

# Vital pulp therapy and regenerative procedures in endodontics

# Minimally invasive endodontics (Endolight)

- Dentin is a bioactive substance (vital tissue with cells - odontoblasts)
  - complex dentin and pulp – endodont
  - reparative and regenerative potential (sclerosis, reparative dentine)
  - differentiation of new odontoblasts
  - growth factors in dentine that are releasing during carious demineralization can have positive effect on reparation and regeneration of dental pulp
  - pulp vitality can be kept also in case of irreversible pulpitis

# Correlation between clinical picture and histological finding in dental pulp

- Traditional concept
  - There is very small accordance between clinical symptoms and histological finding in dental pulp (Seltzer a Bender 1963; Garfunkel a spol. 1973).
- Contemporary concept
  - There is quite good accordance between clinical symptoms and histological finding in dental pulp (Ricucci a spol. 2014).

# Clinical x histological finding

- In cases of irreversible pulpitis are pathological changes in coronal part of dental pulp.



- Dental pulp in the root canal can be conserved.

# Benefits of minimally invasive approach

- Healing potential and defense mechanism of dental pulp can be kept.
- Simple procedures – less risk of complication due to difficult morphology of the root canal system.
- Less painful
- Lower costs

# Classification of pulpitis

## Hashem 2015

- Mild reversible pulpitis MRP
  - Sensitivity on cold, hot and sweet stimuli

Persistence 15 – 20 s, regress spontaneously
- Severe reversible pulpitis SRP
  - Sensitivity on cold, hot and sweet stimuli
  - Persists several minutes, analgetics could be necessary
- Irreversible pulpitis IP
  - Spontaneous pain, sharp, throbbing, after lying down
  - Pain on percussion

# New classification and guidelines for the therapy

- Initial pulpitis

Increased but not prolonged pain on cold, absence of spontaneous pain.

Histologically: hyperaemia

Therapy:

Indirect pulp therapy –IPT.

Mostly Indirect pulp capping

# New classification and guidelines for the therapy

- Mild pulpitis
  - Increased reaction on cold, hot and sweet stimuli, prolonged max 20s, spontaneous regression.
  - Histologically: inflammation of the coronal part of dental pulp.

Therapy: IPT – indirect pulp therapy.

Mostly intermittent excavation

# New classification and guidelines for the therapy

- Moderate pulpitis

Clear symptoms, strong pain, very prolonged reaction on cold, hot (minutes), possible pain on percussion, spontaneous pain, analgetics have only partial effect.

Histologically: Extensive inflammation affecting the coronal pulp completely

Thrapie: Coronal pulpotomy –partial/complete

# New classification and guidelines for the therapy

- Severe pulpitis

Heavy spontaneous pain, very strong pain on stimuli, sharp, throbbing, strong pain after lying down, pain on percussion and

Histologically:

Extensive inflammation in dental pulp, spreading probably into root canal .

Therapie: Deep pulpotomy or pulpectomy

# Therapeutic procedures

- Indirect pulp capping

Caries next to dental pulp (caries pulpaе proxima). Carious dentin is possible to remove almost completely. Decay is deep in small region. Appr 1 mm<sup>2</sup> carious dentin can be left.

Kalciumhydroxide cement, permanent filling

Alternativs: MTA, Biodentine

Formation of tertiary dentine.

