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Modern methods in treatment of deep caries

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Abstract

Background: Deep carious lesions cause pulpal inflammation, if not managed, they may result in pulp necrosis and involvement of the periradicular tissues, with possible pain requiring, endodontic treatment or extraction.
Material and methods: This study included 35 patients with deep dental caries, 14 males and 21 females with the age range 25-37. The patients are divided into 2 groups. First group – with deep caries treated by capping material "Trioxident" based on mineral trioxide aggregate (MTA), and second group – with deep caries treated using calcium hydroxide.
Results: In our work for the treatment of deep caries, we used the preparations: "Trioxident" based on MTA and "Ultra Blend Plus" based on calcium hydroxide. Applications by material "Ultra Blend Plus" for 3-6 weeks on dentin surface show good results because sterile environment, significant alkaline reaction and calcification of the dentinal tubules. In this regard, it should be noted that the material "Trioxident" does not have porosity in the formed "dentin bridge" and is free from this disadvantage. The use of medical pads with MTA and calcium hydroxide with direct and indirect pulp capping methods did not reveal negative results (complicated caries).
Conclusions: Theoretical data is important for setting correct diagnosis and most suitable protocol of treatment. The described in the article materials – "Trioxident" and "Ultra Blend Plus" provide anti-inflammatory, analgesic and plastic effect. They stimulate the formation of a new secondary dentin layer. The first material – "Trioxident" (based on MTA), in our opinion, is more preferable because it has a number of useful advantages.
Key words: deep caries, treatment, trioxide mineral aggregate, calcium hydroxide.

Introduction

Dental caries is the most common disease. In economically developed countries, its prevalence among the population reaches 95-98%. According to the data of the World Health Organization (WHO), there is a sharp increase in the incidence of caries among the population of developing countries.

Caries is one of the problems of dentistry, important in theoretical and practical terms. A progressive lesion of the hard tissues of the tooth, such as pulpitis and periodontitis, is the cause of severe humidification – periostitis, phlegmon, osteomyelitis, mediostenitis and septic conditions [1]. In order to prevent these complications, it is necessary to try to keep the tooth living. The use of medical pads based on calcium hydroxide and the mineral trioxide aggregate (MTA) can stop the development of the carious process.

Medical pads should have the following properties:
- Stimulate the reparative functions of the pulp of the tooth;
- Have a bactericidal and anti-inflammatory effect;
- Have an analgesic effect;
- Do not irritate the pulp of the tooth;
- Have good adhesion;
- To be plastic;
- Have pressure resistance after hardening.

The treatment of acute deep caries has the following features. The acute course of the disease leads to a more rapid spread of the pathological process (the entire thickness of the dentin is affected).

The protective layers of transparent and secondary dentin do not have time to form. The carious cavity is separated from the pulp only with a thin layer of partially or fully demineralized dentin. In the pulp, the first manifestations of its focal inflammation are usually noted. Such clinical features of acute deep caries lead to the fact that during its treatment, in addition to the preparation and filling of carious cavity, additional measures are necessary to prevent pulp inflammation. It is necessary to stimulat pulp plastic aimed at remineralization of softened dentin. All this determines some features of the preparation, sterilization of the cavity and the need for additional use of medications for the treatment of acute deep caries [2].

While preparation of the carious cavity, the softened dentin from the bottom of the cavity must be removed carefully – with light movements with an excavator, and not with bur. In this case, you need to be very careful not to accidentally open the tooth cavity. The supra-pulp dentin layer is thinned and demineralized. Partially demineralized dentin can be left at the bottom of the cavity. Medicaments during treatment remineralize it. Antiseptic treatment of the cavity is carried out in warm solutions (36-37 °C): 0.02% furatsilin solution, microcid, 0.5% ethonium solution, 0.05% chlorhexidine solution, 4% betadine solution. Dry the carious cavity by stream of warm air and sterile cotton balls.

For drug treatment of acute deep caries, you can use a large number of antibacterial therapeutic pastes – suppressing microflora and odontotropic (plastic stimulating) – stimulating the deposition of pulp of secondary dentin.

