Proper selection of dental cements in fixed prosthodontics

Vhodný výber zubných cementov vo fixnej protetike

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Abstract
Numerous dental cements were introduced in the dental field over the past few years. However, in spite of the variety of their composition and technique of application, none of them is universal [27, 11]. Thus, a proper selection of a cement based on the case requirements and on prosthodontist experience is a must to guarantee a successful enduring restoration. The purpose of this article is to guide the dentists through the decision-making process to select suitable cement along with its manipulation technique in tooth-supported cases.

Key words: Cements, luting agents, resins, glass ionomer, GIC.

Abstrakt
Za niekoľko posledných rokov bolo v zubnom lekárstve zavedených množstvo zubných cementov. Napriek rôznorodosti ich zloženia a spôsobu aplikácie však žiaden z nich nie je univerzálny (27., 11.). Správny výber cementu na základe požiadaviek a skúseností zubného špecialistu je nevyhnutnosťou pre zaručenie úspešnej trvalej náhrady. Cieľom tohto článku je pomôcť zubným lekárom pri výbere vhodného cementu, ako aj spôsobu manipulácie v prípade fixných náhrad.

Kľúčové slová: cementy, fixačné prostriedky, živice, skloionomery, skloionomerný cement.

Abbreviations and acronyms: RMGI = resin-modified glass-ionomer; ZOE = zinc oxide eugenol; GIC = glass-ionomer.

Introduction

Cement is defined as a material that, on hardening, will fill a space or bind adjacent objects [35]. The procedure is called cementation. The words *Luting agent* and *cement* are used interchangeably in the literature. It will be confined to *cement* in this article.
Taking into consideration the various options of the available cements nowadays with different physical and mechanical properties [16], the choice of the optimal cement can be confusing, even for the most experienced clinician [22]. This article aims to help the clinicians to determine the suitable cement along with its manipulation technique in indirect restorations.

Classification

Dental Cements are classified into provisional and definitive [12]. They are also classified based on matrix bond type as following [14]:

I. Phosphate (zinc phosphate)
II. Phenolate (zinc oxide eugenol)
III. Polycarboxylate (zinc polycarboxylate, glass ionomer)
IV. Resin modified glass ionomer
V. Resin cements

I. Phosphate-based cements

This group includes: zinc phosphate, modified zinc phosphate, and silicophosphate cements [21]. Zinc phosphate will be discussed in this review as a representative of the group as it is the most frequently chosen by practitioners cement from this group.

Zinc phosphate

Zinc phosphate is a mixture of zinc oxide powder and phosphoric acid liquid [33]. The liquid is an aqueous solution of phosphoric acid containing about 30 to 40 % water. It is not adhesive and does not form a chemical bond with tooth structure and the restoration. It has been widely blamed for contributing to pulpal irritation due to its low initial pH [11]. Cavity varnishes can reduce the exposure of the pulp to the cement [28]. Another disadvantage is its opaqueness.

It has high mechanical properties (table 2), a reasonable and long working time about 5 minutes, a thin film thickness, and provides a good flow (table 2).

When the powder and liquid are mixed, an exothermic (heat-releasing) reaction occurs.

surface pretreatment

a vital tooth should be cleaned with very light or no pumicing to maintain the smear layer then two coats of cavity varnish or a resin sealer should be applied. This may help reduce the potential negative effect on a vital pulp [14].

Manipulation:

The powder is added into the liquid in small increments spreading on a cool but dry glass slab then mixed with a spatula over a broad area [3]. A large portion of the glass slab must be used during mixing, in order to dissipate the heat of this reaction [3].

It allows easy removal of excess cement because it develops brittle properties.

II. Phenolate-based cements

This group includes zinc oxide eugenol and modified zinc oxide eugenol.

On many occasions, temporary cementation of a final restoration is advised so that the patient and dentist can assess its appearance and function over a longer time than a single visit [26]. In other cases, a provisional restoration should be cemented after preparation until the next visit when the final restoration will be ready.

