, 36:1-15

Role of Accessory Anatomy

- Filling of accessory spaces
  - radiographically filled canals: histologically incomplete
  - inflamed tissue and bacteria are also present

- Fate of tissue
  - tissue follows fate of main canal tissue
  - LC/AR content partially removed by cleaning & shaping

- Clinical conclusion
  - "It appears that strategies other than finding a technique that better squeezes sealer or gutta-percha within LC/AR should be pursued..."
New in Obturation

- Gutta Core (Dentsply Tulsa)
  - modified gutta percha replaces plastic carrier
  - little research available, handles similar to Thermafil

- EndoSequence (Brasseler)
  - part of ActiveGP, special coated points adhere to sealer
  - overall little research into outcomes, a single-cone fill

- Cordless heating devices (various companies)
  - both heated pluggers and GP extruders

- Flowable materials and their application
  - experimental MTA derivatives and others

Bioceramics

- Osteoconductive materials
  - questions about setting time
  - intended for single cone obturation
  - no definitive conclusion possible at this time

Key Evidence

- In vitro
  - multiple leakage studies in various models, clinical impact questionable

- Others
  - temperature measurements, homogeneity etc
  - sealer chemistry and biocompatibility

- Clinical
  - Toronto study, adjunctive observation in others
  - overextension appears to be negative
Adverse Outcomes

- Overfill / Overextension may cause
  - (endodontic) failure
  - nerve lesion, fungal infection etc.

Key 4: Follow-up Care

- Detect failing root canal treatment
  - tools: recall, p.a. film, CBCT
  - clinical impression

- Decisions: treat if needed
  - individual decision based on the merit of the case
  - non-surgical, surgical endo, implant

- Toolkit
  - have the clinical skill set to manage retreatment

Radiographic Success

- Cumulative healing
  - looking at healed cases only
  - if it has not healed after 1 yr, chances are less that it will
 6m outcomes less predictive
  - if no healing after 4 years, it will likely never heal
Healing assessment
- CBCT is sensitive tool
- likely to detect significantly more lesions compared to P.A. films

Case reports

Problem: Healing Assessment

Current Discussion
CBCT Healing Assessment

- Higher sensitivity (clinical cases)
  - p. a. films reveal ~30% with lesions
  - small FOV CBCT reveal ~65% with lesions

  Estrela 2008

- Better accuracy (dog study /w histology)
  - p. a. films correct in ~78% of cases, CBCT in ~92%
  - sum of true positives and true negatives

  Da Silva 2009

- Potential impact on success rates
  - current numbers may be not valid
  - better discrimination for different treatment modalities

Decision Making

- Continuous disease scale

Retreatment (UN, 05)

Case history

Pre-op radiograph

Final radiograph

Recall radiograph

- 20 yr old fill
- asymptomatic
- restoration adequate
- very motivated patient
Key Evidence

- Clinical
  - retrospective data from many groups
  - cross-sectional data, overall poorer outcomes

- Assessment tools
  - clinical impression, p.a. radiographs, CBCT

- Data from large cohorts (insurance, PBRN)
  - retention of root canal treated teeth is very high
  - reasons other than primary endodontic failure often associated with extractions

A Tooth’s “Career”

Patient’s Age (years)

Integrity

Restorations

Endodontics

RCT

PA lesion

The Future
Non-Instrumentation Technique

- NaOCl at low atmospheric pressure
  - complicated tubing system for delivery
  - in vitro successful, clinically problematic

Unique Cleaning Technology

- Targets pulp tissue with controlled, varied energy waves
- Simultaneous cleaning of pulp chamber and root canals
- No need for individual sequential canal treatment

Result:
Cases that previously required extensive time/irrigation/instrumentation now can be cleaned quickly and completely regardless of chamber/canal morphology
Basic Research
A Comparative Study of Biofilm Removal with Hand, Rotary Using a Novel Nickel-Titanium, and Self-Adjusting File Instrumentation