Today, pastes containing calcium hydroxide are the most effective. This calcium compound creates an alkaline environment due to the high pH value (12.2), which, together with calcium ions, has an anti-inflammatory effect on the pulp and remineralizes the demineralized supra-pulp dentine. The high alkaline reaction of calcium hydroxide neutralizes the acid reaction that occurs with inflammation. These drugs have antibacterial effects. With direct capping of the pulp, calcium hydroxide causes surface coagulation of its proteins and stimulates the formation of a protective barrier from secondary dentin (dentinal bridge). Widespread compositions with calcium hydroxide based on acrylic resins (chemical and light polymerization), glass-ionomer cements, Life (Kerr), Calcimol LC.

Treatment pads are applied to the bottom of the carious cavity with a thin layer of 1-1.5 mm. Do not cover the paste with calcium hydroxide isolation pad of phosphate cement, because it contains phosphoric acid, which neutralizes the alkaline reaction of calcium hydroxide and the paste loses its effectiveness.

Acute deep caries is usually treated in two visits. In the first visit, a medical curative lining is applied and the carious cavity is closed with a temporary filling for 7-14 days. In the second visit, in the absence of patient complaints, a temporary seal is removed. Then carry out inspection of the cavity and electroodontomerty (6-10 μA). If necessary, carry out intraoral targeted radiography. Then, an isolating pad and a permanent filling are applied. If necessary, a temporary filling in the cavity can be saved for several months, i.e. extend the duration of the medical curative paste.

Modern filling materials allow departing from the classical rules for the preparation of the carious cavity in the treatment of caries.

You can carry out a necrotomy of the hard tissues of the tooth with hand tools (excavator, enamel knife). This is an Atraumatic Restorative Treatment (ART) technique [2]. Subsequently, the cavity is treated with an adhesive system and sealed with glass ionomer cement or composite. Modern filling materials release fluorine continuously and intensively, which provides anti-carious effect. In the absence of complaints and signs of inflammation, the seal may be left for a long time. After this time, the temporary seal is replaced with a stronger permanent seal.

The appearance of new filling materials leads to a change in the traditional methods of preparation and treatment of caries [1-5]. Flowable composite materials and compomers: "Filtek Flow (3M)", "Dyract Flow" ("Dentsplay"), "Revolution" ("Kerr") – they can be easily inserted into carious cavities and there is no polarization stress during polymerization. They firmly connect with the hard tissues of the teeth when filling. The organic matrix specific for resin composites ("Dyract Flow") and filler (reactive silicone glass) provides a significant and long-lasting fluoride release, which provides a pronounced anti-carious effect. "Dyract Flow" is characterized by minimal irritating effect on the pulp. These materials can reduce the amount of intact tooth tissue removed. When using them, there is no need to form box-shaped carious cavities [6, 7].

Purpose of the study. To evaluate the success result of deep acute caries treatment using calcium hydroxide and MTA.

Material and methods

This study included 35 patients with deep dental caries, 14 males and 21 females with the age range 25–37.

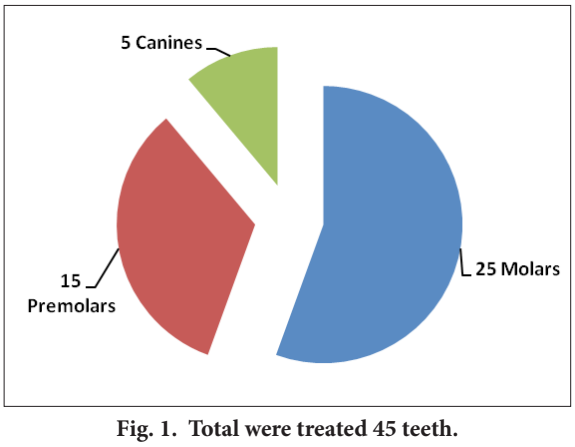

Fig. 1. Total were treated 45 teeth.