# Therapeutic procedures

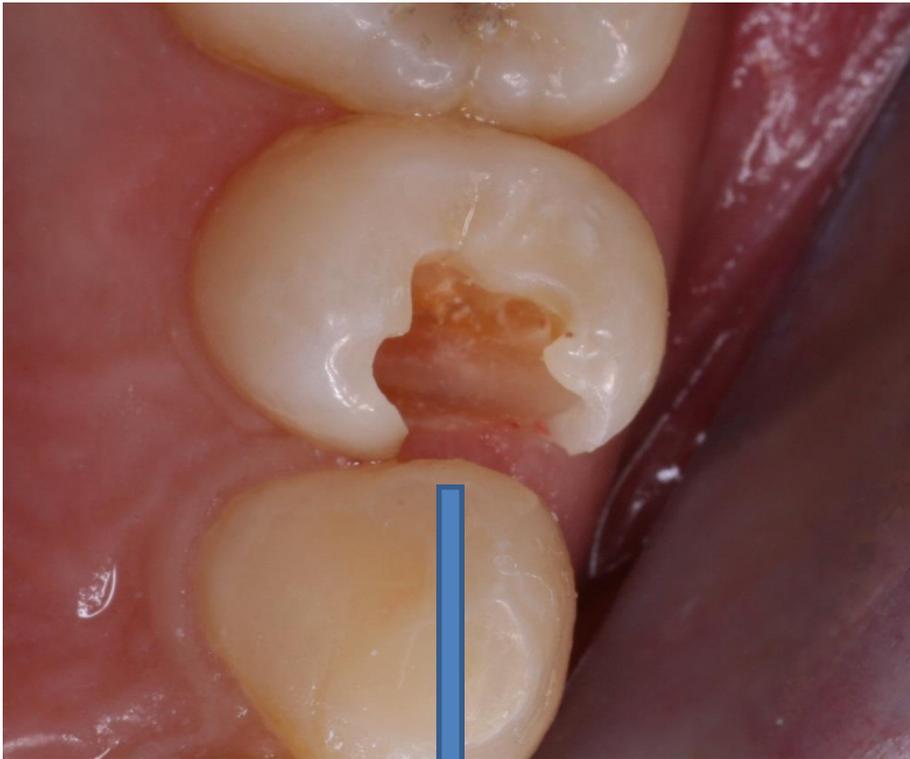
- Intermittent excavation

Large dental caries spreading towards dental pulp. Big amount of carious dentine.

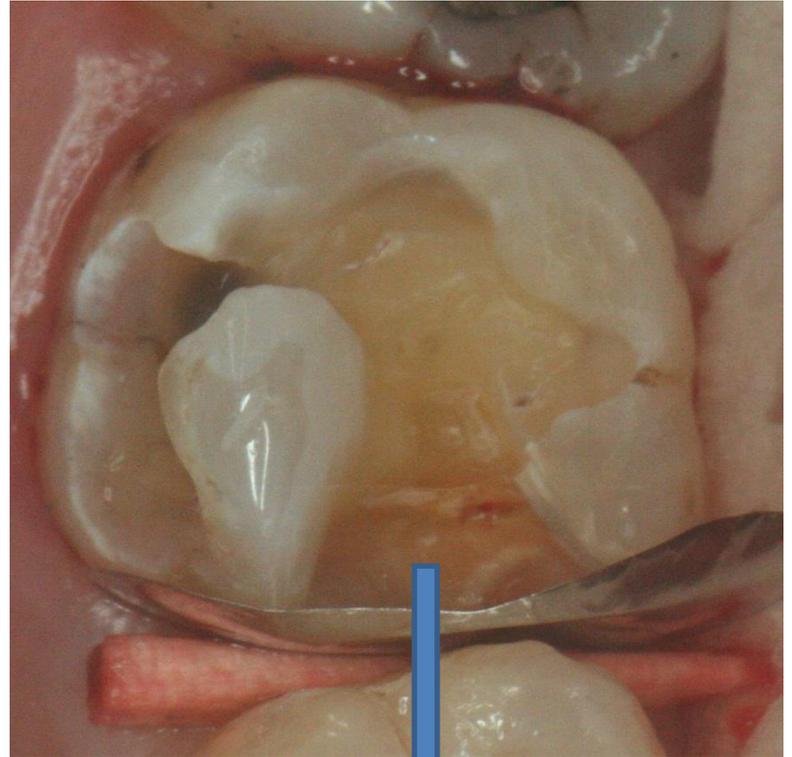
High risk of perforation

Suspension of calcium hydroxide, temporary filling for 6 weeks.

Dessication of soft dentine, formation of tertiary dentine.



Intermitentní exkavace



Pulpotomie



Nepřímé překrytí materiálem Biodentine

# Therapeutic procedures

- Direct pulp capping
- Treatment of small perforation after preparation or traumatic dental injury in non carious dentine.

Immediately ( 2 – 3hours).

Suspension of calcium hydroxide hydroxidu vápenatého, calcium hydroxide cement, permanent filling.

Alternatives: MTA, Biodentine aj.

Dentin bridge formation

# Therapeutic procedures;

## Pulpotomy

- Coronal

- ✓ Partial (removal cca 2 mm of dental pulp)
- ✓ Total (removal dental pulp from the pulp chamber completely)
- ✓ Deep (removal of dental pulp to the root canal cca 4 mm of dental pulp apically can be left)

# Pulpotomy

- Aseptic approach
- Excavation of soft dentine
- Opening of the pulp chamber with sterile bur or diamond)

Stopping bleeding (2,5% sodium hypochlorite)

Capping using calcium hydroxide or bioactive cement, permanent filling.