Zinc oxide with eugenol

Unmodified zinc oxide eugenol cement is designed for temporary cementation because of the palliative effect on the pulp and the low strength properties allowing non-traumatic removal of the restoration [15]. Residual eugenol has been shown to inhibit resin polymerization [22]. In practice, all traces of eugenol-containing temporary cement have to be removed thoroughly for maximum adhesion of the resin cement, because they can reduce the tensile bond strength of resin cements. Conventional and resin-modified glass-ionomer cements do not seem to be affected by eugenol. In rare cases, eugenol can be allergen [34].

Manipulation:

The recommended mixing ratio of base to accelerator is 1 : 1, they mixed until uniform colour [15].

Modified zinc oxide with eugenol

Modified by the addition of alumina to the powder and EBA to the eugenol liquid.

EBA forms a crystalline form of zinc eugenolate which is stronger and less soluble [7].

Adhesion is only mechanical. It is extremely biocompatible and provides a palliative and sedative effect to the pulp. It has limited strength properties, a short working time, a high film thickness, and a good flow. It is opaque and removing excess cement is difficult.

Manipulation: it has a high powder/liquid ratio that should be used as per manufacturer, followed by vigorous spatulation. The mixing pad or slab should be thoroughly dry [21]. Adequate setting time in the mouth should be allowed. The cement will not reach maximum strength until several days later.

III. Polycarboxylate-based cements

Zinc polycarboxylate

The powder is composed of zinc oxide containing less than 10 % magnesium oxide. The liquid is a 40 % aqueous solution polyacrylic acid [14, 33].

Compared to zinc phosphate cement, its early compressive strength is lower, but the tensile strength is much higher, and it has some adhesion to tooth structure although retention is primarily mechanical [12].

The cement provides a strong adhesive bond to non-precious alloy but not to gold or porcelain (unless the fitting surface is plated with tin). Because of the large size of the polyacrylic acid molecule, there is apparently little penetration into the dentinal tubules, thus it causes little pulpal irritation [28].

It has low compressive strength and modulus of elasticity but high tensile strength.

It is opaque, viscous and soluble. It has a short working time of about 2.5 minutes, a low film thickness.

Manipulation: Powder and liquid are mixed rapidly in 30 to 40 seconds in proportions as per manufacture [21].

Glass ionomer:
Glass ionomer (GI) has many properties of an ideal cement. The powder is mainly composed of aluminosilicates with high fluoride content, while the liquid is mainly polyacrylic acid [29].
Glass-ionomer cement has a bacteriostatic effect [13].
Its solubility in water is much higher than that of other dental cements, and it must be protected by a coating of petrolatum or varnish at the crown margins [28] It expands when they absorb fluids. This property is advantageous because the expansion contributes to a snugger fit of metal crown, but it is also disadvantageous because the expansion causes crazing of ceramic crowns [33].
Although it undergoes an initial rapid setting reaction, full maturation may take up to several months to reach completion [14].
surface pre-treatment
the substrate tooth be carefully cleaned (very light or no pumicing) to maintain the smeared layer this helps to reduce post-operative sensitivity. Placement of a resin-based sealer before cementation may also reduce the possibility of sensitivity for deep dentinal preparations and can enhance the retention of the cement [12, 14].

Manipulation: Some brands are encapsulated, mechanically mixed, and injected. For the powder- liquid form spatulation should occur on a chilled slab and the powder should be chilled and the powder/liquid ratio is about 1.3 : 1 [21].

IV. Resin-modified glass ionomer cement:
Resin-**M**odified **G**lass **I**onomer (RMGI) is a hybrid material derived from adding polymerizable resins to glass ionomer cement in order to combine the strength and insolubility of resin with the fluoride release of glass ionomer [14]. They differ from other composite resin cements in that the glass filler particles react with the liquid during the hardening process [28].
In general, fully set RMGI cements have superior physical and mechanical properties compared to conventional glass-ionomers [12, 14].
Adhesion is achieved by both chemical and mechanical means.
The cement is not irritant. It has high compressive and tensile strength but lower modulus of elasticity. It has a working time of about 3.5 minutes, Low film thickness, high flow and easy removal of excess cement. RMGI cements provide a sustained release of fluoride, which occurs in the same way as with conventional glass ionomer cements [7].
Although RMGIs have more clinical application than the conventional glass ionomers and zinc phosphates because of their improved properties, they do not have enough bond strengths to retain restorations with poor retention forms such as short clinical crowns and preparations with too much taper and veneers [33].
The following products are examples for some available RMGI cements in the market: Fuji II LC (GC America) and Ketac cem (3M ESPE)
surface pre-treatment
cleaning of the tooth is the same as conventional glass ionomer, also the smeared layer should not be removed by heavy pumicing [12]. However, some authors recommend surface pre-treatment to prevent microleakage [4].

