The Republic of Iraq Ministry
of Higher Education
and Scientific Research
Al-Qadisiyah University
College of Dentistry

"Base and liner materials in restorative dentistry"

***A graduation project Submitted to
the college of Dentistry in partial fulfillment of
the requirement for the Degree of Bachelor in dental
and oral surgery (B.D.S)***

By the student:

Fatima Drgham Nasser
Fatima Saad Hakem
Kawthar Abbas Faleh
Karar Ali Abies

Supervisor by :

Lect . Luma Hafidh Abed

H.A. 1442/1443 D.A. 2021/2022

جمهورية العراق

وزارة التعليم العالي

والبحث العلمي

جامعة القادسية

كلية طب الاسنان

"المواد الأساسية والبطانة في طب الأسنان الترميمي"

مشروع تخرج مقدم ل

كلية طب الأسنان في الوفاء الجزئي

شرط الحصول على درجة البكالوريوس في جراحة الفم والأسنان (B.D.S)

تم الاعداد بواسطة :

فاطمة ضرغام ناصر

فاطمة سعد حاكم

كوثر عباس فالح

كرار علي عبيس

اشراف :

د.لمى حافظ عبد

وَقُل رَّبِّ زِدْنِي عِلْمًا

Dedication

We dedicate our humble work to the believers in this country and the martyrs of Iraq Those who sacrificed their lives in order to keep Iraq dear, and we pledge to them that we will be loyal to them by adopting sober academic research as a promising way to build the beloved Iraq.

And to all our brothers and families

Supervisor Certification

I certify that the preparation of this project entitled A graduation project Submitted to the college of Dentistry in partial fulfillment of the requirement for the Degree of Bachelor in dental and oral surgery (B.D.S) Prepared by (Fatima Drgham Nasser, Fatima Saad Hakem , Kawthar Abbas Faleh , Karar Ali Abies,) was made under my supervision nder my supervision at Al Qadisiyah University , College of dentistry in partial fulfillment of the requirements for the degree of Bachelor in dental and oral surgery (B.D.S)

Signature :

Name : Lect . Luma Hafidh Abed

Date :

(Supervisor)

Table of Contents

Abstract

One of the most controversial areas of restorative dentistry is the subject of liners and bases. Currently, there is no single protocol, with respect to the use of liners and bases, for clinicians to follow. This article is an in-depth literature review that discusses the use of liners and bases and the types of materials that are available to the restorative dentist. The new emerging concept of minimally invasive dentistry will require new restorative techniques. These changes will require the clinician to reevaluate their use of liners and bases. Other clinical considerations and findings from recent research are discussed.

الخلاصة

أحد أكثر مجالات طب الأسنان الترميمية إثارة للجدل هو موضوع البطانات والقواعد. حاليًا ، لا يوجد بروتوكول واحد ، فيما يتعلق باستخدام البطانات والقواعد ، ليتبعه الأطباء. هذه المقالة عبارة عن مراجعة أدبية متعمقة تناقش استخدام البطانات والقواعد وأنواع المواد المتاحة لطبيب الأسنان الترميمي. سيتطلب المفهوم الجديد لطب الأسنان طفيف التوغل تقنيات ترميمية جديدة. ستتطلب هذه التغييرات من الطبيب إعادة تقييم استخدامهم للبطانات والقواعد. تمت مناقشة الاعتبارات والنتائج السريرية الأخرى من الأبحاث الحديثة.

Chapter I : Introduction

1. Introduction

Restorative dentists have many decisions to make in their general practice, one of which is which material to use for any given procedure. To make matters more difficult for the clinician is the vast number of available choices. Published papers and lectures which conclude that different materials are ideal add to this confusion. Dental manufacturers do not make the decision making any easier, as they constantly introduce ‘new and improved’ versions of existing products.

The subject of liners and bases is not immune to this confusion. In 1991, Christensen wrote that the use of bases and liners is confusing: the state-of-the-art use varies enormously; many different procedures are successful; and unanimity of opinion is not likely to be achieved soon[1]. Surveys of North American dental schools both five and 15 years later came to the same conclusion[2,3] .In order to lessen this confusion, Cox and Suzuki suggested that clinicians re-evaluate the liners and bases they use[4]. Should clinicians decide to make a change, they should do as Asa recommends, and do so to obtain a better outcome, as opposed to making a change for its own sake[5]. He goes on to say that the selection process necessitates that dentists confer with colleagues and review current literature.

Another aspect of the confusion surrounding liners and bases involves the terminology used, and this can be seen in current dental materials textbooks. In the textbook, Restorative Dental

Materials, the authors define a ‘cavity liner’ as a suspension of calcium hydroxide in an organic liquid. Upon evaporation of the solvent, the remaining film on the tooth is the liner[6]. Contrast this to Ferracane, who defines a liner as a material that is applied as a thin layer to seal the dentine floor and walls of the cavity from the influx of bacteria and irritants from restorative procedures[7]. Additional confusion with nomenclature is seen in Phillip’s Science of Dental Materials which defines a liner as a thin layer of ‘cement’ used for the protection of the pulp[8].

This same perplexity is seen with bases. Anusavice defines a base as a layer of insulating, sometimes medicated, cement placed in the deep portion of the cavity preparation to protect the pulp from thermal and chemical injury. This is similar to Ferracane but he adds that bases are placed in thick layers and must be strong enough to support a restorative material during its placement and function. Additionally, it should provide thermal and electrical protection (from galvanic activity). Craig and Powers separate bases into two categories. The first is for low-strength bases of calcium hydroxide (CaOH) and zinc oxide eugenol (ZOE) cements which are referred to as liners. The second category covers high strength bases, which has the same description as Ferracane.

It has been generally accepted that the materials that were used to restore teeth posed a danger to the tooth and allowed for the occurrence of postoperative sensitivity. If this were true, then a barrier or protective layer needed to be placed on the tooth before the final restoration. This buffer would, in part, act to reduce or even eliminate postoperative sensitivity.

Over time we have come to learn that it is not the restorative material that causes problems, but bacteria and the by-products of bacteria. These bacteria, present in the oral cavity, enter the tooth at the margin of the restoration through capillary action of oral fluids. This is referred to as microleakage.Others have defined microleakage as ‘the marginal permeability of bacterial, chemical, and molecular invasion at the interface between the teeth and restorative material[9].

Chapter II : Review

2. Review

2.1 A liner defined

a material that is applied in a thin layer, usually 0.5 mm thick, to seal the dentin on the floor and walls of a cavity from the influx of bacteria or irritants from restorative materials and procedures[10]. Additionally, a liner (other than a varnish) may provide some therapeutic benefits[11]. Varnish, calcium hydroxide, zinc phosphate, glass ionomer, and resin can be used as a liner.

2.2 A bases defined

Bases are applied in thick layers to provide the pulp with thermal protection. These materials must be strong enough to support a restorative material during placement and function[13]. They encourage the recovery of the injured pulp. Essentially, bases serve as a replacement or substitute for dentin that has been destroyed by caries or removed during cavity preparation[14]. Bases can be shaped and contoured to specific forms.Craig and Powers subdivided bases into low strength and high strength categories, with the low-strength bases referred to as liners. Varnishes and calcium hydroxide materials are not suitable for use as a base.

