Purpose: Fifty-four mini reviews that summarize and evaluate a wide range of clinical and scientific articles that relate to the practice of endodontics and range from COCHRANE reviews to preclinical research. The topics included: Surgery, Restorative Dentistry, Pulpotomy, Pulpectomy, Pharmacology, LAs, Periodontics, Non-surgical Endodontic treatment, Endodontic Microflora, Indirect/Direct Pulp capping, Diagnosis, The root Apex, Trauma.

Table 1 - Classification Criteria:

- **LEVEL 1** – Highest level of evidence
  - *High-level randomized controlled clinical trials* – a clinical study in which participants are randomly assigned to either an experimental group or control group. The experimental group receives the new intervention, and the control group receives a placebo or standard intervention. These groups are followed up for the outcomes of interest. (i.e. Article #5 pg 1098)
  - Systematic Reviews of randomized controlled clinical trials

- **LEVEL 2**
  - *Low-level randomized controlled clinical trials* (i.e. Article #12 pg 1104)
  - *High-level Cohort Study* – a clinical study that has 2 groups (cohorts) of subjects, one that did receive the exposure of interest and another that did not, and that followed these cohorts forward for the outcome of interest. (i.e. Article #11 pg 1103)
  - Systematic review of cohort studies (i.e. Article #10 pg 1102)

- **LEVEL 3**
  - *High-level Case-Control Study* – a clinical study that involves identifying subjects with a clinical condition (cases) and subjects free from the condition (controls), and investigates whether the 2 groups have similar or different exposures to risk indicator(s) or factor(s) associated with the disease or condition.
  - Systematic review of case-control studies

- **LEVEL 4**
  - *Case series* – a report on a series of cases with an outcome of interest. No control group is involved. (i.e. Article #1 pg 1094)
  - Retrospective studies
    - *Low-level Cohort study* (i.e. Article #4 pg 1097)
    - *Low-level Case-Control study*

- **LEVEL 5**
  - *Case reports* (i.e. Article #9 pg 1101), *Animal studies, Bench research, Biological Plausibility and Expert Opinion*

Table 2- Criteria for assigning a quality status in any one level:

- Sample size
- Group/subject homogeneity or difference
- Standardization of techniques
- Quality of clinical evidence
- Calibration of evaluators
- Multiple evaluators of interpretive data
- Appropriate statistical analysis

Conclusion: The levels of evidence were designed to provide the reader with a better understanding of the quality of information that is being disseminated, and to allow for more systematic conclusions to be drawn from the current literature.
Title: Outcomes of nonsurgical retreatment and endodontic surgery: a systematic review

Author: Mahmoud Torabinejad et al.


Reviewed by: Aneel Belani, DDS

Purpose: To systematically review and compare the clinical and radiographic outcomes of nonsurgical retreatment and endodontic surgery.

Materials and Methods: Articles from peer reviewed journals from January 1970- July 2008. Only studies using a minimum of 25 teeth and a 2 year follow up were considered. Studies examining individual roots were excluded. The search was performed using Medline, Cochrane, PubMed, and an article list from major endodontic textbooks, along with major endodontic journals. Studies were rated according to number of patients, procedures, provider experience, length of follow up, and other relevant factors. Data was then analyzed using statistical computer software.

Results: After all relevant articles were sorted for inclusion criteria, there were 8198 teeth included in the meta-analysis. These teeth were from a collection of 34 relevant studies. Studies were coded based on where they were done, which materials were used, use of magnification, and procedural techniques. Weighted success rates for endodontic surgery fell from 77.8% at 2-4 years to 71.8% at 4-6 years. On the other hand, weighted success rates for retreatment went from 70.9% at 2-4 years to 83% at 4-6 years.

