Proper Selection of Contemporary Dental Cements

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Abstract
Today proper selection of dental cements is a key factor to achieve a successful restoration and will greatly increase the chances of long-term success of the restoration. In recent years, many newly formulated dental cements have been developed with the claim of better performance compared to the traditional materials. Unfortunately, selection of suitable dental cement for a specific clinical application has become increasingly complicated, even for the most experienced dentists. The purpose of this article is to review the currently existing dental cements and to help the dentists choose the most suitable materials for clinical applications.

Key Words: Dental Cement, Zinc Phosphate Cement, Zinc Polycarboxylate Cement, Glass-Ionomer Cement, Resin Cement

Introduction

The number of choices for indirect restorations has evolved greatly over the last decade. In literature, the primary function of a dental cement is to fill the space between restorative material (definitive or provisional) and tooth preparation (or implant abutment), as well as to enhance the resistance to restoration dislodgement during function [1,2]. Of utmost importance, the long-term success of a restoration is heavily dependent on the proper selection and manipulation of dental cements. Loss of retention has been found to be one of the most common causes of restoration failure [3].

In literature, although the terms “cement”, “luting”, “bond” have different meanings, they have frequently been employed as interchangeable terms. Luting refers to a mechanism in which micromechanical locking occurs between the objects to be joining. Bond is a term that implies that chemical or physical interaction occurs to both surfaces that to be attracted. Cement is a generic term for a joining medium provided adhesion and/or micromechanical locking between the two surfaces to be connected [4]. Generally speaking, a proper generic description of material that provides the link between restorative material and the tooth preparation (or implant abutment) should be “dental cement”.

According to the expected longevity of the restoration, dental cements can be divided into 2 groups: provisional (temporary) and definitive cements. All definitive cements can be further separated in 2 subgroups: luting cements and bonding cements. Currently there are 4 types of commonly used luting cements, including zinc phosphate cement, zinc polycarboxylate cement, conventional glass-ionomer cement, and resin-modified glass-ionomer cement. The only type of bonding cement is resin cement, which is composed of different subtypes. With the development of material technology, dental cements have evolved into stronger and more durable materials. The choice of dental cements has become increasingly complicated as new materials become available and application procedures are being changed accordingly. Therefore, the objectives of this review are to help the clinicians understand the specifics of the dental cements being used as well as scientifically select dental cements for clinical application.

History of Dental Cement

Although dental cements have evolved from humble beginning, currently dentists are faced with a broad choice of options. *Figure 1* provides an overview of dental cements development from the old days.

Key Factors to Consider When Selecting Dental Cement

Ideally, dental cement should fulfill specific biological, physic-mechanical, and handling requirements to establish retention of the restorations to tooth preparation or implant abutment and maintain its integrity.

The properties required for a successful cementation would be [5-7]:

- Good biocompatibility: biocompatible with dental pulp and soft tissue;
- Good physical properties: proper film thickness to ensure optimum seating of a restoration, low solubility, extended working time and short setting time, low viscosity, radiopaque;
- Good mechanical properties: high shear/tensile/compressive strength, high bonding strength to tooth structure/restorative material;
- Good handling properties: easy to mix/clean-up.

Although no currently available dental cement is ideal for all situations, the material scientists and manufacturers have been getting closer to that goal.

Provisional (temporary) Cement

Provisional (temporary) cements are of 2 categories: calcium hydroxide and zinc oxide cements with eugenol or alternative substances. The earliest provisional dental cement was zinc oxide eugenol cement, which was invented in 1850s. Zinc oxide eugenol cement is created by mixing zinc oxide powder and eugenol liquid. For many years, zinc oxide eugenol cement has been frequently used for provisional (temporary) cementation [8]. Despite its well-documented obtunding effect on dental pulp, its main disadvantages, including inhibition on the polymerization of resin cement and high film thickness, have limited its use in contemporary clinical practice [9,10]. Many researchers found a reduced bonding strength of resin cement when eugenol-containing provisional cement were used previously [11,12]. Therefore, it is advisable to use eugenol-free provisional cement prior to resin cement bonding procedure. While in the past eugenol-free cements meant the cements still had zinc oxide, currently there are choices of resin or polycarboxylate based eugenol-free provisional cements, e.g., HY-Bond Polycarboxylate Temporary Cement (Shofu).

