Endodontic Considerations and Alveolar Preservation in Children After Severe Dental Trauma

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Past President of IADT

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Young and growing child

If a permanent tooth (teeth) are lost prematurely:
- Esthetic problem.
- Arrested/abnormal growth of the alveolus.
- Difficult and often complicated surgery required prior to placement of implant once fully grown (18+y).

2

Impact of treated/untreated traumatic dental injuries on quality of life among Brazilian schoolchildren

A cross-sectional study on 668 schoolchildren.

The impact of dental injury on quality of life was assessed using the Child Oral Impact on Daily Performances (Child-OIDP)

(Ramos-Jorge, J et al 2104)

3

Impact of treated/untreated traumatic dental injuries on quality of life among Brazilian schoolchildren

A cross-sectional study on 668 schoolchildren.

Child-OIDP demonstrated that schoolchildren with untreated dental injury were more likely to experience an impact on 'eating and enjoying food', 'smiling and showing teeth', and 'overall score'

No difference between uninjured and those with treated injury.

(Ramos-Jorge, J et al 2014)

4

The impact of crown fracture in the permanent dentition on children's quality of life

A cross-sectional study on 1589 schoolchildren.

Child-Oral Health Related Quality of Life questionnaire:

Enamel fracture had no significant impact on children' quality of life.
Enamel-dentin fracture did have an impact on quality of life.

(Soares, JP et al 2018)

5

Root Resorptions

Dr. Jens Andreasen and Hjörting-Hansen 1966 :
Introduced Classifications of Root Resorption:

External:
- Surface
- Inflammatory
- Replacement

Internal:
- Inflammatory?

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Root Resorption

Diagnosis of root resorption:

- Multiple Peri-Apical radiographs with different angulations.

7

Consequences of Tooth Luxation and Avulsion

Pathologic root resorption due to dental injuries is always (at least initially) inflammatory in origin. It is either:

Self-limiting if the only stimulus for the resorption is the injury itself.

Progressive if after the initial injury an additional stimulus is present or there is a severe damage to the protective layer.

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Root Resorption

External Root Resorption (self limiting):

Surface Resorption

- Localized injury to PDL and/or cementum
- No significant inflammatory changes in PDL
- Self limiting
- Spontaneous repair with cementum
- Not related to contents of root canal
- Hard to detect on radiograph

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Surface Root Resorption

It is important to not mis-interpret these cases as progressive in nature.

If the pulp is vital but some surface changes on the root are seen on a radiograph:

- no treatment should be performed
- a wait and see attitude taken
- allow spontaneous healing to take place!

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Root Resorption

External Root Resorption (progressive)

Replacement Resorption (Ankylosis)

- Fusion of alveolar bone with root surface.
- Absence of vital PDL.
- Continuous replacement of tooth substance.
- No cementum repair.
- No direct relationship with content of root canal.
- Tooth structure fuse with bone on radiograph.

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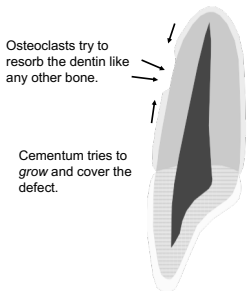

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Replacement Root Resorption

It is important to remember that only the initial inflammatory resorption is pathologic and the subsequent osseous replacement should be considered physiologic.

Therefore there is no known way to reverse the process without affecting normal bone turnover in the whole body.

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Prevention of Resorption

Intracanal bisphosphonate:
- Does it inhibit replacement resorption?
- Monkey study, incisors, 60 min extra-oral dry
  - Ankylosis:
    - 27% calcium hydroxide group.
    - 41% bisphosphonate group.

"Overall, bisphosphonate resulted in a worse outcome than calcium hydroxide in terms of both root resorption and ankylosis."
(Thong, YL et al. 2009)

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Root Resorption

External Root Resorption (progressive)

Inflammatory Resorption

- Injury to PDL and cementum
- Significant inflammation of PDL
- Continuous replacement of tooth substance
  - No cementum repair
- Direct relationship with content of root canal
- Tooth structure and bone loss on radiograph

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Root Resorption

* occurs when pulp is "heavily" infected (takes time)

16

Inflammatory Root Resorption

How can one treat these things?

17

Inflammatory Root Resorption

All evidence point to the fact that this type of root resorption is caused by inflammation,

- that is in many, if not most, cases driven by bacteria.