Conclusion: There was over three times the amount of articles for surgery as opposed to retreatment. It appears that surgery cases have a higher initial success rate than retreatment, but this success rate declines over time. All of the studies had a relatively low level of quality rating. The size and presence of lesions was not taken into account in this study, although it has been shown that this is an important factor in success. Additionally, the amount of times surgery had been done, intraoperative complications, specialist involvement, use of magnification, and techniques were not accounted for in these results. The papers analyzed were from up to 38 years ago, and much has changed in the field of endodontics. It is necessary to do randomized controlled trials, using today's technology (ultrasounds, microscopes, MTA) in the hands of specialists, in order to get a more realistic idea of the success rates of surgery vs non-surgical retreatment.

LOE: 4
Title: A retrospective study of endodontic treatment outcome between nickel-titanium rotary and stainless steel hand instrument techniques

Author: Cheung G et al

Journal: JOE, Vol. 35, Number 7, July 2009

Reviewer: Jay Gupana, DMD

Purpose: To compare periapical healing of molar root canal tx using two instrumentation techniques

Materials and Methods: Two hundred twenty-five max and mand molars treated by undergrad and post grad students were randomly selected from a hospital database. One hundred ten of the molars were prepared using a hybrid rotary technique (table 1) and 115 with hand stainless steel instruments.

<table>
<thead>
<tr>
<th>TABLE 1. A Hybrid Rotary Technique based on a Combination of NiTi Engine Files* and Hand NiTi Instruments (Used in a Continuous Running Motion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Estimate the working length from radiographs and check patency of canal(s) using no. 10 or 15 hand files to within 1 to 2 mm of this estimated length.</td>
</tr>
<tr>
<td>2. Profile orifice shaper (OS #3, OS #2, then OS #1) to the beginning of curvature, or where resistance is felt, gradually advancing deeper with each file.</td>
</tr>
<tr>
<td>3. Working length (WL, being 1 mm short of the radiographic apex) determination with a no. 15 file in place and a measurement radiograph.</td>
</tr>
<tr>
<td>4. Canal preparation using Profile in the following sequence: Profile 0.06 taper, no. 15 engine file at WL+1.0 mm (or to resistance) Thermafil Verifier no. 20 (hand) at WL. Profile 0.06 taper, no. 20 engine file at WL Thermafil Verifier no. 23 (hand) at WL. Profile 0.06 taper, no. 25 engine file at WL Thermafil Verifier no. 30 (hand) at WL. Profile 0.06 taper, no. 30 engine file at WL Thermafil Verifier no. 35 (hand) at WL.</td>
</tr>
<tr>
<td>5. Recapitulation using a no. 15 hand file in between each irrigant of the following final rinse sequence: NaOCl (1%-2.5% solution), EDTA (17%), and then NaOCl.</td>
</tr>
</tbody>
</table>

Five types of procedural errors were identified: Ledging, perforation, apical, transportation, stripping, and fractured instruments. All selected patients were invited to return for a clinical and radiographic recall. Each case was rated as: favorable, uncertain (no change in PARL size), and failure to heal. All data was entered into a spreadsheet and analyzed with computer software.

Results and Discussion: A higher rate (77%) of periapical healing was evident in the Ni Ti Rotary Group. Factors contributing to success were use of rotary, max molar, experienced operator and absence of radiolucent lesion. The most common error in both groups was ledging, but was more evident in the hand filing group.

- 19% of teeth in Ni Ti Rotary group had some form of procedural error
- 39% of teeth in Hand filing group had some form of procedural error
- 60% healing was found in the hand-filing group

In this study a better treatment outcome was evident with the use of the Hybrid Rotary technique. (Less procedural error, allowed adequate shaping and obturation). The author suggests that NiTi instruments should be used for preparing root canals in primary endodontic tx, especially for inexperienced operators.

This study is a retrospective cohort study with limitations such as operator skill, type of final restoration, and radiographic interpretation. There is still a lack of a Randomized Control Clinical Study on this particular topic.

LOE: 3
Title: Evaluation of the effect of two chlorhexidine preparations on biofilm bacteria in vitro: a three-dimensional quantitative analysis

Author: Shen Y, et al.