It is important to point out that the application of the provisional cements with or without eugenol, contaminates the tooth structure, which might eventually affect the bonding strength of definitive

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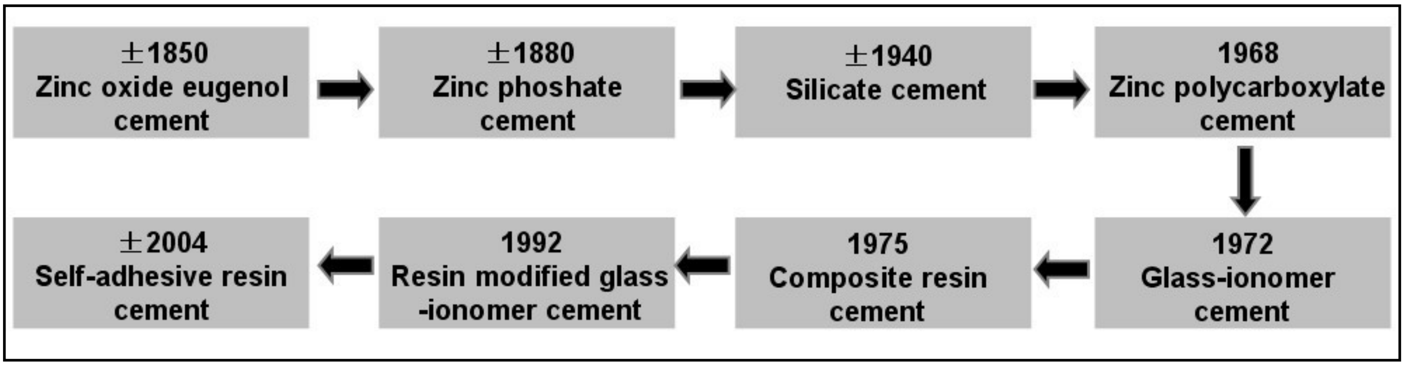

Figure 1. *An overview of the chronological development of luting agents starting around 1850 until today.*

cement [13]. However, recent studies found that the bonding strength of self-adhesive resin cement (RelyX Unicem, 3M ESPE) remained unchanged when provisional cement was used previously [14,15].

Definitive Cement

In the past (and still), the term "permanent cement" has been frequently employed when describing dental cements for the final restorations. As a matter of fact, a more proper description of cement should be "definitive cement" when describing a cementation can not be removed at a later time [2]. Among cements in this category are: zinc phosphate cement, zinc polycarboxylate cement, conventional glass-ionomer cement, resin-modified glass-ionomer cement and resin cement (*Table 1*).

Zinc Phosphate cement

It is the dental cements having a long-term successful track record of more than a century since its introduction in 1880s [16]. Zinc phosphate cement is mixed using phosphoric acid liquid, and powder that is composed of zinc oxide and magnesium oxide. Even though its use has declined remarkably, significant amount of clinical success makes zinc phosphate cement still readily available in many developing countries [17]. Zinc phosphate cements lack chemical bond to tooth structure and exhibit a moderate compressive strength (62 to 101 MPa), a low tensile strength (5 to 7 MPa), and a high degree of solubility (0.36%). After being mixed, zinc phosphate cement exhibits a low pH of 2. The pH then increases and reaches 5.5 after 24 hours. Despite its low initial pH, Brannstrom and Nyborg [18] reported that zinc phosphate cement has no irritating effect on the dental pulp and the potential irritant effect of zinc phosphate cement might be due to the bacteria left on the prepared tooth surface. However, in clinical practice, the tooth preparation with low Residual Dentin Thickness (RDT) to be cemented with zinc phosphate cement may suffer from sensitivity during and after cementation. Owing to its lengthy history of use, zinc phosphate cement is considered as the "gold" standard against other definitive dental cements compared [19]. Fleck's (Mizzy) is the leading brand of zinc phosphate cements.

Zinc Polycarboxylate Cement

Similar to zinc phosphate cement, zinc polycaboxylate cement is also an acid-base reaction cement. It is mixed using polyacrylic acid and a powder containing zinc oxide and magnesium oxide [1]. Zinc polycarboxylate cement, invented in 1968, was the first cement exhibiting chemical bond to tooth structure [17]. Its adhesive properties produce a weak bond to enamel and an even weaker bond to dentin (1-2 MPa) through the interaction of free carboxylic acid groups with calcium from tooth structure [20]. Zinc polycaboxylate cements exhibit a low compressive strength (67 to 91 MPa), and a low tensile strength (8 to 12 MPa). It has been reported that zinc polycarboxylate cement may undergo significant plastic deformation under dynamic loading after set [21]. This property limits the use of zinc polycarboxylate cement for single unit restoration or short span fixed partial denture cementation. Perhaps the biggest advantage of this cement is the good biocompatibility with the dental pulp, which could be partially due to a rapid rise in pH after mixing and lack of tubular penetration from the large and poorly dissociated polyacrylic acid molecule [22]. This property has motivated its use as provisional cement to reduce the possibility of post-cementation sensitivity for tooth preparations with low RDT. Although zinc polycarboxylate cement has the merit of producing a chemical bond to enamel and dentin, its use has lessened over the years [8]. Durelon (3M ESPE) and Tylok Plus (Dentsply) are examples of zinc polycarboxylate cements.