Introduction
James Lin, DDS, MSc, Ya Shen, DDS, PhD, and Markus Haapasalo, DDS, PhD

Abstract

Introduction:

Discussion

Strategies

In Vitro Biofilm Model

A biofilm is present either as free-floating (planktonic) single cells or attached to each other or to the root canal walls to form (sessile) biofilms. Although planktonic microorganisms biofilm bacteria from the root canal remains a major challenge community the biofilm bacteria express different phenotypes, often with different characteristics, than do the same bacteria in their planktonic state. Notable among these differences is the increased resistance to antimicrobial agents that can be 100- to 1000-fold greater for a species in a mature biofilm relative to that same species grown planktonically.

Although mechanical preparation of the infected root canal has been shown to be most effective in reducing the number of bacteria, it allows for cleaning beyond what might be achievable through instrumentation complexities of the root canal system present physical constraints that pose a serious challenge to adequate root canal disinfection using currently available techniques such that residual bacteria are often found in areas such as fins, isthmuses, ramifications, deltas, accessory and lateral canals, and dentinal tubules. nickel-titanium (NiTi) rotary files, the SAF system uses a hollow reciprocating instrument that allows for simultaneous irrigation throughout the mechanical preparation. The instrument is used in a trans- continuous irrigation of long oval canals were more effective than rotary NiTi instrumentation adapting itself to the canal shape 3-dimensionally line (in-and-out) motion, and the abrasive surface of the lattice threads promotes a uniform removal of dentin.

Decontamination-Disinfection

Decontamination-Disinfection

The threshold
- no sterile root canals but low numbers (10-100)

The outcome
- out of hand instrumentation ProFile and SAF, none was removing all biofilms, SAF was most effective

Apical Size & Disinfection

Apical Size & Disinfection

The threshold
- no sterile root canals but low numbers (10-100)
Issue: Longevity

- Patient demographics
  - anecdotally, many patients are >75 years old
  - cost of treatment is high
  - alternatives are available

- Healing or survival?
  - which goal should we consider
  - what determines survival of treated teeth

- Pathways for improvement
  - less invasive treatment strategy
  - specific issues when this is adopted

Conclusion

- Evidence-based endodontics
  - an effort to practice based on knowledge
  - understand that for many procedures there is little....

- Willingness to continue to self-educate
  - new materials and devices
  - cognitive and hand skills

- Treatment potential
  - conventional root canal therapy, retreatment, surgery
  - regenerative endodontics, traumatology, implants....
Preparation Possibilities

- "More of the same"
  - refined instruments that are more efficient and safer
  - easier market penetration but limited innovation

- Minimal invasive
  - limited enlargement and retained structural integrity
  - specific set of challenges

- Not at all
  - specific non-instrumental techniques
  - alternatively, vital pulp therapy or regeneration

How Are We Doing Now?

- 1987
  - necrosis, s. p. p.
  - Giromatic
  - lateral compaction

- 2006
  - irreversible pulpitis
  - NiTi rotary
  - vertical condensation

Brief Summaries

- Key 1: Access
  - as small as practical

- Key 2: Cleaning and Shaping
  - many strategies, some hints to best practices

- Key 3: Obturation
  - no best technique established, no overextension

- Key 4: Follow-up care
  - the current tools are poor and decisions empirical
Clinical Studies

- Some surrogate outcome variables
  - disinfection capability
  - presence and incidence of preparation errors

- One variable among several others
  - outcome analyses in endodontics are multifactorial
  - other variables can be overriding

- Added benefit may be too small to measure
  - clinical (prospective) studies indicate high healing rates with a wide range and little change in the last 60 years

Conclusions

- Long-range: two pillars
  - vital pulp therapy
  - minimal invasive conventional endodontics

- Transition period
  - gradual R & D for both
  - special cases: define indications and techniques

- Cognitive framework
  - establish best practices, currently insufficient evidence
  - socioeconomics and access to care

Time for Another Break!