Reviewer: Felicitas Wibowo, DMD

Purpose: To quantify and compare the efficacy of two endodontic irrigating solutions currently used in root canal treatment and to introduce a new in vitro multispecies biofilm model that closely mimics the in vivo biofilm for evaluating the efficacy of endodontic irrigants.

Materials and Methods:

- Collagen-treated hydroxyapatite (C-HA) and hydroxyapatite (HA) discs were inoculated with subgingival plaque from three healthy volunteers under anaerobic conditions at 37°C for 21 days.
- The presence of specimens of C-HA and HA biofilms were examined by SEM.
- After 21 days, the biofilms were immersed in either saline (negative control), 2% chlorhexidine (CHX) or CHX-Plus for 1, 3, or 10 minutes.
- The volume ratio of red fluorescence (dead cells) to green –and-red fluorescence (live and dead cells) was analyzed by confocal laser scanning microscopy (CLSM) for each medicament.

Results and Discussion:

- SEM images of the C-HA and HA discs showed the presence of multispecies, heterogeneous biofilm consisting cocci, rods, filaments and spirochetes.
- The C-HA biofilm was thicker than the HA biofilm.
- Less bacteria were killed in C-HA than in the HA biofilm.
- The proportion of killed bacteria was dependent on the type of disinfecting agent and the time of exposure in both C-HA and HA biofilm models.
- CHX-Plus killed more cells than 2% CHX at all time periods and in both C-HA and HA biofilm models.

Conclusion: These biofilm models and the 3-D quantitative analysis with CLSM may be useful in evaluating the effectiveness of endodontic antimicrobial agents.

LOE: 4
Title: Should endodontists place implants? a survey of U.S. endodontists

Author: Potter K et al.


Reviewer: Michael Sha, DMD

Purpose: To assess endodontists’ opinions about whether dental implant placement should be within the scope of endodontic practice and to identify the predictor variables associated with these opinions.

Materials and Methods: A 17-item written survey was developed and distributed to a random sample of currently-practicing endodontists in the United States (N=1505).

In the survey:
- The main dependent variable: “In your opinion, should endodontists place implants?”
- Predictor variables: age, gender, year of completed endo training, geographic location, etc.

Various statistical analyses were used to test the association between the main dependent variable and each potential predictor variable.

Results:
- Survey response rate is 46%
- 57% of respondents believed that implant placement should be within the scope of endodontic practice.
- 5.7% of respondents are currently placing implants.
- 25.4% were interested in placing implants in the future.
- Strong predictor variables:
  - The belief that implant placement should be incorporated into the endodontic surgical curriculum.
  - Interests in placing implants in the future.
  - Endodontists who graduated from a residency program 10 or more years ago.

Discussion/Conclusion: The majority of the responders (57%) believed that endodontists should be placing implants, while only a few endodontic residency programs in the country include implant training. The responders, who have been practicing longer, believe that implant placement should be included in the residency training and were personally interested in placing implants in the future, are more likely to support implant placement by endodontists. Future studies should focus on other aspects of this topic, such as whether GPs will refer to their endodontists for implant placement.

LOE: 4
Title: An *in vivo* comparison of the Root® ZX II, the Apex NRG XFR, and Mini Apex Locator™ by using rotary Ni-Ti files

Author: Siu C et al.

Reviewer: Sorin Purtuc DMD

Purpose: To compare the accuracy of working length (WL) measurements by using the Root® ZX II, Apex NRG XFR, and Mini Apex Locator™with Ni-Ti rotary instruments.

Materials and Methods: Twenty-eight teeth scheduled for extraction had their WL determined with electronic apex locators (EAL) by using 0.04 taper ProFiles sizes 40-20 in crown down method. Four control teeth had their WL determined using EAL and SS k-files hand files. Files were cemented in place and then the teeth were extracted. The apical 4mm were shaved to reveal the files, and magnified pictures were taken. Two blinded investigators determined the MC (minor constriction) of each root canal, which corresponds to the point the WL is ideally measured to.