18

Treatment of Resorption

Calcium Hydroxide-$Ca(OH)_2$

- Alkaline (Tronstad, et al 1981)
- Antibacterial (Byström, et al 1985)
- Proteolytic (Andersen, et al 1992)

19

Prevention of Resorption

Calcium Hydroxide-$Ca(OH)_2$

Current recommendations include instrumentation and placement of $Ca(OH)_2$ into the root canal space within 7-14 days following replantation.

20

When to place the $Ca(OH)_2$?

"Effect of immediate calcium hydroxide treatment and permanent root filling on periodontal healing in contaminated replanted teeth".

A lesser shift from inflammatory resorption to ankylosis, and higher incidence of "healed" periodontium occurred after permanent root filling than after treatment with calcium hydroxide.

(Lengheden et al. 1990)

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Effect of $Ca(OH)_2$ on Strength of the Tooth

It has been proposed that immature teeth are weakened by filling of the root canals with calcium hydroxide dressing and gutta-percha.

(Cvek 1992)

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Effect of $Ca(OH)_2$ on Strength of the Tooth

Root canals were filled with $Ca(OH)_2$ (Calasept) and sealed with IRM(R) cement, and stored in saline at room temperature for 0.5, 1, 2, 3, 6, 9, or 12 months.

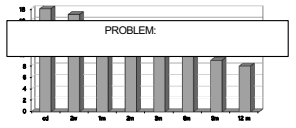
All teeth were tested for fracture strength in an Instron testing machine.

The results showed a markedly decrease in fracture strength with increasing storage time for the calcium hydroxide dressing group.

(Andreasen et al. 2002)

23

Effect of $Ca(OH)_2$ on Strength of the Tooth



(Andreasen et al. 2002)

24

Effect of $Ca(OH)_2$ on Strength of the Tooth

There are though several major flaws in this study:

1. Storage conditions
2. Instron Testing Machine
3. Lack of control:
   - Intact teeth only tested after 2 months and not at another time!!!

(Andreasen et al. 2002)

25

The Effect of Long-term Dressing with Calcium Hydroxide on the Fracture Susceptibility of Teeth

Extracted lamb teeth n=330

The apical section of the root was sectioned 10 mm from the cemento-enamel junction.

Root canal preparation was undertaken through the open apex to a size Profile #30 and a 0.04 taper.

Seventy-five roots were randomly assigned to the 3 brands of calcium hydroxide and 45 roots for each of the positive and negative controls (Calasept Plus, UltraCal XS, and Calmix).

(Kahler SL et al. 2018)

26

The Effect of Long-term Dressing with Calcium Hydroxide on the Fracture Susceptibility of Teeth

Extracted lamb teeth n=330

No statistical differences were observed between the different calcium hydroxide products and the negative controls.

(Kahler SL et al. 2018)

27

The Effect of Long-term Dressing with Calcium Hydroxide on the Fracture Susceptibility of Teeth

"The material presented by Cvek categorically relates an association with the stage of root development with weak, fragile roots more prone to cervical root fracture.

Therefore, the stage of root development rather than the use of calcium hydroxide apexification techniques may be more related to the incidence of fracture".

(Kahler SL et al. 2018)

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Prevention of Resorption

Calcium Hydroxide-$Ca(OH)_2$

No direct anti-inflammatory action provided.

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Prevention of Resorption

Corticosteroids

Block production of inflammatory stimulators including prostaglandins and leukotrienes, produced by cyclo-oxygenase and lipooxygenase pathways.

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Prevention of Resorption

Ledermix® Paste

- **1% Triamcinolone**
  - **Corticosteroid**
- **3% Demeclocycline**
  - **Broad spectrum antibiotic**

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Prevention of Resorption

Ledermix® Paste

Ledermix® has been shown to diffuse through dentin.

Ledermix has a rapid initial release followed by a slow steady release.

(Abbott, et al 1988, **1989)**

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Results 60 min Drytime

Ledermix®	$Ca(OH)_2$
Maintained 81% of root cross-sectional surface area	Maintained 13% of root cross-sectional surface area

Values determined from 0-6 scale of remaining root structure

(Dr. Bryson et al. 2002)

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***Prevention* of Resorption**

Dog Study:

After 4 months, roots were evaluated histologically for signs of periodontal healing.

