Contemporary Strategies in Root Canal Treatment

Ove A. Peters, DMD MS PhD
Diplomate, American Board of Endodontics

Washington State Association of Endodontists

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Seattle WA

§ 1917 - access, cleaning & shaping, gutta percha, radiographs
- even some instruments look exactly the same as today
Items for Consideration

- "Success/Failure" concepts
  - comparison to implant data ("retention")
  - numbers may change with advent of CBCT

- Overall health considerations
  - data not clear regarding cardiovascular events and endo
  - emergence of host defense as an important factor

- Treatment modalities
  - conventional root canal, improved version
  - biologic treatment, such as regenerative endodontics

Initial Treatment

Follow-up studies (2000-2012)

- n = 52

Healed (%)

Current best evidence

- n = 11

S. Friedman
Alternative Treatments

Which Are Key Strategies?

- **Access**
  - ideal configuration BUT “do not harm”
  - prevent preparation errors, *e.g.*, ledges etc.

- **Cleaning and shaping**
  - balance size, antimicrobial effect, debris production
  - irrigation efficacy, antimicrobials

- **Obturation**
  - occlusion of space and leakage pathways

- **Follow-up care**
  - understand success and failure
  - select retreatment vs surgery vs implant

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**Key 1: Access**

- **Basics**
  - size of pulp chamber
  - shape of pulp chamber
  - design of root canal system
  - demands of instrumentation technique
How Are We Doing?

- We are able to do beautiful work

**Strategies**

Introduction

Strategies

Discussion

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**Laws of Orifice Location**

- Law of centrality (1)
  - pulp chamber floor is centered at the CEJ

Fig. 3. Scatter diagram of the orifice locations on a maxillary second molar. Each dot represents an orifice projection finding.

Wilcox 1989

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**Tooth Development**

- Programmed and detailed succession of events
  - morphogenesis and differentiation

D’Souza 2002
**Geometrical Principles**
- Outer root surface follows cross sectional pulp shape
  - remember morphogenesis and differentiation!
- CLINICAL HINT: Track root contour with explorer

**Straight-Line Access**
- Instruments are constrained cervically
  - WL shortens during procedure
  - preparation is affected by coronal tension
- Rotary instrument fatigue more
  - coronal curves are more dangerous
  - should go straight into middle 1/3
- Transition from chamber to canal
  - cutting NiTi: lateral, push
  - US tips: sanding, digging, troughing, undercutting
  - SS White Access burs

**Searching for Evidence**
- Evidence-based dentistry
  ... is the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients.
- For practical reasons:
  - 1/3 literature, 1/3 clinician, 1/3 patient
  - searched databases, reference lists
- Issues with written evidence
  - levels of evidence: clinical trials vs bench top
  - “biological plausibility”, “surrogate outcomes”
  - room for interpretation, conflicting results

Sackett 1996
Searching for Evidence

- www.ebd.ada.org
  - large compilation of access portals and materials
  - an attempt to help general dentists

- Some centers have their own collection
  - San Antonio: CATs
  - Detroit: evidence-based endodontics

- Search for original data
  - pubmed, Cochrane group and others
  - hand search from textbooks and reviews

Key Evidence

- Overall shape
  - dictated by anatomy, tooth development
  - visibility of all orifices

- Overall size
  - dentin removal equals loss in stiffness
  - largest contributor MOD cavity (63%) vs access (5%)

- Crown down strategy
  - better tactile feedback: working length determination
  - essential for many rotary instruments

- Clinical
  - no studies identified
The Classics

- Stiffness and fracture load depend on preparation extent
  - most tests address catastrophic failure load

Strategies

What Is Important?

- Be centered
  - based on: laws of symmetry

- Understand the long axis
  - based on: “Do not harm”

- Find all orifices
  - based on: microbiological principles

- Provide straight-line access
  - based on: engineering principles

- All of the above
  - based on: common sense

Access Modified

from Ingle's Endodontics 6th ed
Key 2a: Cleaning & Shaping

- Overall shape
  - “Schilder-type” shape
  - “standardized” shape

- Apical size
  - small: conserving dentin, providing tapered seat
  - larger: providing more access for irrigants

- Apical end point
  - location and determination of “length”
  - patency a goal/dangerous?

"... the Root Canal Must be Shaped so That a Tapering Funnel is Created With its Narrowest Diameter at the Periodontal Ligament and the Largest at the Coronal Opening.“

Schilder 1967

**Aim**
- to investigate the effect of two methods of canal enlargement on apical seal

**Methods**
- 46 teeth, 4 controls, 22 specimens prepared to .02 taper (standardized) & 20 specimens to .10 taper (step back)
- obturation with lateral compaction, ZOE sealer
- leakage evaluated using 45Ca & micro-radiography
- teeth were immersed to allow apical and coronal penetration of isotope
- spreader insertion depth recorded

The influence of the method of canal preparation on the quality of apical and coronal obturation.