Results: All WL used with SS K-files were able to locate the MC within 0.5 mm, with a mean distance of 0.16, 0.17, 0.22mm for respectively, Root® ZX, Apex NRG, and Mini AL™. Ni-Ti rotary files used in conjunction with EAL determined the WL to within 0.5mm of the MC only 50% or less of the time, with mean distances of 0.45, 0.57, and 0.31mm beyond the MC. The authors think this is due to the rotary files rotating/ moving in canals while the measurements are being taken.

LOE: Level 2 due to low sample #.
Title: Interventions for treating traumatized necrotic immature permanent anterior teeth: inducing a calcific barrier & root strengthening

Author: Mohammad A.D. et al.


Reviewer: Avedis Encioiu, DDS

Purpose: A systematic review of randomized controlled trials was undertaken to evaluate the effectiveness of apexification and apical plug techniques as well as root strengthening procedures for treating traumatized necrotic immature permanent anterior teeth.

Materials and Methods:

- Structured electronic and hand search, with no restriction on language of publication.
- Only RCTs comparing different apical barrier formation techniques and root strengthening procedures (adhesive resins, GI cements, and Fiber-glass posts) in traumatized necrotic immature teeth were assessed.

Results:

- 200 studies identified with only two suitable for inclusion.
- The two studies investigated multi-visit apexification techniques using Ca(OH)₂ and tri-calcium phosphate.
- No eligible studies investigating root strengthening procedures or any other intervention for apical barrier formation in necrotic immature anterior teeth.
- One study reported 6.7 months for both calcium hydroxide and tri-calcium phosphate as the time required to complete treatment, with no number of visits reported.
- The second study reported 6.8 months for one type of Ca(OH)₂ paste with an average of 3.1 visits, and 5.1 months with an average of 2.1 visits for another type of Ca(OH)₂ paste.
- No reliable information available on long-term adverse effects of the reported interventions or cost implications.

Conclusion:

- Based on the 2 studies, there is weak evidence supporting the use of either calcium hydroxide or tri-calcium phosphate for apical barrier formation in necrotic immature anterior teeth employing multi-visit apexification techniques.
- There is insufficient evidence to provide guidelines, however, factors affecting apical barrier formation are: the rate of change of Ca(OH)₂ and the initial apical width.
- The presence of infection and/or PA radiolucency on treatment time is inconclusive.
- No reliable evidence on adverse events or long-term effects after the use of calcium hydroxide or tri-calcium phosphate.
- Caution should thus be used when using these materials in apical barrier formation techniques.

LOE: 1
Title: Immediate vs. late orthodontic extrusion of traumatically intruded teeth

Author: Medeiros R et al.

Journal: Dental Traumatology, vol. 25, number 4, 380, August 2009

Reviewed by: Andrew Cho, DMD

Purpose: To review clinical case reports to quantify success rate of immediate vs. late orthodontic extrusion of traumatically intruded teeth. And to review likelihood of injury such as root resorption and ankylosis between immediate and late orthodontic extrusion.

Materials and Methods:

- Computerized search of Pubmed and Medline from 1974 – 2008 looking for articles containing traumatically intruded permanent anterior upper teeth treated by orthodontic extrusion that was followed up for at least 12 months.
- The sample were divided into 2 groups:
  1) Immediate orthodontic extrusive forces applied less than 7 weeks post trauma
  2) Late orthodontic extrusive forces applied greater than 3 months post trauma.
- Clinical outcomes of the orthodontic extrusion fell under 3 categories:
  1) Success-Retained tooth, asymptomatic, no root resorption
  2) Success w/ complications-Retained tooth, symptomatic, < 50% root resorption
  3) Unsuccessful-failure due to rapid progressing root resorption.
- Endodontic treatment (accessed, pulp expirtation and Ca(OH)_2 placement) initiated only when necessary
- Analysis was done in following ways:
  1) Success of outcomes of both groups
  2) Duration of orthodontic extrusion between 2 groups
  3) Stage of root development vs. pulpal modification between 2 groups
  4) Severity of intrusion vs. treatment success between 2 groups