2.3 Use of liners and bases

The rationale for the use of liners and bases has changed over the years. Initially it was believed that prior to placement of a final restoration, a medicament was needed on the dentin surface to protect the tooth and pulp. Dental schools taught that this medicament was intended to protect the tooth from what was thought to be the toxic effects of the restoration, even though irritation from the restoration is mild and temporary. When postoperative pulpal inflammation did occur, the cause of this inflammation was bacteria and their byproducts within the dentin[15]. Bacteria in the dentin can lead to severe inflammation and even necrosis of the pulpal tissues[16].

A new model for the cause of postoperative sensitivity has emerged. According to Brannstro[17],postoperative sensitivity is not caused by bacteria or their byproducts but is due to fluid that is found in the gaps at the tooth-restoration interface. It is the movement of this fluid that causes changes in osmotic pressures under the restoration, leading to postoperative sensitivity. More dentinal fluid is found in the tubules in deeper cavity preparations compared to that found in shallow ones, so there would be a greater osmotic effect with deeper restorations. Therefore, conservation of dentin would help combat postoperative sensitivity. In addition, an increase in the remaining dentin thickness will reduce the number of bacteria that reach the pulp. This was shown by Meryon, who demonstrated that increasing the remaining dentin thickness (RDT) by 0.5 mm would reduce the amount of bacteria reaching the pulp by 75%, and an increase in the RDT by 1.0 mm would decrease the bacteria by as much as 90%[18].

2.4 Requirements for Liners and Bases

1. They should be non-harmful, and it does not irritate to the pulp and other tissues.

2. It is not soluble in saliva and fluids taken into the mouth.

3. It provides good mechanical properties which fulfil the requirements filling material to be packed on liner.

4. Protect the pulp from pulpal reactions caused by different restorative material.

5. Under a large metallic restoration cement is used to provide thermal insulation to the pulp e.g. amalgam

6. Liners and bases also provides chemical protection to prevent infiltration of hazardous chemicals from the dental material to the pulp.

7. It provides electrical insulation under the metallic restoration to reduce the galvanism.

8. Optical properties for cementation of a translucent restoration (for example, a porcelain crown) the optical properties of the cement should be parallel to those of tooth substance.

9. A cement should ideally be adhesive to enamel and dentin, and to gold alloys, porcelain and acrylics, but not to dental instruments.

10. It should be bacteriostatic while inserted in a cavity with residual caries.

11. Cements should have a minimum adverse effect on the pulp.

12. For luting purposes, cements should have a low film thickness.

2.5 TYPES OF LINERS AND BASES

Desirable properties for liners and bases include the absence of adverse effects on the pulp, high compressive and tensile strengths, and radiopacity[19]. Certain ideal properties of temporary cements would also be desirable in liners and bases. Ideal features of temporary cements include controlled dispensing, compact kit (resulting in minimal waste), easy mixing and easy cleanup, and rapid setting[20]. The ideal liner or base would have properties from both lists. When using any such material, proper isolation is essential to reduce bacterial contamination of the cavity preparation. Use of the rubber dam is the ideal method for achieving isolation.

Numerous products can function as a liner, base, or cement. These can include varnish and calcium hydroxide-based, zinc oxide eugenol/noneugenol-based, zinc phosphate-based (zinc oxyphosphate), zinc polycarboxylate-based, glass iono-mer-based, or resin-based products .

2.5.1 Calcium hydroxide

2.5.1.1 Definition

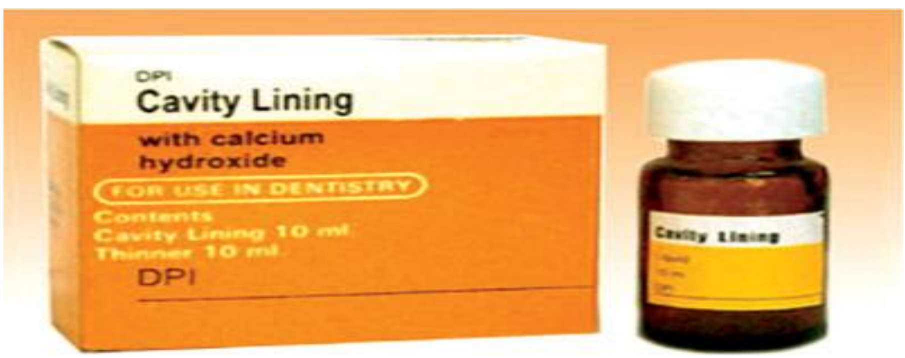
for the purpose of pulp protection is avail- able in various forms, such as in aqueous suspensions or as cements, liners, or filled risens. Calcium hydroxide aqueous suspensions are suspensions of calcium hydroxide in water. After application, the solvent evaporates, leaving behind (as a liner) a layer of calcium hydroxide, for example, Pulpdent (Pulpdent, Brookline, MA, USA). Calcium hydroxide liners, however, are a combination of calcium hydroxide with a var- nish to modify the viscosity and to improve handling,[21]for example, Hydroxline (George Taub, Jersey City, NJ, USA).

2.5.1.2 History of CaOH2 liner

Between 1928 and 1930 he studied the reaction of vital pulp tissue to calcium hydroxide to prove that it was a biocompatible material. Since then, calcium hydroxide has been recommended by several authors for direct pulp capping, but it took until the middle of 20th century until it was regarded as the standard of care[22].

2.5.1.3 Composition of Conventional calcium hydroxide liners

Powder contains zinc oxide approximately 90.2% and magnesium oxide 8.2% which reduce the temperature of calcination process during manufacture, other oxides 1.6% which alters the working characteristic and final properties of the cement. Bismuth trioxide imparts smoothness to the freshly mixed cement. Magnesium oxide also imparts white colour to the cement besides improving the strength. The liquid is composed aqueous solution of phosphoric acid (50 to 60%), which is combined with aluminium and zinc 16.2 % and acts buffers and partially neutralize the phosphoric acid, thus tempering the reactivity of liquid and water 33%. The rate of acid base reaction is influenced by water. Large amount of water results in reduction of both compressive strength and tensile strength. The setting time for zinc phosphate cement is 2.5 and 8 minutes.



2.5.1.4 properties of Conventional calcium hydroxide liners

Ideally, liners should possess antibacterial properties. The ability of these liners to prevent bacterial growth under restorations is of great importance as the numbers of bac- teria in a cavity decrease the extent of pulpal inflammation is reduced. Calcium hydroxide liners are reported to display antibacterial properties[23]. The antimicrobial properties of calcium hydroxide come from its dissociation into calcium and hydroxyl ions. The hydroxyl ions create an alkaline pH that is unfavorable for remaining bacteria in the cavity. Hydroxyl ions are highly oxidant free radicals that show high reactivity[24].