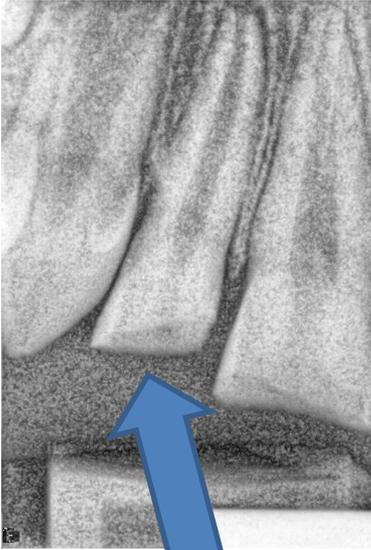
Dentine bridge

# Pulpotomy - indication

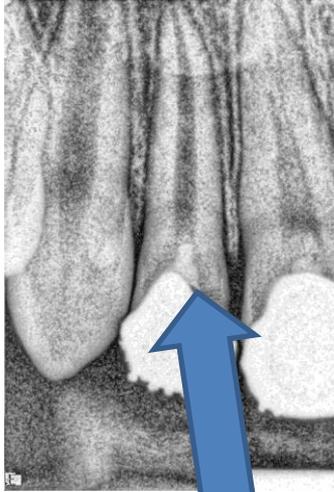
- Traumatic dental injury – opening of the pulp chamber - bigger perforation or longer time after the injury (more than 2 -3 hours)
- Perforation in carious dentine
- Reversible pulpitis

It is necessary to consider

- Age of the patient
- Aseptic approach



Fracture



Pulpotomy



Calcification, resorption

# Apexification

- Permanent teeth with widely open root canal (immature teeth)
- Calcium hydroxide – temporary root canal filling

Approximately 1 year

- MTA plug
- Combination

MTA x CH comparable results, MTA – hard barrier.

# Apexification

Disadvantages

Root canal walls remain thin

Risk of the fracture

Time consuming procedure

The tooth usually does not complete the development

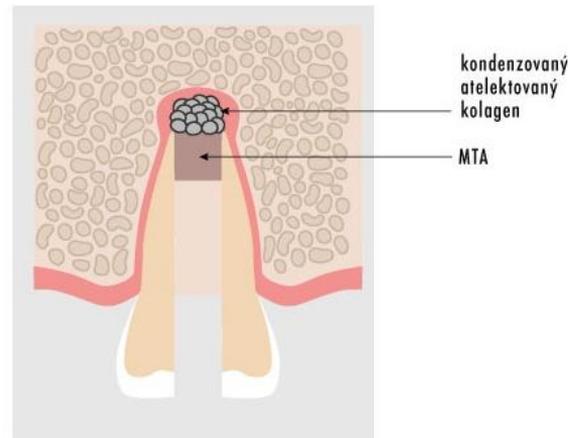
Benefit

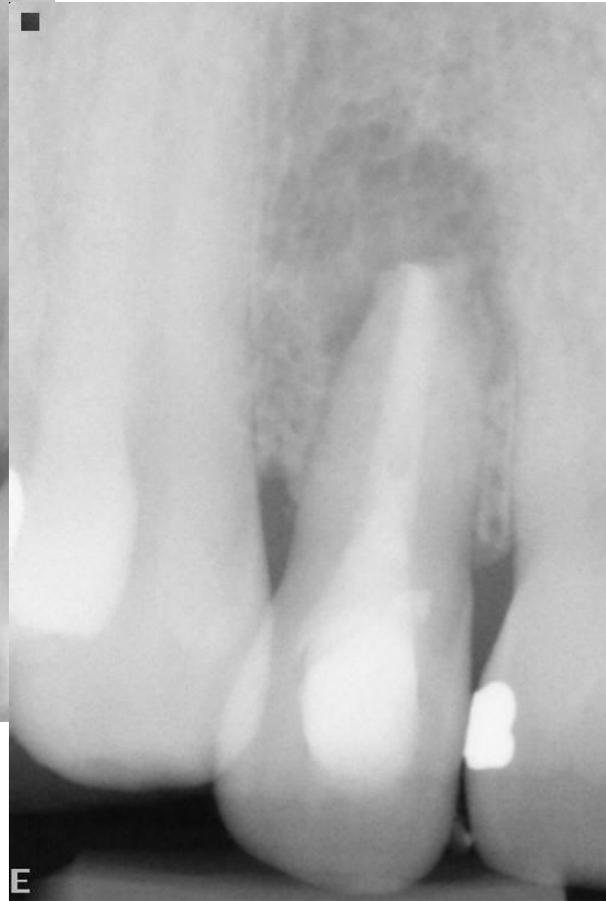
Undemanding on equipment

Predictable result

# Technique of MTA plug

- High % success -95%. Elongation of root for appr. 6%.
- Disadvantage: highre price and difficult manipulation with MTA.