Roots treated with clobetasol and fluocinonide healed more favorably than roots filled with gutta-percha and were different from each other at 60 minutes

(Kirakozova, et al. 2009)

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Ledermix/Corticosteroid

In the new IADT (2022) guidelines its use is recommended as an alternative tx to $Ca(OH)_2$

"If a corticosteroid or corticosteroid/antibiotic mixture is chosen to be used as an anti-inflammatory and anti-resorptive intracanal medicament, it should be placed immediately or shortly after replantation and left in situ for at least 6 weeks."

(Fouad AF et al. 2020)

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Ledermix/Corticosteroid

The issue with it is that:

- Has to be placed immediately or shortly after the avulsion/luxation.
- No preparation is commercially available in many countries.
- Ledermix has the potential of staining crowns/roots.

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Ledermix/Corticosteroid

The issue with it is that:

- Has to be placed immediately or shortly after the avulsion/luxation.
- No preparation is commercially available in US.
- Ledermix has the potential of staining crowns/roots.

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Root Resorption

External Root Resorption

Cervical Resorption

(Subepithelial external inflammation)

- Injury to PDL and cementum
- Lesion located at the attachment level of the tooth
- Crestal bony defect associated with the lesion
- No relationship with content of root canal
- Pink spot on crown possible

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Root Resorption

External Root Resorption

Cervical Resorption

(Subepithelial external inflammation)

Histology similar to "classical" inflammatory root resorption except:

- Does usually not penetrate through predentin.
- Does often leave much of the cementum intact.

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Root Resorption

External Root Resorption

Cervical Resorption

(Subepithelial external inflammation)

Several etiologic factors suggested:

- Dental trauma.
- Orthodontic treatment.
- Intracoronal bleaching.
- Periodontal therapy.
- Idiopathic etiology (e.g. bruxing, restorations, developmental defects, systemic diseases)

(Patel et al. 2009)

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External Cervical Resorption

Treatment Options

- ✓ No Treatment
- ✓ Non Surgical (internal)
- ✓ Surgical
- ✓ Extrusion
- ✓ Extrusion followed by intrusion
- ✓ Implants

41

Geristore

Resin-Ionomer & Hybrid Ionomer Cements Part II
Human clinical and histologic wound healing responses in specific periodontal lesions.

Dragoo MR et al. 1997; 25 pt. 50 subgingival restorations

"Clinical and histologic evidence of epithelial and connective tissue adherence to resin-ionomer restorative materials was observed during the healing process."

42

Internal Inflammatory Root Resorption

When resorption is present, chronic inflammation is adjacent to areas of internal root where the odontoblastic layer and the predentin are lost or altered.

Reasons for the loss of pre-dentin adjacent to the granulation tissue are not obvious.

Reasons suggested have been lack or alternations of blood circulation after traumatic injury or extreme heat produced when cutting on dentin without adequate water spray.

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Internal Inflammatory Root Resorption

Usually asymptomatic and is first recognized clinically through routine radiographs.

For internal resorption to be active, at least part of the pulp must be vital.

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Internal Inflammatory Root Resorption

Internal root resorption is treated with the endodontic methods

Pulpectomy removes the blood supply to the granulomatous tissue and the rest of the treatment is concentrated on removing tissue from the irregular resorptive defect and obturating the space.

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Internal Inflammatory Root Resorption

Internal root resorption close to the root fracture site (without any lesions in the bone at the same level) are to be considered part of the normal healing process.

And no treatment is needed or should be done!

(Andreasen and Andreasen 1988 and Andreasen et al. 1989)

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Intentional Reimplantation

Clinical outcome of intentional replantation with preoperative orthodontic extrusion: a retrospective study.

Human, n=280

The mean follow-up = 25.4 ± 9.3 months.
The overall success rate = 89.5%(periradicular healing)
The overall survival rate = 95.1%.

No affect of variables, such as age and gender, tooth type and location, did not affect the survival of intentionally replanted teeth.

(Choi YH 2014)

47

Infra-Positioned Tooth (Ankylosed)

What can be done?
Nothing
Not a good esthetic option.

Orthodontics: Not possible – the tooth will not move because of the ankylosis.

Composite buildup on incisal edge
Possible with low smile line and minor infra-position.

48

Infra-Positioned Tooth (Ankylosed)

What can be done?