The antimicrobial action of hydroxyl ions on micro- organisms can be explained by their influence on growth, structure, metabolism, and bacterial cell division. The antibacterial properties of calcium hydroxide were reported inferior to RMGI liners[25]and stronger than other materials commonly used for lining (especially the conventional glass ionomer cement).

Calcium hydroxide liners were also reported to reduce bacterial numbers much more effectively than only sealing the cavity.However, calcium hydroxide liners show reduced antibacterial activity overtime.

The antibacterial properties of calcium hydroxide were reported inferior to RMGI liners and stronger than other materials commonly used for lining (especially the conventional glass ionomer cement). Calcium hydroxide liners were also reported to reduce bacterial numbers much more effectively than only sealing the cavity. However, calcium hydroxide liners show reduced antibacterial activity overtime[26].

Another properties is

Properties:

1- The set material has an alkaline PH (9.2-11.7), which reduces the acidity of zinc phosphate when used as a sub base material in deep cavities.

2- The antimicrobial action of calcium hydroxide makes this material useful in indirect pulp capping procedures.

3- Calcium hydroxide stimulate the odontoblast cells for the formation of secondary dentin (stimulate the formation of dentinal bridge) when it is put directly over exposed pulp tissue, so calcium hydroxide is used for direct pulp capping.

4- Water is important component for the setting reaction of calcium hydroxide based liner.

2.5.1.5 Advantage of Calcium hydroxide

Has the ability to slightly demineralize dentine, and in turn release transforming growth factor-β1 from the matrix that signals tertiary dentinogenesis that is responsible for repair in dentine pulp complex and, in turn, supports the success of much of restorative dentistry[27]. About et al[28]reported that calcium hydroxide maintained the highest number of odontoblasts (compared to zinc polycarboxylate, ZOE, and RMGI) beneath restored cavities when the RDT is <0.5 mm. Murray et al[29]reported that in cases with a cavity RDT is <0.5 mm and no pulp exposure is present; calcium hydroxide liners displayed the greatest area of reactionary dentine deposition when compared with other pulp-protecting materials, such as RMGI, ZOE, and zinc polycarboxylate.

2.5.1.6 Disadvantage

Calcium hydroxide has significant drawbacks; the low elastic modulus and low compressive strength of calcium hydroxide cavity liners restricts their usage to thin layers in specific areas, which is not critical to the support of restorations[27]. Calcium hydroxide liners have low thermal conductivity, but they are usually not used in thick enough layers (≤0.5 mm) to provide thermal protection;therefore, thermal protection should be provided with a separate base.

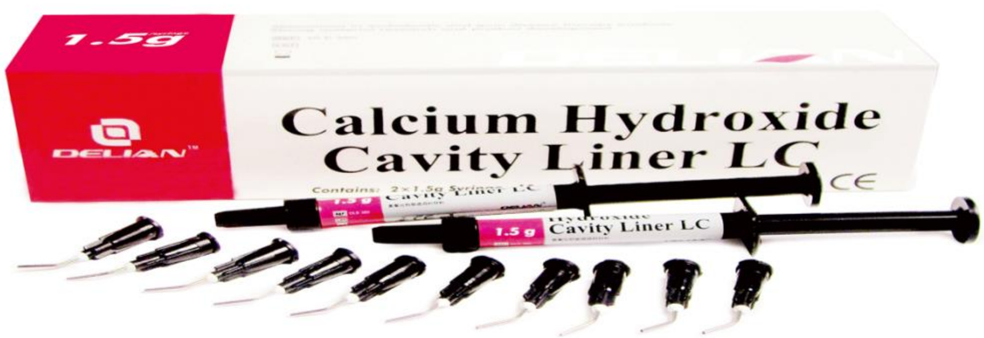
2.5.2 Light-cured calcium hydroxide liners

2.5.2.1 Definition

A single component liner that contains calcium hydroxide and is polymerized by visible light was introduced in 1988 to help address the limitations of the chemical cure calcium hydroxide; that is, they set on command, improved strength, essentially no solubility in acid, and minimal solubility in water[30].

2.5.2.2 Composition of light cured calcium hydroxide liner

A visible light-cured (VLC) calcium hydroxide liner consists of calcium hydroxide and barium sulfate dispersed in a urethane dimethacrylate resin containing initiators and accelerators activated by visible light[31].



2.5.2.3 Advantage

Ca ions help in the differentiation and mineralization of pulp cells.[32] The released Ca ions increase the proliferation of human dental pulp cells which is dependent on the dose.[33].In addition, Ca ions modulate osteopontin and BMP-2 levels during the pulp calcification,[34] and the release of Ca also enhances the activity of pyrophosphatase which maintains dentin mineralization and forms a dentin bridge.[35] Thus, continuous release of Ca ions from a pulp capping material is the main reason for the proliferation and differentiation of human dental pulp cells.

Ca neutralizes lactic acid released from osteoclasts which prevents dissolution of mineral components from dentin. It also inactivates the lipopolysaccharide endotoxin which causes inflammation by acting on macrophages and induces the periapical pathosis [36] and osteoclastogenesis. Superficial coagulation of dental pulp is caused by damage to blood vessels. This coagulation necrosis helps in the differentiation of odontoblasts and elaborates the matrix. Ca ions also reduce the permeability of new capillaries to Ca. Thus, more Ca ions are retained in healing because source of Ca for reparative dentin formation is blood and the Ca from Ca(OH)2 cement is only the stimulating agent.

2.5.2.4 Disadvantage

Unfortunately, self-curing Ca(OH)2 cement (Dycal) is soluble, raises alkalinity, and forms a necrotic layer at the material–pulp interface and also it has greater chances of microleakage. Pulp capped with lack of tight restoration showed inflammatory response in pulp tissues and became necrotic.[37] The success of pulp capping agents relies on the ability of Ca(OH)2 to disinfect the superficial pulp and dentin. The qualified bacteria-free or bacteria tight seal provided by the restoration is a very important factor in successful pulp capping. Recontamination through microleakage of restoration increases the failure of the procedure.[38]

2.5.3 Zinc oxide eugenol

2.5.3.1 Definition

combination of zinc oxide and eugenol finds its principal applications as a cavity liner in deep cavity preparations, root canal sealing but has certain additives, in the cementation of temporary crowns and temporary filling.

In dentistry the indications for use of zinc oxide-eugenol(ZOE) materials include pulp protection and temporaryrestoration. The major goal of eugenol-based temporarymaterials for filling is to protect the pulp from physical andchemical injuries from the oral cavity [39] and to sterilizethe remaining affected dentine in acute caries lesions.

2.5.3.2 Properties

1.Film thickness about 40 μm.

2.The solubility is high, about 1.5% by weight in distilled water after 24 hours.

3.Presence of eugenol in the set cement gives a sedative effect on the pulp in deep cavities. Also antibacterial action appears to facilitate pulpal healing. But in direct contact with connective tissue, the material is an irritant.

4.Eugenol interferes with polymerization of resin based filling material cause discoloration so not used as alining with these filling.

5.High solubility so not used as a luting agent. Effective thermal barrier.

2.5.3.3 Composition

Powder is zinc oxide, silica, zinc acetate or sulfate may be present to accelerate the setting.