Manipulation: This cement comes in capsules that are mechanically mixed then injected.

V. Resin cements
Resin cements are the most used materials for the cementation of indirect restorations [25] due to their high compressive and tensile strengths, low solubility, favorable aesthetic qualities and high fracture resistance of ceramic restoration [20]. Their major shortcomings are: difficult excess removal; technique sensitive; a restoration which has to be removed may have to be removed in pieces rather than intact; and they are relatively expensive [12]. Different shades of resin cements are available in the market to improve esthetics [14].

Classification of resin cements
They are classified according to:
i. polymerization method as self-cure (auto polymerizing), dual-cure, or light-cure [31].
ii. bonding procedure as conventional or self-adhesive [33].

Conventional resin cements require a separate pre-treatment procedure of etching of the tooth surface before applying the cement [17]. These conventional cements are further subclassified into:
a. two-step system that does not include a rinsing step after etching, and
b. three-step system that is also called etch-and-rinse. Therefore, the application technique

is sensitive and consequently might compromise bonding effectiveness, because each step represents a possible contamination point [31].

Self-adhesive cements are also called one-component "universal adhesive cements," these cements do not require a separate bonding procedure on the tooth as phosphoric acid is grafted in the resin in the form of phosphoric esters [7, 25]. Although this simplification of the application procedure reduces the technique sensitivity, it might compromise the bonding capacity [30, 23, 32].
The current self-adhesive resin cements are two-part materials that require either hand mixing, capsule trituration or delivery by an auto-mixing dispenser [9].

Tab. 1. *Examples of some available cements in the market according to the method of polymerization: [33]*
Tab. 1. *Príklady niektorých dostupných cementov na trhu podľa metódy polymerizácie (33)*

self-cure	dual-cure	light-cure
Comspan	Panavia F 2.0	Rely X Veneer
C&B Cement	Variolink 2	Variolink Veneer
Superbond	Duolink	Ultrabond Plus

indications
Auto polymerizing and dual-cure resin cements can be used for all cementation applications while light-cure resin cements should be limited to the restorations with enough translucency to allow sufficient transmission of polymerizing light to reach the underneath cement, an example of these restorations is porcelain veneer [10].
Cementation with resin cements of short tapered crown preparations and low to medium strength ceramics that are not supported by a core, benefits from the adhesive properties of resin cements and increases retention [37, 18].
Another indication is cementation of all-ceramic fixed prosthesis to benefit from the low solubility and aesthetic properties [12].
A strong, durable resin bond provides high retention, increases fracture resistance of the restored tooth and the restoration, and improves marginal adaptation and prevents microleakage [6]. A proper marginal fit is an important factor in the success of restorations [19] because poor marginal fit may lead to cement dissolution, microleakage, or secondary caries [2].

Understanding adhesion mechanism
In order to achieve adequate adhesion to dental tissues, the dentist should fully understand the mechanism of adhesion to the enamel and to the dentin as they differ widely in composition and homogeneity. Enamel composes 96 % by weight hydroxyapatite crystallites, 3 % water and 1 % organic material. While dentine composes 70% by weight hydroxyapatite crystallites, 10 % water and 20 % organic material [5]. This understanding helps avoiding the multitudinous mistakes that are common during clinical practice. Bonding to dental tissues is a very sensitive challenge facing dentists because of the marked difference between different dental substrates aiming to obtain reliable immediate bond strength between the synthetic resinous materials and the natural dental tissues and more importantly is the durability of such gained bond in the complicated fluctuating oral environment [24]. The aim of enamel conditioning is to create microporosites since bonding to enamel is principally micromechanical via resin tag, this is different from dentine conditioning where the aim is to demineralise the surface dentine gently and dissolve or modify the smear layer to expose a microporous scaffold of collagen fibrils [8].There is a significant difference between the types of resin cements in the handling of this smear layer; three-step systems remove the smear layer, while two-step systems and self-adhesive preserve it [17]. The bond strength is considered to be the most important factor affecting the success of resin cements [33]. Self-adhesive cements provide reasonable adhesion to dentin its adhesion in enamel is still a concern [25]. Although manufacturers claim that bonding with self-adhesive resin cements can be achieved without any pre-treatment steps, etching of enamel and dentine with phosphoric acid has a positive influence on bond strength [25, 23, 32]. However, a study found that etching is only beneficial for enamel and should be avoided for dentin [36].