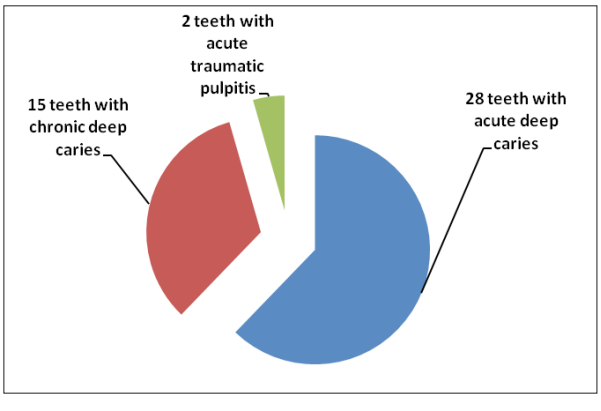

Fig. 2. Teeth distribution by disease.

The patients were divided into 2 groups. First group – with deep caries treated by capping material based on MTA "Trioxident", and second group – with deep caries treated using calcium hydroxide (fig. 1, 2).

Mineral Trioxide Aggregated material "Trioxident"

In 2002, Loma Linda University (USA) developed and currently successfully uses the new Mineral Trioxide Aggregated (MTA) material. This material is truly revolutionary and not replaceable in modern dentistry (fig. 3).

The chemical composition of MTA includes oxides SiO_2, K_2O, Al_2O_3, Na_2O, Fe_2O_3, SO_3, CaO_2, Bi_2O_3, MgO, as well as insoluble precipitate CaO, KSO_4, $NaSO_4$ and crystalline silica. MTA powder consists of small hydrophilic particles; when mixed with water, it first goes into a gel form and then hardens within 10-15 minutes. Final crystallization occurs in a day. Moreover, to complete the treatment procedure, it is not necessary to wait for the complete solidification of MTA [6].

Now MTA is used for retrograde filling, for filling upper apex part of canal with unfinished root formation, for sealing perforations of root canal, for treatment-isolating pulp covering.

Advantages of MTA

1. Water based chemistry, so requires moisture for setting,
2. Excellent biocompatibility,
3. Normal healing response without inflammation,
4. Least toxic of all the filling materials,
5. Reasonably radiopaque,
6. Bacteriostatic in nature,
7. Resistance to marginal leakage.

Disadvantages of MTA

1. Difficult to manipulate,
2. Long setting time (3-4 hours),
3. Costly.

The main indications for the use of MTA are:

- Direct pulp capping,
- Closure of perforations in the bifurcation area,
- Closure of lateral root perforation,
- Closure of root resorption,
- Pulpotomy,
- Apexification in the teeth with an unformed root apex,
- Retrograde filling after resection of the apex of the root.

A wide range of applications of the material makes it possible to save even "hopeless" teeth. The material is biologically fully compatible with natural tissues, hardens in a humid environment, providing reliable sealing.

The material has excellent sealing properties, has pronounced antibacterial properties, prevents the migration of microorganisms, stimulates the healing process and osteosynthesis. The material has excellent edge adaptation. Immediately after mixing, MTA has a pronounced alkaline reaction (pH = 12). In terms of X-ray contrast, MTA is comparable to gutta-percha – higher than that of dentin and bone tissue, which makes it possible to distinguish it well in X-rays. The original color of MTA is light gray-brown. Over time, it was proposed for aesthetic reasons to produce white powder for the frontal group of teeth.

Method of application

On a sterile glass for mixing, one measured spoon of powder or the contents of one sachet of MTA and one drop of distilled water are applied.

1. Using a spatula, the powder and distilled water are mixed for 30 seconds to achieve a homogeneous consistency similar to wet sand.

2. Using a suitable sterile instrument or gutta-percha pin, the paste with MTA is applied to the desired area and condenses it.

3. Excess water that appears on the surface is removed using a cotton ball or paper pin.

4. Ultrasound can be used to get the best result.

Based on MTA was created material "Trioxident". Main components of "Trioxident" material are calcium, silicon and aluminum oxides. Standard powder to distilled water ratio is 3:1. Obtained dough keeps its plasticity for 10-15 minutes at temperature 18-23°C and 50±10% humidity due to plasticizer introduced into powder.

The material begins to harden during 4 hours. Total hardening time in root canal is 24 hours.

The material comprises copper-calcium hydroxide, i.e. active bacteriostatic additive.