Liquid is eugenol, olive oil (control viscosity) with small amounts of water, which is essential to the setting reaction.

A chemical reaction occurs between zinc oxide and eugenol, with the formation of zinc eugenolate.

The reaction is reversible because the zinc eugenolate is easily hydrolyzed by moisture to eugenol and zinc hydroxide. Thus, the cement disintegrates rapidly when exposed to oral conditions[40].

2.5.3.4 Advantages

The main advantage of these materials is their effect on the pulpal tissues, together with their good sealing ability and resistance to marginal penetration.

2.5.3.5 Disadvantages

Disadvantages include low strength and abrasion resistance, solubility and disintegration in oral fluids, and little anticariogenic action.

2.5.4 Zinc Polycarboxylate

2.5.4.1 Definition

Zinc Polycarboxylate cement was the First cement that was developed with the property of an adhesive bond to tooth structure along with some metallic cast restorations. is one of the few dental materials that demonstrate true adhesion to tooth structure. The powder is primarily zinc oxide, and the liquid is polyacrylic acid or a copolymer of that acid. Although the final pH of the set cement is comparable to that of zinc phosphate cement, its biologic properties are excellent. For this reason, polycarboxylate cement is useful as a base or as a luting agent, particularly when the cavity preparation is close to the pulp[41].

2.5.4.2 COMPOSITION:

Zinc Polycarbolylate cement is available as powder and liquid Also as a Water settable cement in which the polyacrylic acid is a freeze-dried powder that is mixed with the cement powder. The liquid is water or a weak solution of NaH2PO4

POWDER:

◦ Zinc oxide

◦ Magnesium oxide

◦ Bismuth oxide

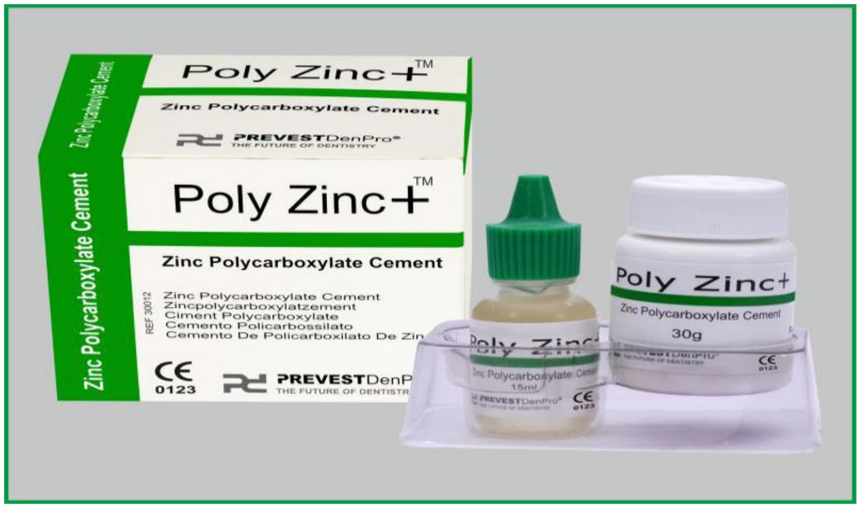
◦ Aluminum oxide

◦ Stannous oxide – Modifies the setting time, increases the **STRENGTH** and acts as Anticariogenic agent.

LIQUID:

◦ 30 to 40% aqueous solution of Polyacrylic acid and its Copolymers of molecular weight between 30,00 to 50,000

◦ Unsaturated Carboxylic Acid Ex: Itaconic acid, Maleic Acid, Tricarboxylic acid.



2.5.4.3 Properties of Zinc Polycarboxylate Cement:

1 The pH of Liquid in Zinc Polycarboxylate: 1.7 which is readily neutralized by the addition of powder which makes the pH higher than Zinc Phosphate cement.

2 In spite of the initial low pH of Zinc Polycarboxylate cement it is not an irritant to the Pulp. This can be attributed to the large size of the Polyacrylic acid molecules which limit the diffusion through dentinal tubules.

3 It is highly biocompatible to the Pulp which is similar to ZOE cement.

4 It is Anticariogenic, Fluoride release from this cement is only 15 – 20% of the amount released from glass ionomer cement.

5 Working time: 2.5 minutes

6 Setting time is 6 to 9 minutes

7 Compressive Strength: 55Mpa (inferior to Zinc phosphate cement)

8 Tensile Strength: 6.2 Mpa (Slightly higher than Zinc phosphate cement)

9 Film Thickness: 21 micrometers. It is pseudoplastic and more viscous than Zinc phosphate cement.

10 Solubility: 0.6% solubility of the cement in water is low ut more in acids. It is comparable to that of zinc phosphate cement.

11 Viscosity is slightly higher than Zinc Phosphate cement. The mixed cement appears thick but flows readily when applied to the tooth surface.

12 Thermal insulation: Good. In the thickness of 1.5mm. At less than 1.5 mm thickness it is not an effective thermal insulator when compared to the other cement+.

13 Opaque nature: It is Opaque because of the large quantity of unreacted zinc oxide.

2.5.4.4 Advantages of using Zinc Polycarboxylate Cement:

1 Low irritancy

2 Adhesion to tooth

3 Easy manipulation

4 Strength tensile (similar to Zinc Phosphate)

5 Solubility (similar to Zinc Phosphate)

6 Film thickness (similar to Zinc Phosphate)

2.5.4.5Disadvantages of using Zinc Polycarboxylate Cement:

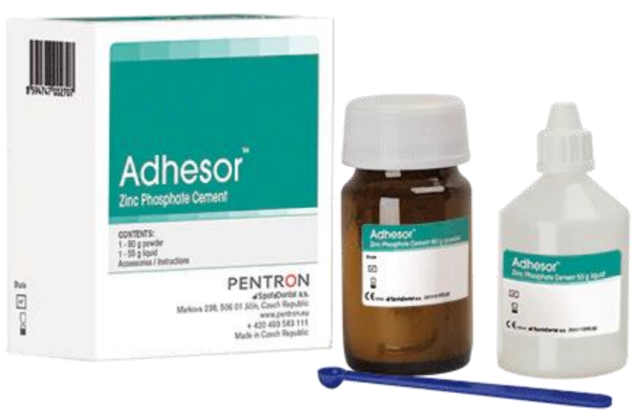
Needs accurate proportioning of the powder and salt Lower compressive strength (similar to Zinc Phosphate cement) Shows greater visco elasticity (similar to Zinc Phosphate cement)[42].

2.5.5 Zinc Phosphate cement

2.5.5.1Definition

is composed of a powder and other liquid can each with its own characteristics.The working time is measured from the beginning until the viscosity of the mixture is low enough to flow when compacted and form a thin layer.

It does not cause any reaction with the hard tissues and other surrounding restorative materials, since the adhesion is done by mechanical gear and not by chemical interactions[43].



2.5.5.2 Properties

• Mechanics

• Solubility

• The prosthesis can be disinfected if the underlying cement is subjected to stresses above its strength.

• The high solubility can cause the loss of cement necessary for retention and can form plaque accumulation zones.