Pretreatment of internal surface of ceramic restoration before cementation:
A good adhesion to the internal surface of the restoration requires: 1) roughening of the internal surface of the restoration to increase the surface area for bonding is done through etching with a hydrofluoric acid for etchable ceramics, or application of an alloy primer for restorations with a metal subsurface. 2) increasing the wettability of the cement to the restoration and forming chemical bonds between the ceramic, the fillers, and the cement. This is achieved by applying a silanating agent on the etched porcelain or composite [33, 1].

Tab. 2. *Comparison of physical properties between definitive cements [14, 21]*
Tab. 2. *Porovnanie fyzikálnych vlastností medzi konečnými cementmi (14, 21)*

Cement	Film thick-ness (mm)	Solubility (wt%)	Strength (MPa)		
			Compressive	Tensile	Modulus of elasticity (GPa)
Zinc phosphate	25 – 35	0.2 max	80 – 100	5 – 7	13
Zinc Polycarboxylate	20 – 25	0.06 – 0.1	55 – 85	8 – 12	5 – 6
Zinc oxide-eugenol EBA-alumina	40 – 60	1	55 – 70	3 – 6	3 – 6
Glass ionomer	25 – 35	1	90 – 140	6 – 7	7 – 8
Composite resin	20 – 60	0.05	70 – 200	25 – 40	4 – 6

Tab. 3. *Reference Guide for Cements [21, 33, 3]*
Tab. 3. *Príručka pre cementy (21, 33, 3)*

Cement	Mixing Technique	Characteristics of a proper Mix	Mixing Time (sec)	Setting Time (min)
Zinc oxide–Eugenol	incorporate small portions of powder to the liquid by deliberately pressing with spatula.	Thick, putty-like, and almost "crumbly"	90	2.5 – 3.5
Zinc phosphate	Add divided increments in specified time, using large slab area	Mix will stretch 1 inch between slab and spatula	60 – 90	5 – 14
Zinc Polycarboxylate	Add powder to liquid in one portion	Use while glossy	30	6 – 9
Zinc oxide-eugenol EBA-alimina	Add half-scoop increments, using small mixing area	Thick, putty-like	60	7 – 13
Glass ionomer	Add powder to liquid in one portion	Use while glossy	30 – 45	6 – 9
Composite resin	Mix equal amounts of pastes	Uniform colour	30 – 45	3 – 7

Choosing the cement
The selection of particular cements for specific clinical situations based on material of the fixed prosthesis is summarized in table 4.

Tab. 4. *show the cases where cements are indicated [37]*
Tab. 4. *zobrazuje prípady, pri ktorých je indikovaný cement (37)*

Material of prosthesis	Indicated
All-metal/PFM crowns	1, 2, 3, 4
Traditional feldspathic or press-able all-ceramic restorations	5, 6
Alumina/Zirconium-based all-ceramic restorations	1, 3, 4, 5, 6
Composite/porcelain veneer	5, 6

1. Zinc phosphate cement
2. Zinc polycarboxylate
3. Conventional glass-ionomer cement
4. Resin-modified glass-ionomer cement
5. Conventional resin cement
6. Self-adhesive resin cement

Conclusion:
Cementation is one of the important final steps in a series of meticulous procedures before delivering the indirect restorations and it affects the long-term success. Understanding the mechanism of adhesion, the type of the restoration material behaviour and the exact composition of the cement are key factors for reaching clinical acceptable results. Until now there is no ideal cement that fits in all situations.

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