**Results**
- .02 taper group: mean spreader penetration was to 3.5 mm (0.5 - 5 mm)
  5/22 teeth allowed deep spreader insertion (+2 mm) and had no leakage
  6/22 had gross leakage (> 4.8 mm) and 11/22 had leakage to app. 3.6 mm
- .10 taper group: mean spreader penetration was to within 1mm (20/20)
  no significant leakage overall
  2/20 had leakage to > 1 mm
- coronal aspect was sealed to isotopes in all cases

**Discussion**
- for lateral compaction, spreader penetration is correlated with leakage
  deeper penetration possible with .10 taper compared to .02 taper
- spreader should penetrate to 1 mm or less

Why Small Is Beautiful...
Why Small Is Beautiful...

From: Card et al 2002  From: Buchanan 2001

A MAF 60, 80  B MAF 20

Strategies

Increased Apical Enlargement

- One conclusion
  - "... it may be recommended to keep the apical size of curved canals as minimal as possible provided that a sufficient irrigation is feasible."

- Experimental data overall
  - numerous variables, unclear outcomes
  - "complete" canal preparation unlikely

- Clinical data
  - mixed results, very difficult to tease out real information
  - a rare prospective study suggested larger sizes

El Ayouti, 2011

Raj Saini, 2012


Microbial status of apical root canal system of human mandibular first molars
With primary apical periodontitis after "one-visit" endodontic treatment


- Aim
  - to assess the microbiological status after single visit root canal treatment

- Methods
  - 16 lower molars with periapical periodontitis were treated with K-Files or LightSpeed (apical sizes 25 and 40, respectively) and lateral compaction
  - irrigation was with 5.25% NaOCl and 17% EDTA
  - immediately after root canal filling, mesial apices were resected
  - histological evaluations were done on LM and TEM levels
  - positive and negative controls were teeth extracted due to periapical periodontitis and orthodontic reasons, respectively
Results
- 14/16 treated canals harbored bacteria in their root canal systems
- 8 of the specimens each had bacteria in the canal enlarged with K-Files to size 25 and with LightSpeed to size 40
- 11/16 mesial roots had an isthmus region, 10 of which were contaminated with microorganisms, as were 6 of 8 accessory canals
- numerous PNM were found in the isthmus region

Discussion
- it appears that canals treated in a single visit such in this study cannot be rendered bacteria-free, regardless of the apical size (but it is unclear if multiple visits could have rendered canals sterile from this study)
- the presence of immune cells suggests chemotaxis and a fluid phase in some phases of pulpal necrosis, allowing immune cells to be active

Further Considerations
- Length determination
  - which principle, landmarks?
  - how to determine?

- “Best practices”
  - instrument and case selection
  - clinical usage parameters

- Preparation errors
  - block and ledge
  - role of instrument fracture
Apex “Locators”

Clinical Practice

How did I get there...
Pettiette MT, Olutayo Delano E, Trope M (2001)


**Aim**
- to compare effects of RCT with 2 types of files on changes in bone density

**Methods**
- 60 molars treated by 30 undergraduate students were followed for 1 yr
- all teeth were initially associated with an apical radiolucent area
- treatment was with either stainless steel or NiTi K-files to similar shapes in both groups and all other peri-treatment variables were similar
- individualized bite blocks were fabricated to allow subtraction radiography and densitometric measurement of changes in apical bone architecture
- grey levels were enumerated for the apical and a normal area in each case
- corresponding ratios were calculated and compared with Fisher’s tests

**Discussion**
- for novice clinicians, the potential of NiTi hand files to prevent preparation errors results in dramatically improved clinical prognosis (OR=5, CI 1.3,20)
- the authors concede that skilful operators would have had a better chance to avoid such errors with stainless steel instruments

**Results**
- 40 teeth were available for 1yr recall, with no difference in initial scores
- success was associated with a grey level change of app 78% in NiTi cases and 45% in stainless steel cases; failures, indicated by grey level decrease, were 20% (NiTi) and 55% (stainless steel), respectively
- success probability was 15/19 with NiTi and 9/21 with stainless steel
- this difference was significant and was associated with a higher number of procedural errors in the stainless steel group (*i.e.*, strip perforations)

**Staged Preparation**
- Phase I Coronal Flaring
- Phase II Apical Shaping
The ProTaper System

ProTaper Publications

ProTaper rotary root canal preparation: effects of canal anatomy on final shape analysed by micro CT

Q. A. Petersø 1-3, C. I. Petersø 1-3, K. Schønberger 2, and F. Barbakow 2

Abstract

Aim To evaluate the relative performance of ProTapers nickel-titanium (Ni-Ti) instruments shaping root canals of varying preparable canal geometry.