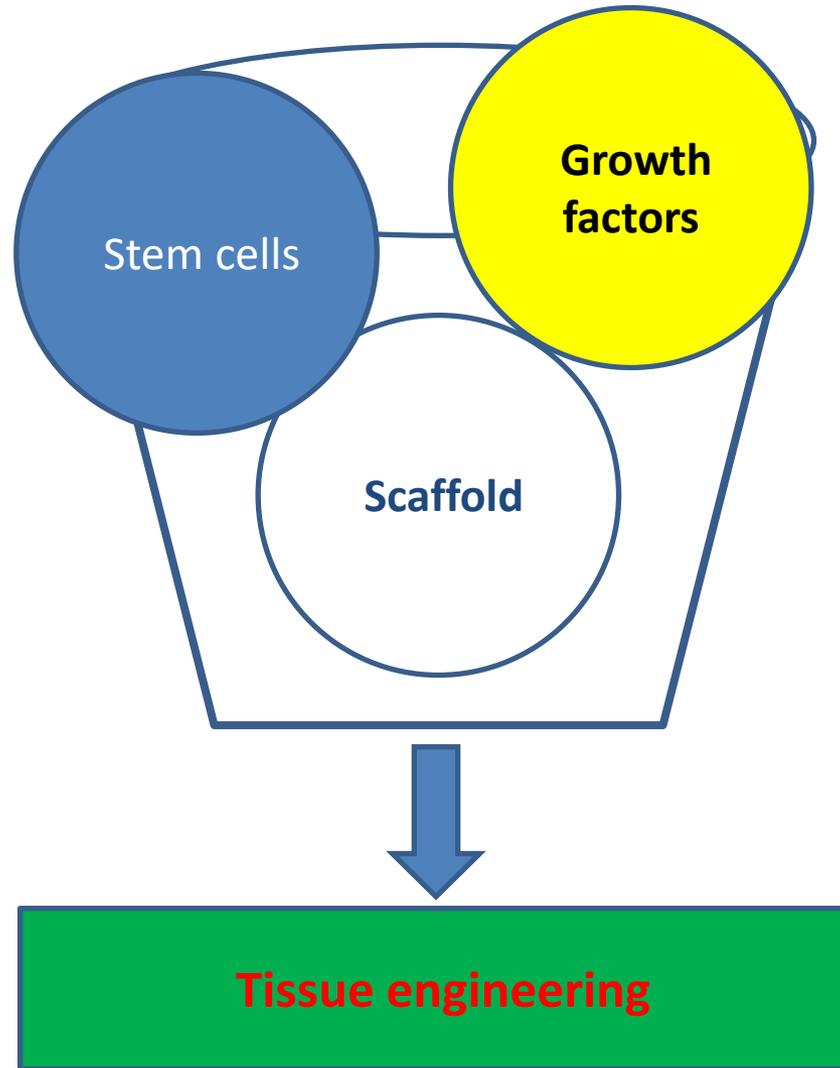




MTA plug in the tooth with widela open apex

# Regenerative endodontics

## Tissue engineering



# Regenerative procedure

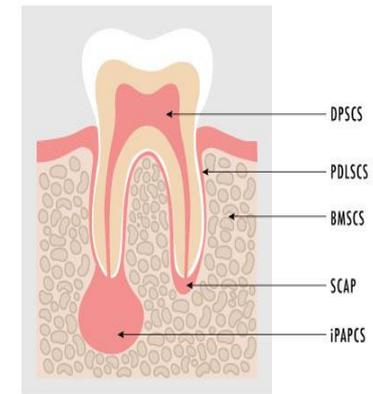
- Revascularisation, maturogenesis, revitalisation.
- Nygaard a Ostby 1960 – Observation of coagulum – ingrowth of fibrotic tissue into the coagulum, production of cellular cement.

# Stem cells

- Multipotential mesenchymal cells, perivascular - small areas (nikes):

# Stem cells

- Apical papilla
- Dental pulp
- Bone marrow
- Periapical inflammation
- Radicular cyst



# Growth factors

- Polypeptides or proteines, they bind on receptors of cells. Local effect
- During dentinogenesis these factors are produced by odontoblasts and are incorporated into collagen matrix. These factors release during demineralization (decay, etching) and have influence on tertiary dentin formation.

# Growth factors

- **Transforming growth factor beta-1, TGF- $\beta$ 1)**

Antiinflammatory effect, accelerates healing, produced by odontoblasts.

- **Basic fibroblast growth factor, bFGF nebo FGF-2)**

Stimululates angiogenesis and induces differentiation of mesenchymal cells.