• The presence of phosphoric acid causes the acidity to be very high at the moment in which the prosthesis is placed.

• 2 min. After the start of the mixture, the pH of the cement is approx. 2, which increases rapidly but will be 5.5 hours after 24 hours.

Zinc Phosphate Cement Components	
Powder	**Liquid**
• Zinc Oxide 90% • Magnesium Oxide 10% • Fluorides and bismuth oxide, silica They melt at a temperature of 1000-1400 ° C, where it becomes a block that is crushed into a fine powder. The size of the particles influences the speed of hardening of the cement mixture. The smaller the size of the particle, the faster the cement hardens	• Ortho-phosphoric acid 64% • Water 30-35% The ortho phosphoric acid has a PH between 2 and 4, which acts as a pulpal irritant, therefore the use of an insulator such as cavitary varnish on the restorations is recommended. The salts of aluminum oxide and zinc oxide, behave like buffers, minimizing the effect of Ortho-phosphoric acid and delaying the reaction of cement

2.5.6 Glass-ionomer cement

2.5.6.1 Definition

Glass-ionomer cements belong to the class of materials known as acid-base cements. They are based on the product of reaction of weak polymeric acids with powdered glasses of basic character [44]. Setting occurs in concentrated solutions in water and the final structure contains a substantial amount of unreacted glass which acts as filler to reinforce the set cement.

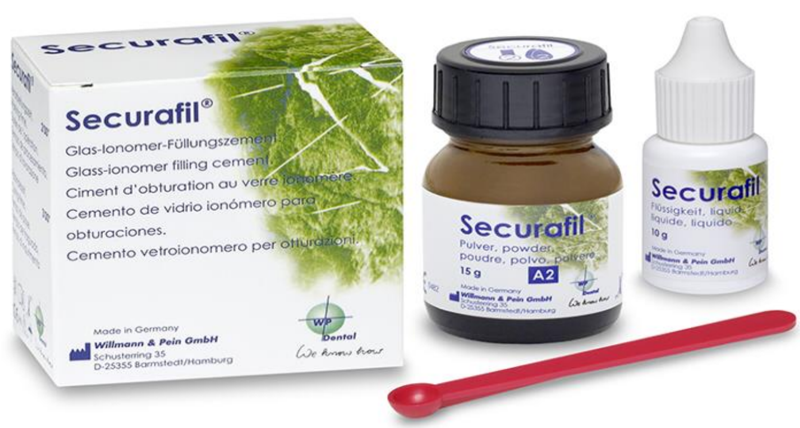
2.5.6.2 Indications

Modern glass-ionomer cement is a versatile, “smart” dental material, with the following applications:

- definitive restorative material in low load-bearing areas in adults
- definitive restorative material for deciduous teeth
- provisional restorative material in adults
- core build-up material prior to crown placement
- liners and base
- luting cement for crowns, posts and bridges
- fissure sealant
- bonding agent for composite resins and dental amalgam.

2.5.6.3 Composition

There are three essential ingredients to a glass-ionomer cement, namely polymeric water-soluble acid, basic (ion-leachable) glass, and water [45]. These are commonly presented as an aqueous solution of polymeric acid and a finely divided glass powder, which are mixed by an appropriate method to form a viscous paste that sets rapidly. However, alternative formulations exist which range from both the acid and the glass being present in the powder, and pure water being added to cause setting, to formulations in which some of the acid is blended with the glass powder and the rest is present in a dilute solution in water. This solution is used as the liquid component in forming the paste for setting. The effect of these differences is not clear, because these formulations are proprietary, so that the exact amount of each component is not widely known. However, there appears to be no obvious effect on the final properties of presenting these materials with the components distributed differently between the powder and aqueous phases.



2.5.6.4 Properties of Glass-Ionomers

The physical properties of glass-ionomer cements are influenced by how the cement is prepared, including its powder:liquid ratio, the concentration of the polyacid, the particle size of the glass powder and the age of the specimens. Care is needed therefore in making generalisations about the properties of these materials. There is also the possibility that part of the success of glass-ionomers may arise because their performance is satisfactory even if they have not been properly mixed, or allowed to mature under ideal conditions.

The current ISO standard for glass-ionomers [46] gives minimum values for certain physical properties. are the least acceptable for a material to be allowed onto the market, rather than typical for materials known to perform well clinically.

The only type of strength that the ISO standard deals with is compressive strength, but glass-ionomers also have reasonable flexural strength . Their biaxial flexure [26] and their shear punch strengths have also been determined. As expected for a composite material, they show the same trends as compressive strength, typically improving at higher powder:liquid ratios and high concentration of polyacid.

2.5.6.5 Advantages

Glass-ionomer cements are popular materials as they display the following clinical advantages:

• they are tooth-coloured

• they bond chemically to tooth substance and non-precious metals without the need for additional adhesives

• they release fluoride

• their coefficient of thermal expansion is equivalent to that of tooth structure

• they have good biocompatibility.

2.5.6.6 Disadvantages

The advantages of glass-ionomer cements are offset by the following disadvantages:

• low fracture toughness, limiting applications in high load-bearing areas

• some types cannot be finished and polished at the same visit they are placed

• some types are vulnerable to acid erosion

• some types exhibit low flexural strength and wear resistance.

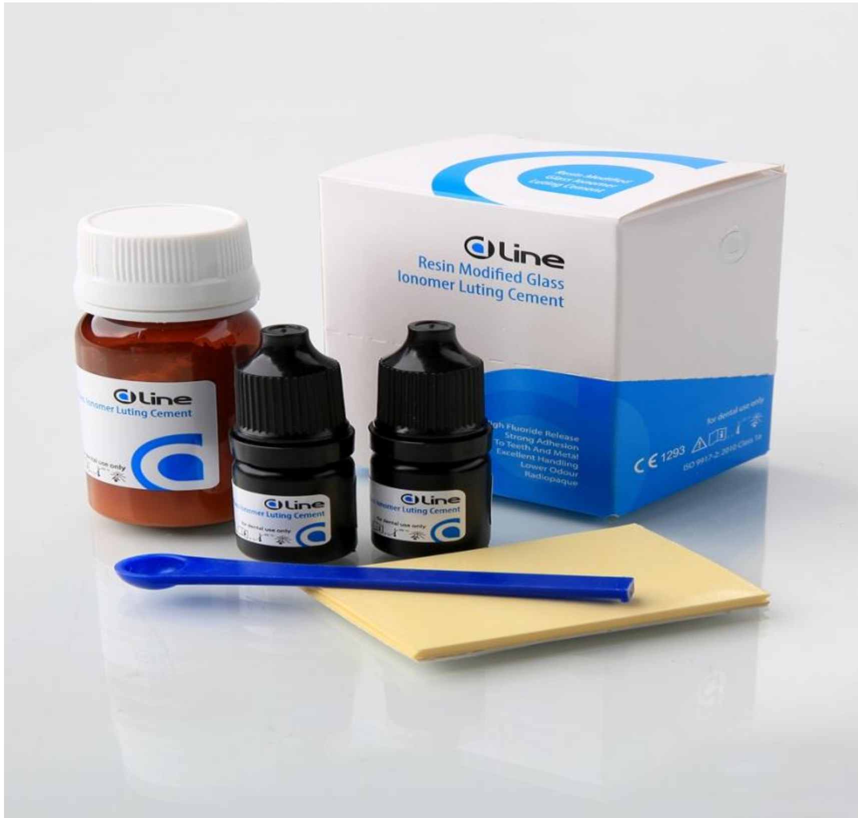
2.5.7 Resin-Modified Glass-Ionomers

2.5.7.1 Definition

Small quantities of light-polymerizable resin groups (usually 2-hydroxyethyl methacrylate or HEMA) into the acidic liquid component was added to modify conventional GIC's physical properties and translucency[45].