Material hardening process comprises 3 stages:

1. First, calcium oxide contacts with water. As a result, calcium hydroxide is obtained providing high pH level (12, 8).

2. Then calcium exudes from solution in amorphous state covering particles of radiopaque filler (bismuth oxide) and uniting all the components into bonded mass. Calcium hydroxide particles compress.

3. Then calcium silicate obtained increasing mechanical strength of the cement.

Calcium hydroxide prevents resorption of supra pulpar dentine bone tissue and stimulates dentinal bridge formation in case of pulp covering.

"Trioxident" material features good bactericidal effect, high biocompatibility, low solubility, high mechanical strength. The material possesses high biocompatability, low solubility and high mechanical durability, and also provides impermeability of bacteria.

By means of set of instruments with various form cannulas and plastic nozzles (applicators) it is possible to be dosed easily without special efforts [8, 9].

Fig. 3. Material "Trioxident" based on MTA.

Calcium-containing "Ultra Blend Plus" material

"Ultra-Blend Plus" is a unique photopolymer pad containing calcium hydroxide and calcium hydroxyapatite based on urethane dimethacrylate. Ultra-Blend plus has a high filler load to minimize shrinkage and a higher viscosity to facilitate ease of placement. It can be easily contoured with a high- or low-speed hand piece and is available in dentin and opaque white shades (fig. 4).

Compared to other liners, "Ultra-Blend plus" liner is highly filled for minimal shrinkage and superior calcium release. It has been proven the best light-cured material for pulp capping.

The material prevents pulp from toxic effect of permanent filling. The material features high stability and low solubility, thermoisolating effect and chemical affinity with polymeric materials providing high adhesion with composites, unlimited manipulation time and short hardening time. The controlled short time of the material hardening at non-limited working time creates additional conveniences in its usage.

Material advantages:

- Bioactive liner and pulp-capping material,
- Superior calcium release,
- Controlled, precise syringe delivery,
- No mixing necessary,
- Will not dissolve over time,
- Light cured when clinician is ready,
- Radiopaque,
- Highly filled.

Fig. 4. Calcium-containing material "Ultra Blend Plus".

Treatment methods in acute deep caries

Indirect pulp capping is a complex therapeutic method that provides disinfection of the wound surface, closure of the dentinal tubules, protection of pulp from physical and chemical agents and prevention of inflammation with the use of anti-inflammatory drugs and stimulation mechanisms of neo-dentinogenesis [10].

Indications for indirect capping method

1. Acute deep caries.
2. Absence of severe concomitant chronic or acute illness before or during the treatment.
3. No changes on X-rays in the apex of the root.
4. Lack of allergic reactions to drugs used.
5. The tooth is not subject to prosthetics.
6. Electro excitability of pulp should be 2-10 mkA.
7. Supra pulpal dentin in consistency and color should be similar to normal (unaffected), dentin.

Contraindications

1. Reduction of pulp electro excitability more than 25-35 mkA.
2. Radiographic changes in the periapical area of the tooth.
3. The tooth is subject to prosthetics.
4. Allergic reactions to drugs.
5. Acute diffuse pulpits.
6. Different forms of chronic pulpits.

Treatment is carried out in one or two visits

Indirect capping method in one visit

1. Antiseptic preparation of oral cavity and washing the carious cavity with a stream of warm water.
2. Anesthesia.
3. The tooth is isolated by cofferdam or by sterile cotton rolls.
4. Mechanical manipulations of the cavity with the principles and stages of preparation. Carious cavity is prepared with sterile sharp spherical burs.
5. Medicamental preparation of carious cavity. Cleaning of caries cavity must be done with not irritant antiseptic solutions, low concentration [11, 12]. We recommend the following drug:
   1. 0.1-10% solution of Dimexidum.
   2. 0.06-0.3% solution of Chlorhexidine.
   3. 1% solution of Iodinol.
   4. 4% solution of Betadine.
6. Degrease and drying of the cavity is carried out with sterile cotton rolls and a jet of warm air. Alcohol and ether are not applied because they are irritant.
7. Using of curative pads (layer): "Trioxident" or "Ultra Blend Plus".
8. Permanent filling of carious cavity with glass-ionomer cements or light cure materials.