Early extraction of the ankylotic tooth and esthetic replacement of the missing tooth by loose appliance or attachment to adjacent teeth:

- For obvious reasons this is not a good option because of the bone/alveolar defect that will undoubtedly form.

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Infra-Positioned Tooth (Ankylosed)

What can be done?

Extraction followed by orthodontic space closure:

This is a good option for children with foreseeable anterior crowding.

- The orthodontic therapy has to be commenced immediately after extraction because of the rapid loss of bone after extraction of the ankylosed tooth.

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Infra-Positioned Tooth (Ankylosed)

What can be done?

Surgical extraction and reimplantation

Possible if there a donor tooth available that is not too damaged or ankylosed.

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Autotransplantation of teeth to the anterior maxilla: A systematic review of survival and success, aesthetic presentation and patient-reported outcome

n=11 studies, follow-up 9 m to 22 y, median: 8.75 years.

Survival rates: 93% and 100%
weighted mean: 96.7%,
median: 100%,

(Akhlef Y et al. 2018)

52

An evaluation of 1654 premolars transplanted in the posterior region A retrospective analysis of survival, success and complications

The mean age 14.5 years.

Only 11 premolars were lost during the study period of 10 years

Open apex survival 99.7% and success 99.4%,

Closed apex survival 95.7% and success rates 95.5%

Success rate after 10- year follow- up is 83.3%.

(Barendregt D et al. 2023

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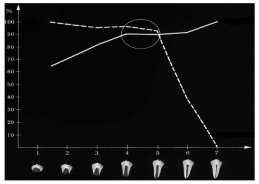
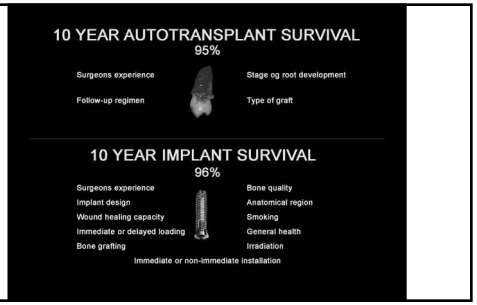
Success Rate of Transplant vs. Pulpal Revascularization



(Andreasen 1988)

54



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Autotransplantation

Best done for pulpal survival when the root has formed about 3/4 to 4/5 formed and the apex is still open.

If a fully formed tooth is transplanted root canal therapy should be done either prior to transplantation or 7 to 10 days after – similar then to an avulsion.

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Implant

+ Good long term survival.
+ Aesthetic results usually good.
- No bone induction.
- A gingival papilla has to be created if possible.
- Requires three dimensional bone support.
- Eruption not possible.
- Can not be moved orthodontically.
- Age relation to procedure: limited to adults.
- Cost efficiency in relation to implant survival to be debated.

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Autotransplant

+ Induces bone.
+ Induces a gingival papilla.
+ No requirement of bone support
+ Eruption possible.
+ Can be moved orthodontically.
+ Long term survival.
+ Aesthetic result usually good.
+ Age relation to procedure: None
+ Cost efficiency in relation to implant survival very good.

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Cervical Fracture

What can be done for a young individual?

Root submersion and transplant or osseous implant later,
- most likely will need an extraction of the root at the time of implant.

Benefits are preservation of the alveolar bone and possibly vertical growth of the bone!

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Root Submersion

Dog study/histology 30 to 120 days

Crowns sectioned off 2 mm below alveolus.
Results:

- Some bone/cementum formation over the root - 12/16
- Inflammation pericoronal - 3/16
- Cyst formation around cervical area - 3/16

-No root resorption

(Gound et al. 1978
O'Neal et al. 1978)

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Root Submersion

Retrospective human study n=53, mean age 12.1 years

Survival of intentionally retained permanent incisor roots following crown root fractures in children.

Over 90% of the roots were retained more that 2 years.
- 5 teeth were vital and remained so.

(Rodd HD et al. 2002)

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Root Submersion vs. Decoronation

Root submersion:

A root is left in situ in the alveolus subsequent to crown root fracture or extensive cervical root resorption:
- PDL is intact.
- Root canal therapy might or might not be needed.
- Done to preserve alveolar bone.
- Or to buy time while the root is maturing (J&J).