2.5.7.2 Composition

These materials were introduced to the dental profession in 1991 [46]. They contain the same essential components as conventional glass-ionomers (basic glass powder, water, polyacid), but also include a monomer component and associated initiator system. The monomer is typically 2-hydroxyethyl methacrylate, HEMA, and the initiator is camphorquinone [47]. Resin-modified glass-ionomers set by the twin processes of neutralization (acid-base reaction) and addition polymerization, and the resulting material has a complicated structure based on the combined products of these two reactions . Moreover, competition between these two network-forming reactions means that there is a sensitive balance between them . This mixture of setting reactions may jeopardize the reliability of the set material, and as a consequence, close adherence to the manufacturer's recommendations on the duration of the irradiation step is essential in order to produce material optimal properties .



2.5.7.3 Advantage

Resin-modified glass-ionomer cements have the advantage of a long working time combined with a rapid set and higher early strength. They are also easily bonded to resins. They have the strength properties comparable to conventional glass-ionomer cements rather than composite resins

2.5.7.4 Disadvantage

they share with composite resins the disadvantage of containing free monomers and therefore may not be as biocompatible as conventional glass-ionomer cements.

2.5.8 Biodentin

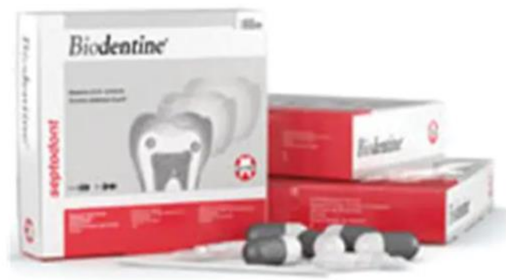
2.5.8.1 Definition

Biodentine material has been recently introduced in dentistry in order to provide dentin substitute for coronal and radicular pulp. Although number of materials like Amalgam, GIC, Composite and MTA are available in market for repair of dentin loss in tooth structure, none of these possesses ideal properties. Despite of number of advantages of MTA, its limitations cannot be overlooked.

2.5.8.2 Composition

Powder component of biodentine consists of Tri-calcium silicate, Di-calcium silicate, Calcium carbonate & oxide, Iron oxide and Zirconium oxide. Liquid consists of Calcium chloride and Hydrosoluble polymer.[48]

Tricalcium silicate and dicalcium silicate are indicated as main and second core materials, respectively, whereas zirconium oxide serves as a radiopacifier. The liquid, on the other hand, contains calcium chloride as an accelerator and a hydrosoluble polymer that serves as a water reducing agent. It has also been stated that fast setting time, one unique characteristics of the product, is achieved by increasing particle size, adding calcium chloride to the liquid component, and decreasing the liquid content [49].



2.5.8.3 Properties of Biodentine

The electrochemical properties of this cement are due to the solid phase and ion mobility of free ions inside the pores filled with the electrolyte [50]. Impedance spectroscopy is a technique that allows studying the process of hardening of cement. This is a non-destructive method that may monitor the hardening process. The electrical resistance increases when the porosity of the system is reduced. The setting reaction of Biodentine leads to the formation of initial porosities that are gradually filled after several days by new crystal compounds. During this final step, the solid phase increases and finally reaches a maximum.

2.5.8.4 Advantages of Biodentine

Amongst the wide range of advantages of this dentin substitute, the ones with clinical significance are:

• Reduced setting time

• Better handling & manipulation

• Improved mechanical properties

• Bioactivity of material

2.5.9 Cavity varnish

2.5.9.1 Definition

provides a barrier against fluid penetration into the underlying dentin. When applied to dentin, a varnish may reduce postoperative sensitivity and limit migration of corrosion products into dentin, thereby reducing tooth discoloration.

2.5.9.2 Indications for use

1.Sealing dentinal tubules

2.Reducing leakage around a restoration

3.Acting as a barrier to protect the tooth from highly acidic cements such as zinc phosphate

This material is contraindicated in its use under composite resins and glass ionomer restorations.

2.5.9.3 Advantages:

• Easy to apply
• Have different flavours
• It has a sticky consistency which helps to stay in contact with tooth for several hours
• Dry rapidly
• Reduce the number of cariogenic bacteria s. mutans by over ten-fold
• It has a higher concentration than the foam and gel

2.5.9.4 Disadvantage

1.They may cause a temporary change in the surface of teeth due to the color and adherence
2.Varnish may damage by eating and brushing so the yellowish color fades
3.Cost is more than gel
4.Some patients can cause nausea due to the taste of varnish especially when consuming food within 24 hours post-treatment

2.5.10 The mineral trioxide aggregate (MTA)

2.5.10.1 Definition

The mineral trioxide aggregate (MTA) is a hydrophilic and biocompatible endodontic cement, capable of stimulating healing and osteogenesis.
In the past 10 years, the MTA found its application in the field of dentistry with specific fit within the conservative and endodontic treatments. A dental trauma is an event that cannot

be predicted and usually it is not easy for the clinicians to manage it. The dentist should therefore be prepared to intervene in patient who has suffered a dental trauma.

2.5.10.2 Composition of MTA

It consists of a powder of fine trioxides (tricalcium oxide, silicon oxide, bismuth oxide) and other hydrophilic particles (tricalcium silicate, tricalcium aluminate, responsible for the chemical and physical properties of this aggregate), which hardens in the presence of humidity[52]. The hydration of the powder results in the formation of a colloidal gel with pH 12.5, which solidifies in a structure in about 3 to 4 hours[53].

2.5.10.3 Indication of MTA

For restorative endodontic, and regenerative dental procedures.

1. Vital pulp therapy (pulp capping and pulpotomy)[54]
2. Apexification
3. Perforation repair(lateral and furcation)
4. Root-end filling
5. Internal bleaching
6. Resorption repair
7. As sealer and as obturating material (partial or complete).

2.5.10.4 Contraindications of MTA

1. MTA is an hydrophilicmaterial, so it requires moisture to set, making absolute dryness [55]
2. Potential for discoloration, especially when used in the anterior esthetic zone
3. MTA not used for post retention.