- **Vascular endothelial growth factor (VEGF)**

Angiogenesis, new vessels formation

- **Bone morphogenetic proteins, BMP)**

BMP osteoinductive and chondrogenic effect.

- **Platelet-derived growth factor, PDGF)**

# Scaffold

- Physical-chemical and biological 3D microenvironment, where the cells can multiply, differentiate and migrate. Transport of nutrients, oxygen and metabolites. It should be replaced with regenerated tissue.

# Coagulum

- Bleeding into the root canal
- Coagulum – scaffold (fibrin, fibronectin, growth factors).
- Coagulum must mature – 15 min.
- Alternative rich platelet plasma.

# Decontamination of the root canal system - irrigation

- Sodium hypochlorite (1,5%)
  - Antimicrobial effect
  - Dissolving of biofilm.
  - Chlorhexidin

Binding to collagen fibers, this binding decreases its effect, the survival of stem cells decreases.

# Irrigation

- EDTA

Chelator – effect on inorganic part of hard dental tissues.

- Removal of inorganic part of the smear layer
- Exposure of collagen fibers and releasing growth factors
- Inactivation of sodium hypochlorite
- Better adhesion of stem cells of apical papilla, enhanced migration, adhesion and differentiation of stem cells from dental pulp.

# Protection of the coagulum

- Antibiotic pastes
  - Minocyklin
  - Metronidazol
  - Ciprofloxacin
  - Amoxicilin
  - Cefaclor
  - Rifampicin

One- two-three component pasts

# Calcium hydroxide

- Ability of dissolution of hard dental tissues and expose collagen fibers with growth factors

# Clinical procedure

## 1. visit

Launch of endo treatment, establishment of WL, temporary root canal filling, atb paste or calcium hydroxide, irrigation NaOCl 1,5%. Teflon, temporary filling.

## 2. visit

Irrigation 17% EDTA, saline solution, induction of bleeding, stabilization of coagulum. Calcium silicate cement, permanent filling (GIC+flow composite)

# Indication

- Permanent teeth with wide open root canal – alternative to apexification.

Benefit: achievement vital tissue in the root canal system, possibility of growth of the root.

Problems

Technologically difficult

Excellent compliance

Complications: discoloration, calcification, reinfection, short root.

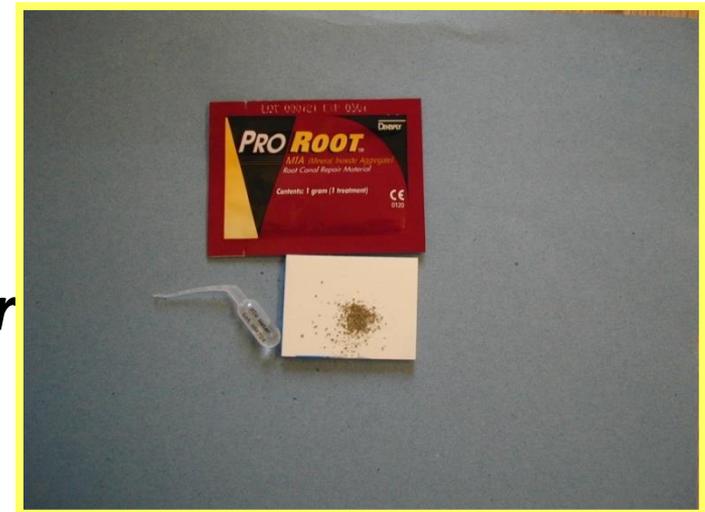
# Materials

# Portland cement - MTA

- $Ca_3Si$       *Calcium trisilicate*
- $Ca_2Si$       *Calcium disilicate*
- $Ca_3Al$       *Calcium aluminate*
- $Ca_4AlFe$     *Calcium aluminoferrite*
- $CaSO_4$       *Calcium sulphate*
- $BiO_3$         *Bismuth trioxide*

+

*Water*



# Portland cement - MTA

- ***Pulp capping***
- ***Pulpotomy***
- ***Apexification (no multiple visit)***
- ***Endodontic repair material***
- ***Surgical endodontics***



# Active biosilicate technology<sup>tm</sup>

## Septodont

Active Biosilicate Technology<sup>TM</sup> is a proprietary technology developed according to state-of-the-art pharmaceutical background applied to the high temperate ceramic mineral chemistry.