Indirect capping method in two visits

The first visit

1. Antiseptic preparation of oral cavity and washing the carious cavity with a streem of warm water.
2. Anesthesia;
3. The tooth is isolated by cofferdam or by sterile cotton rolls.
4. The surface of the affected and the two adjacent teeth is treated with 2% iodine solution, 1% chlorhexidine or other antiseptics.
5. We must prepare thoroughly the caries cavity. This operation should be carried out in a professional manner, with a clear representation of topographic relation –"carious cavity – the cavity of a tooth" [13, 14].
6. Carious cavity must be disclosed maximally to remove all infected tissue. Special attention during the preparation should be paid to the state of supra-pulpal dentin at the bottom of the cavity, success of treatment often depends on this. Softened carious dentin is removed carefully with a sharp bur [15, 16].
7. Medicamentous preparation of dentinal wound of caries cavity. Cleaning of caries cavity must be done with not irritant antiseptic solutions of low concentration. We recommend the following drug:

- 0.1-10% solution of Dimexidum.
- 0.06-0,3% solution of Chlorhexidine.
- 1% solution of Iodinol.
- 4% solution of Betadine.

8. Degrease and drying of dentinal wound is carried out with sterile cotton rolls and a jet of warm air. Alcohol and ether are not applied because they are irritant;
9. Then apply curative base (layer): "Trioxident" or "Ultra Blend Plus". Curative base is applied with a thin layer (0.5 mm) at the bottom of dentinal wound [17].
10. Temporary filling for 1-2 weeks: Cavidur, Zinc-Eugenat, Dentin paste.

The second visit

1. In the absence of patient's complaints and if electro excitability of the pulp is 6-10 mkA, there is an indication for the second visit.
2. The tooth is isolated by cofferdam or by sterile cotton rolls.

3. Antiseptic treatment of the operating field by the 3% solutions hydrogen peroxide and 4% solution of Betadine.

4. Remove the temporal filling from the caries cavity.

5. Impose a paste based on calcium hydroxide or MTA. Its alkaline reaction stimulates the production of secondary dentin. Cover indirect – with "Trioxident" or "Ultra Blend Plus".

6. Place a permanent filling, using glass-ionomer cements or light cure materials.

Direct pulp capping. Removal of altered dentin from deeper cavities can lead to accidental opening of the pulp chamber and imposes direct pulp capping. We used this method in two cases on young teeth with accidental opening of the pulp chamber.

Indications

1. In accidental opening on healthy pulp teeth.
2. At young people with good capacity of pulp reaction.
3. At healthy patients with good immunological reaction.
4. On teeth with good hygiene.

Contraindications

1. The size of pulp chamber opening orifice bigger than 1 mm^2.
2. When the time of pulp tissue exposure is longer than 2-3 hours.
3. Teeth selected for prosthetic therapy.

Vital pulp therapy is indicated in some cases. By placing MTA over the exposed area often allows healing and preservation of vital pulp without further treatment. Rinse the cavity with sodium hypochlorite to disinfect the area. Mix the MTA with enough sterile water to give it a putty consistency. Apply it over the exposed pulp and remove the excess. Blot the area dry with a cotton pellet and restore the cavity with an amalgam or composite filling material.

Results and discussion

In our work for the treatment of deep caries, we used the preparations: "Trioxident" based on MTA and "Ultra Blend Plus" based on calcium hydroxide ($Ca(OH)_2$). The results of our studies allowed us to compile a table of comparative characteristics of both drugs (tab. 1).

Applications by material "Ultra Blend Plus" based on Ca (OH) 2 for 3-6 weeks on dentin surface show good results because of sterile environment, significant alkaline reaction and calcification of the dentinal tubules. The access of bacteria and products of their life activity along the dentinal tubules to the pulp is completely stopped, which prevents its subsequent infection. It should be noted that in the works of E. Joffe data appeared on the inferiority of the structure of the resulting "dentin bridge" when using drugs based on calcium hidroxide. This is due to the porosity of substitution dentin. Bacteria can enter the pulp through them and cause inflammation [18].

In this regard, it should be noted that the material "Trioxident" (based on MTA) does not have porosity in the formed "dentin bridge" and is free from this disadvantage.