2.5.10.5 Properties

1. Compressive strength-within 24 hours of mixing - 40.0MPa-greater in gray MTA than WMTA
2. Setting Expansion- Set MTA exhibit<0.1%.
3. Radiopacity- 7.17 mm[56].
4. Solubility-set cement has no signs of solubility,but increase whenexcess H_2O is added while mixing.The event of cementogenesisis due to calcium hydroxideby reaction of Set MTA with water.
5. Marginal adaptation and sealingability -excellent[57].
6. Antibacterial and antifungal property-Torabinejad et al reported that MTA has no antimicrobial effect against any anaerobes but has some effect on S.mitis,S.mutans,S.salivarius, Lactobacillus andS.epidermidis .
7. Reaction with other dental material-MTAdoes not react or interfere with any other restorative Cements[58]. While remaining calcium hydroxide reacts with the MTA to dentin thereby reducing its sealing.Cements like GIC, composite resins, doesn't affect the setting of MTA. Several intracanal irrigantor oxidizing agents have been found to affect the push-out strength of GMTA as it is susceptible to sodium hypochlorite, sodium perborate mixed with saline, so 30% hydrogen peroxide,sodium perbonate mixed with 30%hydrogen peroxide and saline fora era of 7 days.GMTA is susceptible to oxidizingagents. H_2O_2-based canal preparatory agent showed reduced push-out strength of GMTA to dentin whereas 2% and 5.25%of chlorhexidine and NaOCl respectively did not affect

8. Biocompatibility- MTA is not mutagenic[59], less cytotoxic compared to IRM. Superior to formocresol as pulpotomy medi cament.
9. Tissue regeneration- MTA capable of activation of cementoblasts and production of cementoblast[60].

2.5.10.6 Clinical application of MTA:

In primary teeth:
1. Pulp capping
2. Pulpotomy
3. Root canal filling
4. Furcation perforation repair
5. Resorption .

In permanent teeth:
1. Pulp capping
2. Partial pulpotomy
3. Perforation repair-Apical,lateral,furcation
4. Resorption repair-External and internal
5. Repair of fracture-Horizontal and vertical
6. Root end filling
7. Apical barrier for tooth with necrotic pulps and open apex
8. Coronal barrier for regenerative endodontics
9. Root canal sealer

2.6 Discussion

In addition to selection of appropriate materials for a given clinical situation, it is important to use these materials properly. All new chairside employees should be checked for their knowledge of cements, and all should be educated about any new cement introduced to the practice. If a person is having trouble mixing a product by hand, then it should be determined if that product is available in another delivery system, such as an encapsulated form (that can be triturated). Further, when cementing a restoration, occlusion should be checked immediately after seating and corrected if necessary. Some cements set quickly, making removal of the casting difficult. The staff should remember to check the time of trituration before and after use of these products, as the trituration time may be different than that for amalgam.

Clinicians have seen an increase in the number of products that have been packaged in capsules and automix cartridges/syringes (eg, TempAd-vantage, GC America) due to their ease of use. This format requires no spatulation, allows easier cleanup, and ensures equal dispensing of all components. In addition, there is a recent emergence of resin cements that are self etching (eg, Embrace Wetbond Universal Resin Cement, Pulp-dent; RelyX Unicem, 3M ESPE). These products have initially been shown to reduce the amount of postoperative sensitivity associated with cementation[51]. Another advantage of these products is ease of use. There are less clinical steps involved for the clinician, as all of the necessary materials are included in the cement itself.

2.7 Conclusion

Liner, base, and cement materials are constantly changing. Clinicians have an obligation to keep informed by reading the literature so that the appropriate materials are selected for specific clinical situations.

Reference

1. Christensen GJ. To base or not to base. J Am Dent Assoc 1991; 122: 61– 61. CrossrefCASPubMedWeb of Science®Google Scholar

2. Weiner R, Kugel G, Weiner L. Teaching the use of liners and bases: a survey of North American dental schools. J Am Dent Assoc 1996; 127: 1640– 1645. CrossrefCASPubMedWeb of Science®Google Scholar

3. Weiner R. Teaching the use of liners, bases, and cements: a 10-year follow-up survey of North American dental schools. Dent Today 2006; 25: 74– 79. PubMedGoogle Scholar

4. Cox CF, Suzuki S. Reevaluating pulp protection: calcium hydroxide liners vs. cohesive hybridization. J Am Dent Assoc 1994; 125: 823– 831. CrossrefPubMedWeb of Science®Google Scholar

5. Asa R. Dental materials aren't what they used to be. AGD Impact 2004; 32: 10– 13. Google Scholar

6. Craig RG, Powers JM. Restorative dental materials. 11th edn. St Louis, MO: Mosby, 2002. Wiley Online LibraryGoogle Scholar

7. Ferracane JL. Materials in dentistry: principles and applications. 2nd edn. Philadelphia: Lippincott Williams and Wilkins, 2001. Google Scholar

8. Anusavice K. Phillip's Science of Dental Materials. 11th edn. Philadelphia: WB Saunders, 2003.

9. Gordan VV, Vargas MA, Cobb DS, Denehy GE. Evaluation of acidic primers in microleakage of Class V composite restorations. Oper Dent 1998; 23: 244–249.

10. Baum L, Phillips RW, Lund MR. Textbook of Operative Dentistry. 3rd ed. Philadelphia, Pa: WB Saunders; 1995:117.

11. Craig RG, Powers JM, eds. Restorative Dental Materials. 11th ed. St Louis, Mo: Mosby; 2001:623.

12. Ferracane JL. Materials in Dentistry: Principles and Applications. 2nd ed. New York, NY: Lippincott Williams & Wilkins; 2001:60.

13. Phillips RW. Skinner's Science of Dental Materials. 9th ed. Philadelphia, Pa: WB Saunders; 1991:445.

14. Kugel G. Classification and application of cementation alternatives. Signature. 1997;4:8-11.

15. Farah J. Temporary cements. The Dental Advisor. 1998;15(9):2.

16. Powers JM, Wataha JC, Chen YW. Dental Materials: Founda- tions and Applications. Available from: https://www.libreriauniverso.it/articolo/78043/9780323316378-dental-materials-properties-manipulation-powers-wataha-elsevier-mosby. Accessed April 9, 2017.

17. McComb D, Ericson D. Antimicrobial action of new, proprietary lining cements. J Dent Res. 1987;66(5):1025–1028.

18. Estrela C, Holland R. Calcium hydroxide: study based on scientific evidences. J Appl Oral Sci. 2003;11(4):269–282.

19. Coogan MM, Creaven PJ. Antibacterial properties of eight dental cements. Int Endod J. 1993;26(6):355–361.

20. Till Dammaschke. J Hist Dent. Spring 2008.

21. Coogan MM, Creaven PJ. Antibacterial properties of eight dental cements. Int Endod J. 1993;26(6):355–361.

22. Tam LE, Pulver E, McComb D, Smith DC. Physical properties of calcium hydroxide and glass-ionomer base and lining materials. Dent Mater. 1989;5(3):145–149.

23. Smith AJ, Murray PE, Lumley PJ. Preserving the vital pulp in operative dentistry: I. A biological approach. Dent Update. 2002;29(2):64–69.