Methodology Extracted human mandibular molars were scanned, before and after shaping with ProTapers employing microcomputer tomography (μCT) at a resolution of 34 μm. Canals were then three-dimensionally reconstructed and evaluated for volume, surface area, and distribution of canal walls and apices.

Results Volume of the root canal increased significantly and proportionally in the 1st and 2nd canals, and gross preparative errors were identified infrequently, but canal diameters from 0.35 to 0.86 mm, 0.42 to 1.66 mm, and 0.57 to 2.75 mm for the 1st, 2nd, and 3rd canals, respectively. Overall, canal transportation ranged from 0.65 to 0.80 mm and was independent of canal type. Wide canals had a significantly higher loss of mesiodistal proportion of cross-sectional area than narrower canals.

Conclusions Canals in mandibular molars were prepared to a high degree, ProTaper instruments without major procedural errors. These instruments may be more effective in shaping narrow canals than wide, immature roots.

Keywords: canal geometry, ProTaper, shape, transportation.

Received 10 July 2000; accepted 10 September 2000
Supplemental Instruments

- Orifice relocation with Sx

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

PathFiles

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

ProTaper Next History

- 2001
- 2006
- 2013
Since the beginning of modern day endodontics, there have been numerous concepts, strategies, and techniques for preparing canals. Over the decades, a staggering array of files has emerged for negotiating and shaping canals. In spite of the design of the file, the number of instruments required, and the surprising multitude of techniques advocated, endodontic treatment has been typically approached with optimism for probable success.

The clinical endodontic breakthrough was progressing from utilizing a long series of stainless steel (SS) hand files and several rotary Gates Glidden drills to integrating nickel titanium (NiTi) files for shaping canals. Regardless of the methods utilized, the mechanical objectives for canal preparation were brilliantly outlined almost 40 years ago by Dr. Herbert Schilder. When properly performed, these mechanical objectives promote the biological objectives for shaping canals, 3-D disinfection, and filling root canal systems (Figure 1).

The purpose of this article is to identify and compare how each new generation of endodontic NiTi shaping files served the preparation of root canals. The key evidence for the shaping movement includes:

- **Strategies**
  - Opinion paper
    - clinical handling described
    - cases presented
    - rationale given

- **Routine Root Canals** (SB, 13)
  - Pre-op radiograph
  - WL radiograph
  - Cone Fit
  - Final radiograph

- **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

**Key Evidence**

**Byström 1981**

**Schilder 1974**

**Ng 2011**

**Ricucci 2011**

**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

**Orifice Modification**
- Hard tissues may impede direct access
  - detect and remove
  - without iatrogenic damage
The Logic Of Stages Prep

- We have adequate concepts
  - just need to apply them in the clinic

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

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
  - Sequeira 1997
  - Cheung & Stock 1993

- Effect of ultrasonically activated irrigation II
  - positive effect: bacterial reduction
  - positive effect: removal of smear layer
  - Huque 1998
  - Cameron 1983

- Preparation errors
  - use of cutting ultrasonically activated instruments may lead to undesirable canal shapes
  - Stock 1991
  - Mayer 2002

Temperature & Active Irrigation

- Zeltner 2009
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

Jiang et al 2009

Activation of Irrigants

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

A B C

Positive Samples

before after

Control Intracanal PIPS

DIVito 2010

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

Ng 2011

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

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Sathorn C Int Endod J (2005)

<table>
<thead>
<tr>
<th>Trope et al., 1999</th>
<th>Weiger et al., 2000</th>
<th>Peters &amp; Wesselin 2002</th>
<th>Combined 3 studies</th>
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<tr>
<td>-50%</td>
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<td>0%</td>
<td>25%</td>
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<td>Favors single visit</td>
<td>Favors multiple visit</td>
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</table>
Strategies

For The Time Being...

- Canal instrumentation
  - as effective as possible, removal of 100µm recommended

- Irrigation
  - eliminates planktonic bacteria in main canal
  - may be effective in detaching biofilm

- Activation
  - ultrasonics best supported by evidence
  - other methods may be forthcoming

Constraints
- inaccessible canal spaces
- development of resistance

Key 3: Obturation

- Benefit vs harm
  - is an obvious way to demonstrate proficiency
Klevant FJH, Eggink CO (1983)

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
Strategies

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..."
Strategies

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.

A Chain of Events

- Rubber dam
- Disinfection
- Restoration
- Instruments
- Access
- Medication
- Immune system

Treatment Potential

- Case 1
  - 33yr old patient
  - 4 week old crown
  - deep pocket #8

- Case 2
  - 85yr old patient
  - sinus tract, no marginal bone loss
### Treatment Potential

- **Case 1**
  - 33yr old patient
  - periapical sound tissues at 6m

- **Case 2**
  - 85 yr old patient
  - periapical sound tissues at 12m

### 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
Current Discussion

EDITORIAL

Sharon Patel1, Francesco Mannocci1, Hagay Shemesh2, Min-Kai Wu3, Paul Wesselinck2 and
Paul Lambrechts1

1Department of Conservative Dentistry, King’s College London Dental Institute, London, UK; 2Department of
Endodontology, ACTA, Amsterdam, the Netherlands and 3Department of Dentistry, Section of Endodontology, K.U.
Leuven, Leuven, Belgium

Radiographs and CBCT – time for a reassessment?