Table 1

Comparative characteristics Ultra Blend Plus and Trioxident

Property	"Ultra Blend Plus" based on $Ca(OH)_2$	"Trioxident" based on MTA
Hard tissue formation	Not much	Root and induction
Calcific bridge	Not continuous slow	Continuous with dentin fast
Biocompatibility	Low	High
Degree of inflammation	High	Low
Sets	Not hard	Hard
pH	High	High
Solubility	Partially dissolve	Less soluble
Permeability	Permeable to fluids	Non permeable
Resorbtion	Rate varies with density	Non resorbable

The use of medical pads with MTA and calcium hydroxide with direct and indirect pulp capping methods did not reveal negative results (complicated caries).

We give one clinical case as an example.

Clinical case

Basic information. Patient X, age 35, female.

Subjective examination

➢ **Complaint.** Pain that was triggered by hot\cold stimuli that disappeared immediately after their removal.

➢ **History of the disease (Anamnesis Morbi).** The disease started about two years ago, but the patient didn't visit the clinic.

➢ **History of the patient's life (Anamnesis Vita).** Absence of hereditary, congenital and systemic diseases. The patient smokes up to 10 cigarettes per day. Alcohol and narcotics consumption was denied. No allergic history.

Objective examination of the patient

Extra oral:

• Inspection: The high part of the lower 1/3 of the face is stable, no asymmetry of the face. Normal level of mouth opening. No deviation during mandibular movements.

• Palpation: Trigger points are painless. Regional lymph nodes didn't reveal any pathology.

Intra oral:

Dental formula:

18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38
				R	C		AB	AB		T.P		A	A	A	A

• **Inspection:** Labial mucosa, gums, cheeks, hard and soft palate have pale pink color without pathological changes. Tongue has normal size without deposits. Pathological abrasion of teeth No 31-41. Tooth No 43 nas deep wide caries cavity with dark dentin.

• **Probing:** The bottom of the cavity is painful, without pulp communication.

• **Thermal test:** Positive, when water and air was used, the patient felt pain that disappeared after removal of the stimuli.

• **Percaution:** Horizontal and vertical are painless.

• **EOD:** 10 MkA.

Primary diagnosis: Deep dental caries in tooth No 43.

Radiographic examination

Intense dark line which indicates a caries lesion of hard tissue. Between caries tissue and pulp remains only a small, dense and healthy dentin that can indicate about chronic deep caries of tooth No 43. No pulpal communication. Periapical pathological changes are absent in the affected tooth (fig. 5).

Differential diagnosis

• Acute deep caries.
• Acute focal pulpitis.
• Medium caries.

Final Diagnosis

Chronic deep caries of tooth No 43

Treatment

- Rinsing the mouth with antiseptic "Mouth wash solution" (sodium benzonate, menthol, thymol, coloring and flavor).
- Infiltrative anesthesia Septanest sol. with adrenalin 4% – 1.7 ml.
- Isolation of the treated tooth from saliva by using "Rubberdam".
- Preparation of caries cavity tooth No 43.
- Antiseptic cleaning with a Chlorhexidine solution of 0.05%, and drying of the cavity with varm air jet.

Fig. 5. Deep dental caries in tooth No 43.

- Application of medical pads on the cavity floor based on MTA "Trioxident" and thin layer of SDR.
- Etching with 37% phosphoric acid for 20 sec, washing 20 sec; drying with air jet.
- Bonding application "All bond universal" Bisco.
- Application of protective base by using SDR.
- Restoration of the cavity with photopolymer material "G-aenial" tooth No 43.
- Finishing and polishing of the restoration by using burs, polishing discs and polishing paste.

A total of 45 teeth were cured

- 28 teeth with acute deep caries.
- 15 teeth with chronic deep caries.
- 2 teeth with acute traumatic pulpitis.

Out of 28 teeth with acute deep caries 18 teeth were

Fig. 6. Tooth No 43 during caries cavity opening.

Fig. 7. Tooth No 43 after cavity enlargement and necrotomy.