24. About I, Murray PE, Franquin JC, Remusat M, Smith AJ. The effect of cavity restoration variables on odontoblast cell numbers and dental repair. J Dent. 2001;29(2):109–117.

25. Murray PE, Smith AJ. Saving pulps–a biological basis. An overview. Prim Dent Care. 2002;9(1):21–26.

26. Schröder U. Effects of calcium hydroxide-containing pulp-capping agents on pulp cell migration, proliferation, and differentiation. J Dent Res 1985;64:541-8.

27. Lopez-Cazaux S, Bluteau G, Magne D, Lieubeau B, Guicheux J, Alliot-Licht B. Culture medium modulates the behaviour of human dental pulp-derived cells: Technical note. Eur Cell Mater 2006;11:35-42.

28. Rashid F, Shiba H, Mizuno N, Mouri Y, Fujita T, Shinohara H, et al. The effect of extracellular calcium ion on gene expression of bone-related proteins in human pulp cells. J Endod 2003;29:104-7.

29. Nelson-Filho P, Leonardo MR, Silva LA, Assed S. Radiographic evaluation of the effect of endotoxin (LPS) plus calcium hydroxide on apical and periapical tissues of dogs. J Endod 2002;28:694-6.

30. Jung GY, Park YJ, Han JS. Effects of HA released calcium ion on osteoblast differentiation. J Mater Sci Mater Med 2010;21:1649-54.

31. Prager M. Pulp capping with the total-etch technique. Dent Econ 1994;84:78-9.

32. Fouad A, Levin L. Pulp reactions to caries and dental procedures. In: Cohen S, Hargreaves KM, editors. Pathways of the Pulp. 9th ed. St. Louis: Mosby; 2005. p. 515-35.

33. SMITH, D. C. The Setting of Zinc Oxide-Eugenol Mixtures, Brit. dent. J., 105:313-21, 1958.

34. NORMAN,R.D.,PHILLIPS,R.W.,SWARTZ,M.L., and FRANKIEWICZ, T. Effect of Particle Size on the PhysicalPropertiesofZincOxide-EugenolMixtures. J.dent.Res.,43:252-62, 1964.

35. SWARTZ,M.L.,PHILLIPS,R.W.,NORMAN,R.D.,and OLDHAM, D. F. Strength, Hardness and Abrasion Characteristics of Dental Cements, J. Amer. dent. As.,67:367-74, 1963.

36. OLDHAM,D.F.,SWARTZ,M.L.,andPHILLIPS,R.W. Retentive Properties of Dental Cements, J. prosth. Dent., 14:760-68, 1964.

37. SKINNER,W.E.,COOPER,E.N.,andZIEHM,H.W. Some Physical Properties of the Zinc Oxide-Eugenol Impression Pastes, J. Amer. dent. Ass., 41:449-55, 1950.

38. WALLACE, D. A., and HANSEN, H. L. Council on Dental Therapeutics. Zinc Oxide-Eugenol Cements, J. Amer. dent. Ass., 26:1536-40, 1939.

39. MOLNAR,E.J.,and SKINNER,E.W.A Study of Zinc Oxide-Rosin Cements. l. SomeVariables Which Af-fect the Hardening Time, J. Amer. dent. As., 29:744-51, 1942.

40. Oldham, D.F.; Swartz, M.S.; and Phillips, R.W. Retentive properties of dental cements. J Prosthet Dent 14:760 July-Aug 1964.

41. Swartz, M.L. Dental cements and restorative resins. Dent Clin North Am March 1965, p 83.

42. Wilson, A.D., and Mesley, R.J. Zinc oxide-eugenol cem- ents: III. Infrared spectroscopic studies. J Dent Res 51:1581 Nov- Dee 1972.

43. Mount G.J. Color Atlas of Glass Ionomer Cement. 2nd ed. Martin Dunitz; London, UK: 2002.

44. McLean J.W., Nicholson J.W., Wilson A.D. Guest Editorial: Proposed nomenclature for glass-ionomer dental cements and related materials. Quintessence Int. 1994;25:587–589.

45. ISO 9917–1: Dental Water Based Cements. International Organization for Standardization; Geneva, Switzerland: 2003.

46. Higgs W.J., Lucksanasombool P., Higgs R.J.E.D., Swain M.V. Evaluating acrylic and glass-ionomer cement strength using the biaxial flexure test. Biomaterials. 2001;22:1583–1590. doi: 10.1016/S0142-9612(00)00324-0.

47. Hewlett ER, Mount GJ. Glass ionomers in contemporary restorative dentistry--a clinical update. J Calif Dent Assoc. 2003 Jun;31(6):483-92.

48. Mitra S.B. Adhesion to dentin and physical properties of a light-cured glass-ionomer liner/base. J. Dent. Res. 1991;70:72–74. doi: 10.1177/00220345910700011201.

49. Berzins D.W., Abey S., Costache M.C., Wilkie C.A., Roberts H.W. Resin-modified glass-ionomer setting reaction competition. J. Dent. Res. 2010;89:82–86. doi: 10.1177/0022034509355919.

50. Till Dammaschke et al.the dentist Sept 2011;Direct pulping. Biodentine Active Biosilicate Technology Scientific File, Septodont, Paris, France.

51. Andrale C, Blanco V, Collazo A, Keddam M, Novoa XR, et al. (1999) Cement paste hardening process studied by impedance spectroscopy. Electrochim Acta 44: 4314-4318

52.Tu M G, Sun K T, Wang T H et al.Effects of mineral trioxide aggregate and bioceramics on macrophage differentiation and polarization in vitro. J Formos Med Assoc. 2019;118(10):1458–1465.

53.Lapinska B, Klimek L, Sokolowski J, Lukomska-Szymanska M. Dentine surface morphology after chlorhexidine application-SEM study. Polymers (Basel) 2018;10(08):905.

54.BogenG, Kim JS,Bakland LK. Direct pulp capping with mineral trioxideaggregate: an observational study. The Journal of the American Dental Association. 2008 Mar 1;139(3):305-15.

55. Walker MP, Diliberto A, Lee C. Effect of setting conditions on mineral trioxide aggregate flexural strength. Journal of endodontics. 2006 Apr 1;32(4):334-6.

56.TorabinejadM, Hong CU, McDonald F, Ford TP. Physical and chemical properties of a new root-end filling material. Journal of endodontics. 1995 Jul 1;21(7):349-53.

57.Valois CR, Costa Jr ED. Influence of the thickness of mineral trioxide aggregate on sealing ability of root-end fillings in vitro. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2004 Jan 1;97(1):108-11.

58.Loxley EC, LiewehrFR, Buxton TB, McPherson III JC. The effect of various intracanal oxidizing agents on the push-out strength of various perforation repair materials. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2003

59.Kettering JD,Torabinejad M. Investigation of mutagenicity of mineral trioxide aggregate and other commonly used root-end filling materials. J Endod1995; 21:537-42.

60. Torabinejad M, Hong CU,LeeSJ,Monsef M,FordTR.Investigationof mineral trioxide aggregate for root-endfillingindogs.Journal of endodontics.1995 Dec 1;21(12):603-8.