Results:

- 11 of 22 orthodontic extruded teeth were successful with no complications
- 10 of 22 orthodontic extruded teeth were successful with complications
- 1 of 22 orthodontic extruded teeth had to be extracted due to rapid inflammatory root resorption
- Immediate extrusion group included 18 teeth with extrusion starting mean of 17 days post trauma and mean duration of extrusion 12 weeks.
  - 10 teeth (55.55 %) successful with no complications
  - 7 teeth (38.88%) successful with complications
  - 1 tooth (5.55%) unsuccessful and had to be extracted.
- Late orthodontic extrusion group included 4 teeth with mean extrusion starting 204 days post trauma and mean duration of extrusion 87 weeks
  - 1 tooth (25%) was successful with no complications
  - 3 teeth (75%) were successful with complications
- The only unsuccessful tooth was of an immature, severely intruded endodontically treated tooth extruded 26 days (immediate) days post trauma for a time period of 12 weeks with a fixed appliance
- Length of time needed for immediate orthodontic extrusion averaged 12 weeks
- Length of time needed for late orthodontic extrusion averaged 86.75 weeks.
Conclusion: Overall, this review shows the outcomes of immediate and late orthodontic extrusion to be for the most part successful. It was found that immediate orthodontic extrusion took on average 12 weeks for extrusion, 7 times shorter than late extrusion. But this review was done looking at a very few number of handpicked case reports which leads one to be skeptical of any definitive conclusions made.

LOE: 4

Title: The use of $\beta$-tricalcium phosphate, white MTA, white portland cement, and calcium hydroxide for direct pulp capping of primary pig teeth

Author: Shayegan A et al.

Journal: Dental Traumatology 2009; 25:413-419

Reviewer: Ken Lin, DMD

Purpose: To evaluate and compare the response of the pulp of primary pig teeth after capping with beta-tricalcium phosphate ($\beta$-TCP), white mineral trioxide aggregate (WMTA), white Portland cement (WPC) and calcium hydroxide [Ca(OH)$_2$].

Materials & Methods:

- Forty deciduous teeth of two 3-month old pigs were used: including eight incisors and 12 molars per pig.
- All teeth were subjected to class V preparation on buccal surface under general anesthesia. No rubber dam used. A small pulpal exposure was made using a high speed bur. Bleeding was controlled with saline and cotton pellets.
- The teeth of each hemi-maxillary segment (four incisors and six molars) were used for one comparison – for a total of four segments from two pigs.
- Pigs were euthanized (3 weeks later), and jaw segments were removed and prepared for histological examination (stained with hematoxylin & eosin); a second serial section prepared for bacterial recognition using the Brown & Brenn technique.
- All sections were viewed under a light microscope & were evaluated according to a listed criterion. Statistical analysis (PRISM) performed.

Results: There was no significant difference (P>0.05) between the various materials in terms of pulpal response, hard tissue formation and normal pulp tissue preservation and between incisors and molars in each group.

Discussion/Conclusion:

- The results show that vital primary pulp tissue is capable of healing after traumatic injury by perforation.
- These materials have certain disadvantages. For example, both $\beta$-TCP and MTA are expensive; potential limitation and unknown risks involving the use of PC (not currently approved for use in dentistry).
- It is time to admit that the pulp of primary teeth as a greater regenerative power than has previously been expected and direct pulp capping of primary teeth should be reconsidered.
- However, further research with larger samples and a more extended study time is necessary. Clinical studies should also be encouraged.

LOE: 5
Title: Repair of untreated horizontal root fractures: two case reports

Author: Chala S et al.


Reviewed by: Christian Lehr, DMD

Purpose: To present two cases of horizontal root fractures that healed spontaneously.