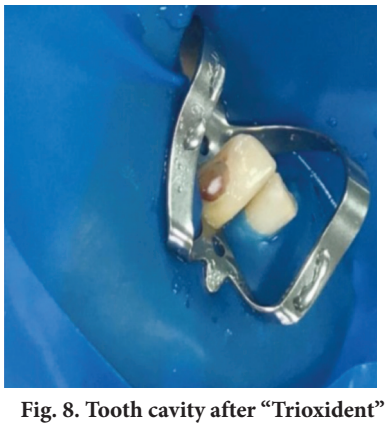

Fig. 8. Tooth cavity after "Trioxident" MTA application.

Fig. 9. Application of etching.

Fig. 10. Tooth No 43 during finishing.

Fig. 11. Tooth No 43 during polishing.

treated using capping material "Trioxident" and 10 teeth were treated using capping material "Ultra Blend Plus". Out of 15 teeth with chronic deep caries 8 teeth were treated using capping material "Trioxident" and 7 teeth – using capping material "Ultra Blend Plus". Two teeth with acute traumatic pulpitis were treated using "Trioxident".

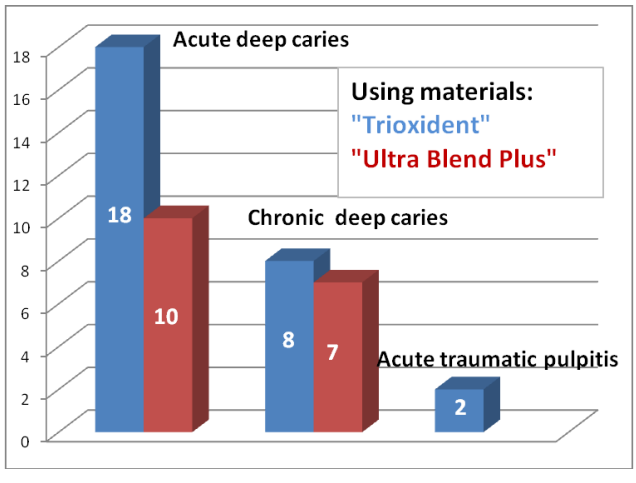

Fig. 12. Distribution of using capping materials.

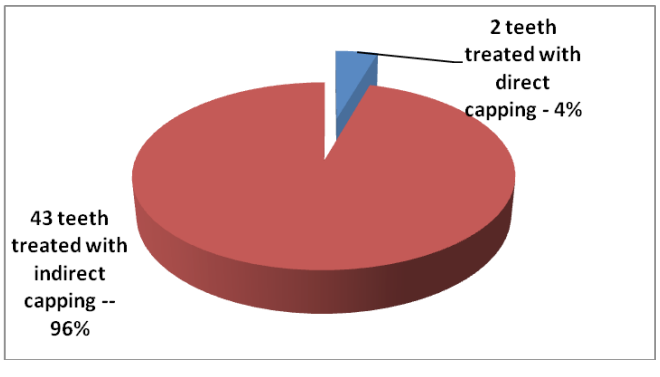

Fig. 13. Number of teeth treated with indirect and direct capping.

Teeth with chronic deep caries were treated with indirect capping in one visit, and with acute deep caries in two visits. Teeth with acute traumatic pulpitis were treated using method of direct capping in three visits.

Conclusions

1. Studying the theoretical data is important in order to give the correct diagnosis and to treat the disease with the most suitable protocol treatment.

2. Therapeutic filling materials containing calcium hydroxide and MTA provide anti-inflammatory. analgesic and plastic stimulating effect on the pulp of the tooth. Overlaying them on carious dentin causes sclerosis of the dentinal tubules and stimulates the formation of secondary dentin, which makes it possible to use them as therapeutic linings in the treatment of deep caries.

3. Testing of "Trioxident" (based on MTA) and "Ultra Blend Plus" (based on Calcium Hydroxide) demonstrated that the former has the following advantages:

- Higher success rate in direct pulp capping.
- Maintains long-term tooth vitality.
- Less toxic and has less pulpal inflammation.
- Has more predictable hard tissue barrier formation.

4. In the case of indirect capping both materials, "Trioxident" (MTA) and "Ultra Blend Plus" (Calcium Hydroxide) have positive effects.

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