(Levin et al. 1974, O'Neal et al. 1978, Gound et al. 1978, Johnson & Jensen 1997, Rodd et al. 2002, Yu et al. 2011)

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Root Submersion vs. Decoronation

Decoronation:

A root is left in situ in the alveolus:
- PDL is severely damaged or lost.
- Tooth infra-occluted due to ankylosis
- Root canal filling material needs to be removed if present.
- Done to preserve alveolar bone.

(Malmgren and Malmgren)

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Infra-Positioned Tooth (Ankylosed)

What can be done?

Decoronation and transplant or osseous implant later.

Benefits are preservation of the alveolar bone and possibly vertical growth of the bone!

64

Decoronation

Maintains the facio-palatal bone dimension.

Induces the alveolar bone to grow vertically.

Allows for an aesthetic temp restoration.

Preserves bone for later implant placement.

(Based on Dr. B. Malmgren)

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Decoronation

- The bone that forms in the area is of good quality and placement of implants.

- No apparent complications in cases where there are some remnants of the root still visible on radiographs (Malmgren et al. 2002).

- Therefore there does not seem to be any need to remove those remnants prior to placement of an implant into the area.

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Alveolar Bone Width Preservation after Decoronation of Ankylosed Anterior Incisors

n=12, human, mean eval. time=50 months, mean age 10y

- All decoronations were performed when the ankylosed teeth were 1–1.5 mm infra occluded.
- The average bucco-palatal dimension of the alveolar ridge at the mid-decoronation area was 9 mm compared with 10.17 mm at the contralateral homologous tooth.

(Lin S et al. 2013)

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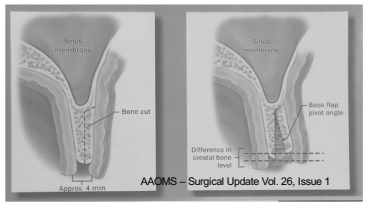
Alveolar Bone Width Preservation after Decoronation of Ankylosed Anterior Incisors



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Decoronation

The Advantages of Decoronation Procedures are:

- ✓It perseveres the alveolar process' width and height.
- ✓It is likely to negate the need for expensive and invasive surgical alveolar ridge augmentation procedure.
- ✓Studies indicate that vertical bone apposition is possible after the crown is removed.

(Sigurdsson, Ped Dent 2009)

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Decoronation

The main disadvantages of the Decoronation procedure are its surgical nature;

- may be challenging in young children,
- the necessity for a long-term esthetic space maintainer.

(Sigurdsson, Ped Dent 2009)

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Revascularization of Non-vital Teeth With Apical Periodontitis

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Pulpal Necrosis

The occurrence of pulp revascularization is enhanced if the apical foramen is more 1.1 mm wide in humans

(Kling *et al.* 1986).

72

Pulpal Necrosis

In case of trauma (severe luxation or avulsion) the pulp revascularization is favored when the apical foramen is not completely formed.

(Öhman, 1965; Skoglund and Tronstad, 1981; Kristerson and Andreasen, 1984; Kling *et al*., 1986; Cvek *et al*., 1990a).

*

73

Pulpal Necrosis

AND pulp revascularization is highly dependent on the presence or absence of bacteria in the pulpal lumen.

(Cvek *et al*. 1990 and 1990)

74

Accidental Extraction

Small statue, healthy but very frighten 6 year old boy

Left central tooth "accidentally" extracted by a dentist who thought that the white speck she saw was fractured off root of the primary tooth.

Extraction done without anesthesia, tooth was elevated out and fell on the floor.

Reimplanted within few minutes and patient referred to the College.

75

Necrotic Pulp

When the pulp in an immature tooth becomes necrotic and the pulpal space infected the success of any endodontic treatment is severely reduced.

- Difficult to treat
- Inadequate strength

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Pulpal Necrosis

Soaking the tooth in Doxycycline (1mg/20ml saline)

Increased the total pulal regeneration from 18% til 41% in monkeys.

(Cvek et al, 1990)

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Research Question

Is Minocycline (Arestin or Dentomycin) more effective than Doxycycline in preventing bacterial penetration along the PDL after replantation?

(Ritter et al. 2004)

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Results - Histology

Saline:
- 33.33% Vital pulp

Doxycycline topical treatment:
72.73% Vital pulp + osteoid tissue

(Ritter et al. 2004)

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Results - Histology

Minocycline topical treatment:
90.96% Vital pulp + osteoid tissue

(Ritter et al. 2004)

80

Where it all started

Sterilization of infected root-canal dentine by topical application of a mixture of ciprofloxacin, metronidazole and minocycline in situ
Sato, Ando-Kurihara, Kota, Iwaku, Hoshino
International Endodontic Journal 1996;29:118-24.