• Summary
  - CBCT is more likely to detect previously hidden pathosis
  - the size of a existing lesion appears smaller on conventional films
  - there is an increased radiographic dose with CBCT use
  - perhaps studies into treatment modalities should use CBCT to
determine outcomes

Int Endod J 2011, 44: 887-888

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

De Silva 2009

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

Healing assessment

• CBCT is sensitive tool
  - likely to detect significantly
more lesions compared to
P.A. films

Case reports
Other Possibilities?

- Various endodontic outcomes
  - hard tissue changes, secondary soft tissue changes?

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<tr>
<th>Condition/procedure</th>
<th>Variable</th>
<th>Species</th>
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<td>bone fill</td>
<td>human</td>
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<td>sinus membrane changes</td>
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<td>surgical endodontics</td>
<td>bone fill</td>
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<td>trauma</td>
<td>horizontal fracture healing?</td>
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<tr>
<td>direct pulp capping</td>
<td>hard tissue bridge?</td>
<td>human</td>
</tr>
<tr>
<td>Regenerative endodontics</td>
<td>root lengthening, root bulk increase</td>
<td>human</td>
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Table 1: Potential and actual areas for endodontic healing assessment with CBCT

CBCT and Outcomes

80% of “short” root filling appeared as “flush” fillings on CBCT, “flush” fillings appeared as overextensions on CBCT.

CBCT detected root fillings with voids in 46% of roots, almost 3 times as many as those detected by radiographs.

Best outcome: filling is 0-2 mm from the apex, and no voids

Apical fenestration / pain with extrusion of canal filling material into the soft tissues and a periosteal reaction were detected by CBCT.

CBCT might change outcome predictors for endodontic treatment.

Decision Making

- Continuous disease scale

Retreatment: High degree of poor health (Big periapical lesion)
No retreatment: Cut off point

Retreat: Perfect health (No periapical lesion)

Kvist 2004
Retreatment (UN, 05)

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

Case history

Pre-op radiograph

Final radiograph

Recall radiograph

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

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
**Introduction**

A biofilm is a community of microorganisms embedded in a matrix of extracellular polymeric substance and attached to a solid surface. It has been accepted that within this 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 their increased resistance to antibiotics, disinfectants, and other antimicrobial agents, with some species growing up to 1000-fold greater for a species in a mature biofilm relative to that same species grown planktonically. Alkaline proteases also play a role in biofilm formation, and their presence is associated with greater bacterial infection. Such proteases are found in Enterococcus faecalis, Staphylococcus aureus, Porphyromonas gingivalis, and other species, and their presence is an indication of high bacterial load [1].

Microbial invasion of the root canal system can eventually lead to microbial overgrowth, which can result in chronic inflammation and tooth loss. This is supported by the fact that chronic inflammation is the most common pathological condition present in periapical lesions, exhibiting a high incidence of necrotic root canals. Pulpal necrosis and apical periodontitis. Because the bacteria in the necrotic root canal grow mostly in sessile forms, the success of endodontic treatment will depend on the effective elimination of such biofilms [2].

Currently, the eradication of a microbial infection is accomplished mainly through mechanical instrumentation and chemical irrigation. Although mechanical preparation of the infected root canal has been shown to be most effective in reducing the number of remaining bacteria, it often produces residual bacteria in areas such as fins, isthmuses, ramifications, deltas, accessory and lateral canals, and dentinal tubules [3]. To clean beyond what might be achievable through instrumentation, continuous irrigation of long oval canals were more effective than rotary NiTi instrumentation [4] [5]. Irrigation and instrumentation now can be cleaned quickly and completely regardless of chamber/canal morphology [6].

**Methods:**

To investigate the presence of microorganisms in the root canal, a new instrumentation and irrigation device, the self-adjusting file (SAF) system, was introduced by ReDent-Nova (Ra’anana, Israel) [7]. The instrument is used in a trans-longitudinal (in-and-out) motion, and the abrasive surface of the lattice threads promotes a uniform removal of dentin. The manufacturer claims that the SAF is capable of adapting itself to the canal shape 3-dimensionally [8].

**Results:**

The model:
- teeth were split and grooves prepared in apical third
- biofilm grown in canal
- halves observed with SEM

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

**Apical Size & Disinfection**

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

- Invasive

Introduction

Strategies

Discussion

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
Thank you Very Much!