# Biodentine - composition

- Powder

$\text{Ca}_3\text{SiO}_5$  (tricalcium silicate C3S)

Main core material

$\text{Ca}_2\text{SiO}_5$  (dicalcium silicate C2S)

Second core material

$\text{CaCO}_3$  (calcium carbonate)

Filler

$\text{CaO}$  (calcium oxide)

Filler

$\text{Fe}_2\text{O}_3$  (iron dioxide)

Shade

$\text{ZrO}_2$  (zirconium dioxide)

Radiopacifier

- Liquid

$\text{CaCl}_2 \cdot 2 \text{H}_2\text{O}$

Accelerator

Hydrosoluble polymer

Water reducing agent

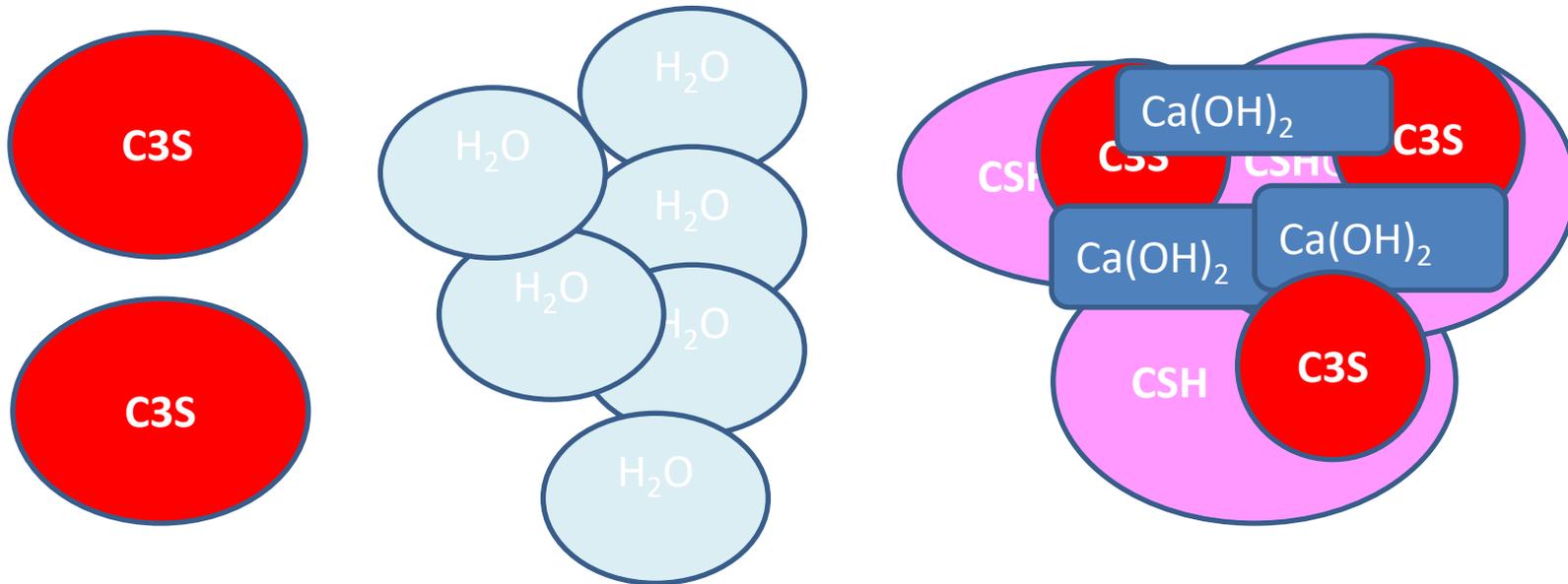
Water

# Biodentine – setting reaction



**C3S**

**CSH**





The hardening process results from the formation of crystals that are deposited in a supersaturated solution.

Setting time: 9 -12 min.