In - vitro antibacterial susceptibility of bacteria taken from infected root dentine to a of 0.5 mg mixture of ciprofloxacin, metronidazole and minocycline
Hoshino, Kurihara-Ando, Sato, Uematsu, Sato, Kota, Iwaku
International Endodontic Journal 1996;29:125-30.

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Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology

"It is easy to be considered stupid and incompetent but this Emperor has no cloth!"

Dr. Spangberg, Section Editor of Endodontics, OOOOE
"I am re-telling this fairy tale as it reminds me of many of the controversial issues we deal with in interpreting endodontic research. The most recent one is the excitement about "pulp regeneration." It is often discussed as a "paradigm shift" in endodontic treatment. *(This is where the cloth is woven.)"*

It sounds great, but unfortunately the "dentin" deposition in the apical part of the root canal is old-fashioned cement tissue.

This new tissue growth only lays down cellular and acellular cementum.

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What Are We Talking About?

Revascularization vs. Revitalization vs. Regeneration vs. Repair?

INTERNATIONAL ENDODONTIC JOURNAL
doi:10.1111/iej.13471

REVIEW
Clinical cell-based versus cell-free regenerative endodontics: clarification of concept and term

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Int Endod J 2021;54:887-901

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So What Do We Know?

There are truly two types of regenerative procedures in teeth:

Cell-Free versus Cell-Based regenerative endodontic therapy.

The revitalization procedures practiced clinically in endodontics are almost all Cell-Free based,

whereas the tissue engineering concept in pulp regeneration is a Cell-Based approach, which so far is at the clinical trial stage.

(Lin L et al. 2021)

84

Caution

There is no consensus on the true meaning of clinical regenerative endodontics,

and there is confusion over the concept and the term.

Commonly used terms include:
- regeneration,
- revitalization and
- revascularization

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And What Shall We Call It?

In the medical field the definition of 'Revascularization:

A surgical procedure to restore the blood supply of ischemic tissue due to blockage or severance of vessels.

For example the pulp of an avulsed tooth has severed blood vessels at the apex.

Immediate replantation may lead to reconnection or anastomosis of some vessels and the blood supply may be re-established and thus revascularized.

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What Are We Talking About?

Revascularization vs. Revitalization vs. Regeneration vs. Repair?

The term 'revascularization' for regrowth in to a necrotic space in a root canal was first used by Iwaya et al. (2001).

Later, revitalization instead of revascularization was proposed as a more applicable term as the tissues regenerated in the canal space were not only blood vessels but also hard and soft tissues (Huang & Lin 2008).

The term 'regenerative endodontics' was adopted by the American Association of Endodontists in 2007 (Murray et al. 2007), based on a tissue engineering concept.

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What Are We Talking About?

Revascularization vs. Revitalization vs. Regeneration vs. Repair?

In the endodontic literature, revascularization, revitalization and regenerative endodontics are used synonymously and interchangeably but some argue we are only looking at repair.

Repair refers to a damaged tissue that has lost its physiological function and most often then replaced by tissue different from the original tissue and loss of biological function.

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Where it all started

Tissue formation in the root canal following pulp removal
Nygaard-Ostby and Hjortdal
Scand J Dent Res 1971;79:333-49

Dental pulp regeneration aided by blood and blood substitutes after experimentally induced periapical infection
Myers and Fountain
Oral Surg Oral Med Oral Pathol. 1974;37:441-50

89

Disinfection of a Root Canal

Study on immature teeth with necrotic and infected canals showed that the revascularization failed primarily because of inadequate disinfection before inducing bleeding into the canal space.

(Myers and Fountain 1974)

90

Where it all started

Sterilization of infected root-canal dentine by topical application of a mixture of ciprofloxacin, metronidazole and minocycline in situ

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International Endodontic Journal 1996;29:125-30.

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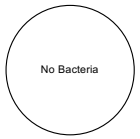
The Three Key Components of Regeneration



92

No Bacteria

Sato et al. 1996:

Confirmed that in extracted teeth there was penetration of the tri-mix-antibiotic paste through dentine.

And the mix had the antibacterial efficacy expected against bacteria infecting the dentine in the root canal area.