Materials and Methods: Routine examination of two patients presenting to a dental clinic for comprehensive care revealed untreated horizontal root fractures. For patient 1, examination of full mouth radiographs discovered cervical and middle third horizontal root fractures of tooth #8 and a middle third horizontal root fracture of tooth #9. A review of the patient’s history of trauma revealed an injury to the pre-maxilla from a fall 2 years prior. For patient 2, discoloration of tooth #9 was noted on clinical examination. The patient was discovered to have a history of trauma dating to more than 10 years prior. A periapical radiograph showed a horizontal root fracture in the middle third of tooth #9 and obliteration of the pulp canal space. For patients, thermal testing, electrical stimulation, mobility, and sensitivity to percussion were observed.

Results: For patient 1, teeth #8 and 9 responded normally to percussion and mobility testing and appeared vital on thermal and electrical stimulation. Periapical radiographs of tooth #8 (cervical and middle third horizontal root fractures) and #9 (middle third root fracture) showed no periapical or periradicular pathology and bone surrounded by connective tissue between the tooth fragments. Six month follow-up radiographs revealed no pathologic changes. For patient 2, tooth #9 (middle third horizontal root fracture) responded normally to percussion and mobility testing. Thermal and electrical stimulation were inconclusive. Periapical radiographs showed the fragments of the fractured tooth to be separated by bone which was normal in appearance. Also, obliteration of the pulp canal space of #9 was noted.

Discussion and Conclusion: Fractured roots can heal spontaneously if pulp vitality is preserved. Healing is influenced by the integrity of the pulp tissue. If the pulp remains intact, a hard tissue barrier is formed, uniting the two fragments. If the pulp is torn, pulpal healing occurs by revascularization and results in calcification of the coronal pulp space. During revascularization, periodontal cells may form a union of connective tissue between the segments. If the segments are separated or mobile, fibrous connective tissue may form between the segments. If the separation is wide, bone may grow between the segments and the fractured segments will be lined with cementum and periodontal ligament. Root canal therapy is not indicated until there is evidence of pulpal necrosis.

Level of Evidence: LOE 5
Title: Consumer products and activities associated with dental injuries to children treated in United States emergency departments, 1990-2003

Author: Stewart G et al.

Journal: Dental Traumatology 2009:25:399-405

Reviewed by: Chinchai Hsiao, DMD

Purpose: To describe the association of specific consumer products and activities with dental injuries among children 0-17 years of age treated in hospital EDs in US.

Materials and Methods: Data regarding age, race, gender, injured body part, diagnosis, consumer product/activity, and comments that describe the injury were obtained from the NEISS (National Electronic Injury Surveillance System) that were recorded over a 14 yr period (1990-2003). Ages were categorized into 3 groups: <7, 7-12, 13-17 years. Consumer products/activities were into 4 groups:

- Home structures/furniture
- Sport
- outdoor recreation
- Miscellaneous.

A retrospective analysis of data was analyzed using SPSS/PC software version.

Results: There were a total of 308, 900 dental injuries treated from 1990-2003 averaging to about 22,000/yr with and avg annual rate of 31.6/100 000 population.

- <7 yrs(primary dentition) sustained over half of the dental injuries recorded, and products/activities associated with home structures/furniture were leading contributors (floors, steps, tables, and beds)
- 7-12 yrs (mixed dentition) outdoor recreational products/activities were associated with the largest number of injuries. Almost half with bicycle.
- 13-17yrs (permanent dentition) sport related products/activities were associated with the highest injuries. Of all sports baseball and basketball were the most common.

Limitations include:

- Information about exposure to risk of injury was not available therefore true injury rates could not be calculated.
- Private dental offices and other types of health care facilities were not included.
- The severity of the injury like Ellis classification was not included.

Conclusion: This is the first study evaluating dental injuries among children in the US using a national sample. By identifying the consumer products/activities associated with dental injuries one can implement strategies towards prevention.

LOE: Level 4