# Bioactivity - angiogenesis

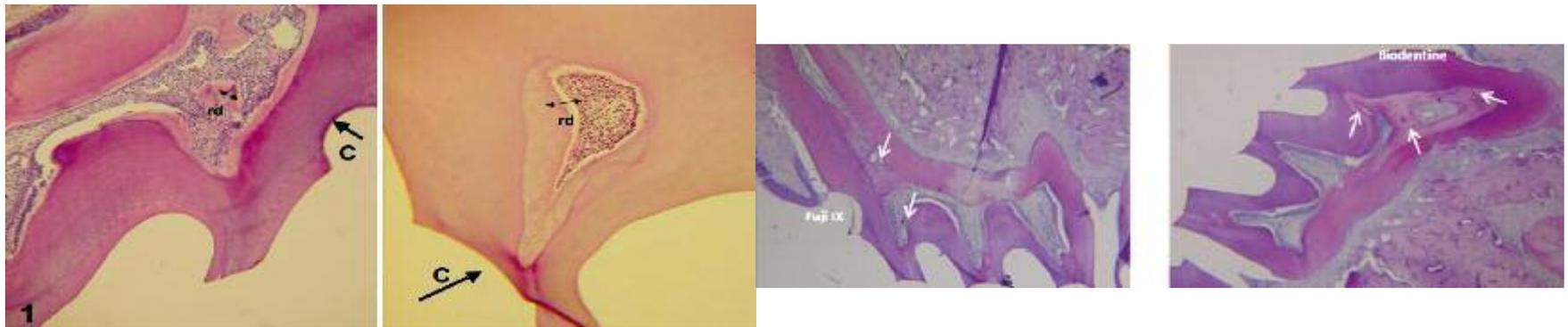
The concentration level of TGF- $\beta$ 1 was enhanced by both ProRoot<sup>®</sup> MTA and Biodentine<sup>™</sup>. Moreover, VEGF and FGF-2 were enhanced in presence of Biodentine<sup>™</sup>.

Biodentine<sup>™</sup> is able to stimulate angiogenesis, in order to heal pulp fibroblasts.

# Bioactivity – indirect pulp capping

Biodentine™ was able to stimulate a reactionary dentine which is a natural barrier against bacterial invasions. The reactionary dentine formation stabilises at 3 months, indicating that the stimulation process is stopped when a sufficient dentine barrier is formed.

Rat model.



Goldberg 2009

# Bioactivity – direct pulp capping and pulpotomy

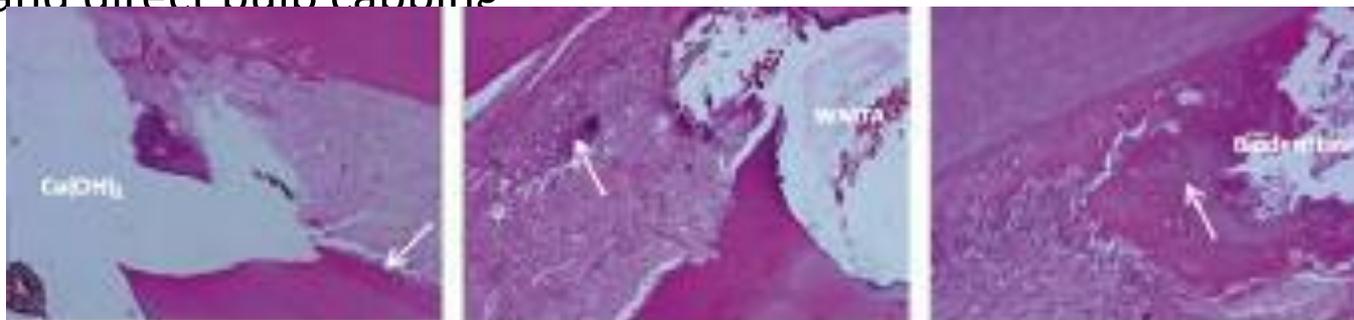
Biodentine™ is a suitable material for pulpotomy

Pig model.



12 weeks

and direct pulp capping



12 weeks

Biodentin is at least equivalent MTA, better than the others

# Overall bioactivity

- Biodentin was well tolerated. Moreover, Biodentine™ was able to promote mineralisation, generating a reactionary dentine as well as a dense dentine bridge. These phenomena illustrate the great potential for Biodentine™ to be in contact to the pulp, by demonstrating its bioactivity in several indications.

As a conclusion, Biodentine™ is bioactive.