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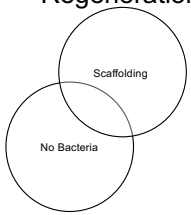
The Three Key Components of Regeneration



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Scaffolding

An empty canal space will not support in-growth of new tissue from the periapical area on its own.

(Torneck 1966 and 1967)

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Scaffolding

Dental pulp regeneration is aided by blood and blood substitutes after experimental removal of the pulpal tissue in immature teeth.

(Nygaard-Ostby 1961, Myers and Fountain 1974)

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Treatment Protocol

After three weeks the patient is recalled and the antibiotic paste irrigated out with saline

DO NOT use epinephrine containing local anesthetics.

Bleeding is created in the canal space with a sterile endo explorer and/or files.

Effort is made to have the blood fill the whole canal space.

This blood should be allowed to begin its initial clotting prior to closing the access.

(Banchs and Trope 2004)

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Treatment Protocol

Hard to control the bleeding and very hard to place a restoration on top of the blood clot, therefore:

Various collagen based materials, polymeric, ceramics, bioactive glass and hydrogels have been tried as a scaffold,

As of yet no consensus on any material, only blood clot.

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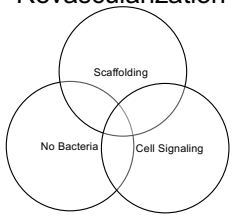
The Three Key Components of Revascularization



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Application of Tissue Engineering Concepts to Regenerative Endodontics

It has been shown that the evoked-bleeding step in pulpal regeneration triggers the significant accumulation of undifferentiated stem cells into the canal space

These cells might contribute to the regeneration of pulpal tissues seen after antibiotic paste therapy of the immature tooth with pulpal necrosis.

(Lovelace TW et al., 2011)

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Application of Tissue Engineering Concepts to Regenerative Endodontics

So where are we now?

Very little is presently known about the exact nature of this tissue growing into the canal and how it may behave in the long term.

In the case of regeneration of necrotic non-infected pulp tissue there are four possibilities:

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However

The use of the three antibiotics have been criticized by many:

- off label use of antibiotics
- risk of resistant bacteria
- reaction of the young patient to the antibiotics.

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Suggested Alternative to Dual- or Tri-Antibiotic Mix

Calcium Hydroxide has been used as an intracanal medicament in endodontics:

It is well established it does help with disinfection
It is thought to be likely to improve prognosis of a treatment of a necrotic/infected pulp.

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Irrigation – Dilemma

Currently recommended to use 1.5% NaOCl

This is mainly based on the studies that show the cytotoxic effect of sodium hypochlorite on survival of stem cells from the apical papilla in vitro rather than on killing of the intracanal bacteria in vivo.

(Trevino et al. 2011, Martin et al. 2014)

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Does Revascularization Work?

Traumatized Immature Teeth Treated with 2 Protocols of Pulp Revascularization
(human, n=23, two groups, $Ca(OH)_2$ and Tri-Mix, 9-19 months obs)

- Periapical repair was found in all except one.
- Increase in root length was demonstrated in:
  - 41.7% - Tri-Mix
  - 27.3% - calcium hydroxide.
- Thickening of lateral dentinal walls was observed in ≈ 40% for both groups.

(Nagata JY et al. 2014)

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Opinion Paper

"Immature teeth with pulpal necrosis with otherwise poor prognosis can be treated with regenerative endodontic procedures (REP).

These procedures do not preclude the possibility of apexification procedures if attempts are unsuccessful. Therefore, REPs may be considered first treatment options for immature teeth with pulpal necrosis."

Diogenes A, Ruparel NB, Shiloah Y and Hargreaves KM
JADA 2016

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Success in Regenerative Endodontics

Primary goal
- ✓ No symptoms and healing of apical periodontitis.

Secondary goal
- ✓ Increased in root wall thickness and/ or root length.

Tertiary goal
- ✓ Response to vitality testing.

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Conclusion

Rather than being discouraged that ideal regeneration has not been achieved to date, repair can be an acceptable outcome in clinical regenerative endodontics as it has also been accepted in medicine.

Repair should also be considered in the context that resolution of the clinical signs/symptoms of pulp necrosis/ apical periodontitis is generally reliably obtained in clinical regenerative endodontics.

(Lin L et al. 2021)

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