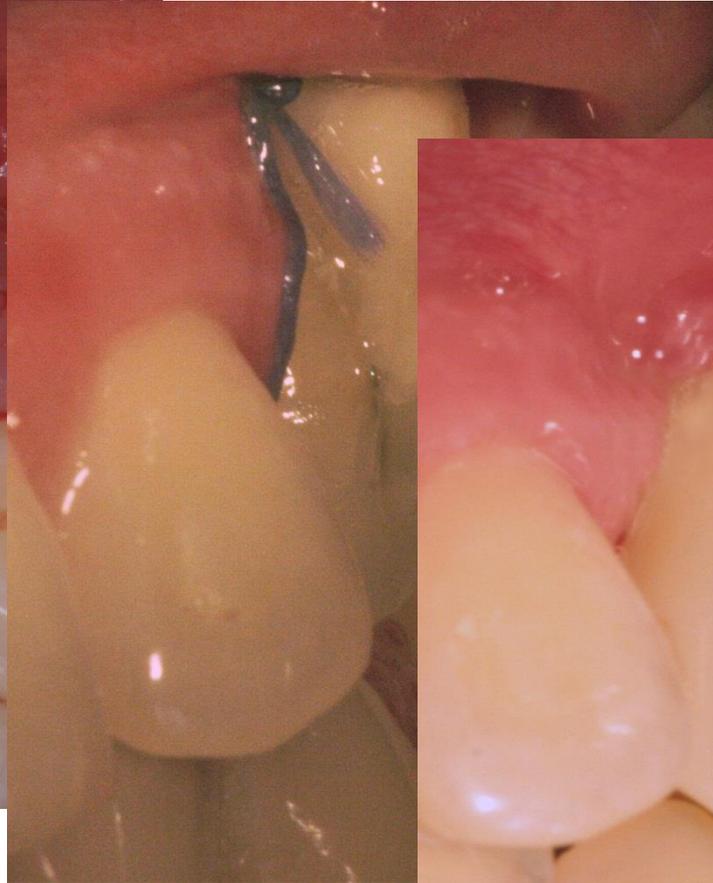
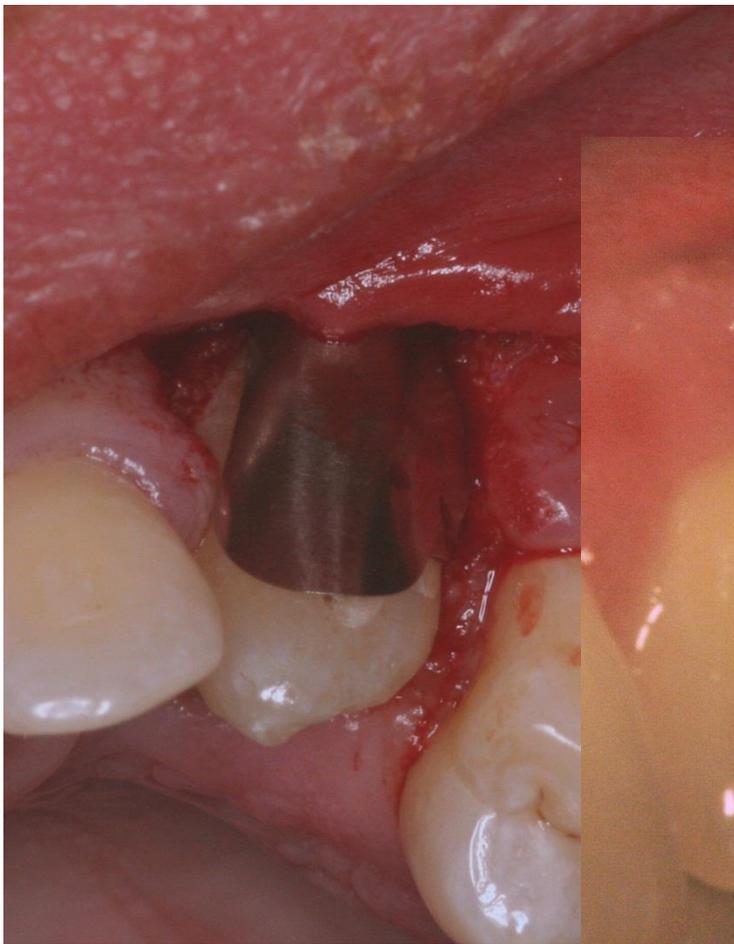


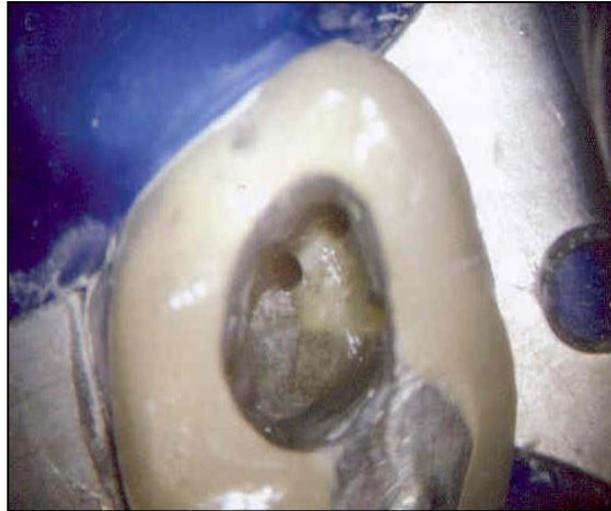


# Indications

- Pulp capping
- Pulpotomy
- Perforation of the root
- Resorption
- Open apex (immature teeth, a stp.apicoectomy) – apical plug
- Revitalisation







Perforation



Apical plug



Apexification and apical plug