Glass-ionomer cement

Conventional glass-ionomer cement: Glass-ionomer cements were introduced as hybrids of silicate cements and polycarboxylate cements to have characteristics of fluoride release (from silicate cements) and adhere to enamel and to some extent to dentin (from polycarboxylate cements) [23]. It consists of a powder containing aluminosilicates with high fluoride content, and a liquid composed of polyacrylic acid and tartaric acid. When conventional glass-ionomer cements are mixed, the polyacrylic acid reacts with the outer layer of the particles resulting in release of calcium, aluminum, and fluoride ions. When a sufficient amount of metal ions are present, gelation occurs. Hardening of the material continues for 24 hours. Conventional glass-ionomer cements exhibit a low bonding strength to tooth structure, a moderate compressive strength (85 to 126 MPa), and a low tensile strength (6 to 7 MPa). It is noteworthy that the physical properties of conventional glass-ionomer cement can be highly variable based upon different powder/liquid ratio so the manufacturer's instruction for mixing should be followed strictly [24]. One of the main advantages of convention glass-ionomer cement is the constant long-term fluoride release and its fluoride recharging ability, which are considered beneficial to caries prevention.

The bonding strength between conventional glass-ionomer cement and dentin significantly reduces when dentin is excessively dried, which also contributes to post-cementation sensitivity [25]. Thus, before cementation the wet dentin surface should be blotted dry with cotton wool. The main disadvantage of this cement is susceptibility to moisture contamination and desiccation during the critical initial setting period [26]. Early exposure to water and saliva contamination has been shown to significantly increase the solubility and decrease the ultimate hardness of conventional glass-ionomer cements [27]. When working with conventional glass-ionomer cement, the material at the restoration margins should be protected with a coating agent (e.g., Ketac Glaze, 3M ESPE) or petroleum jelly [28]. Moreover, conventional glass-ionomer cement has relatively low resistance to acid attack and bleaching so it may not be the proper choice for the patients who have gastric reflux problems or want their teeth to be bleached [29,30].

Resin-modified glass-ionomer cement: Resin-modified glass-ionomer cements combine the technology and chemistry of resin and conventional glass-ionomer cement. This class of dental cement was produced to overcome the two important weakness of conventional glass-ionomer cement, which are sensitivity to early moisture contamination and high solubility [31]. Resin-modified glass-ionomers were formed by replacing part of the polyacrylic acid in conventional glass-ionomer cements with polymerizable functional methacrylate monomers. Compared to conventional glass-ionomer cement, resin-modified glass-ionomer cement showed improved adhesion to tooth structure, higher compressive/tensile strength, and low solubility to ensure the long-term integrity of the margins and low possibility of post-cementation sensitivity while maintaining high levels of fluoride release which is similar to conventional glass-ionomer cement [32]. Resin-modified glass-ionomer cements exhibit moderate bonding strength to tooth structure (around 8 MPa), good compressive strength (93-226 MPa) and tensile strength (13-24 MPa).

An *in vivo* study pointed out that the patients with restorations cemented with resin-modified glass-ionomer cement demonstrated the least post-cementation sensitivity compared to the ones cemented with conventional glass-ionomer cement and zinc phosphate cement at all different intervals of time tested [33]. Setting reaction of this cement is a dual mechanism, which includes acid-base reaction and polymerization. When the powder and the liquid are mixed, acid–base reaction occurs with the formation of polyacrylate salt. Initiation of polymerization can be triggered by either light or sufficient free radicals [34].

Resin cement: As an alternative to acid-base reaction cements, resin cements were introduced in the mid-1970s [35]. Resin cements are based on bisphenol-a-glycidyl methacrylate (Bis-GMA) resin and other methacrylates, which are modified from the composite resin (restorative material). This class of cements has a setting reaction based on polymerization. Resin cements have the advantage of high compressive/tensile/bonding strength, low solubility, and esthetics [36]. These properties allow them to be employed in cases where there are concerns about retention or with weak and esthetic restorations (e.g., restorationss made from glass-ceramic and composite resin). While previous studies considered high film thickness as one of the major disadvantages of resin cements, Kious et al. [37] showed all the recently introduced dental cements meet the ISO standard of film thickness (25 microns) for up to 2 minutes after mixing. Also, some resin cements contain ytterbium trifluoride or barium aluminium fluorosilicate filler and are capable of releasing fluoride after setting stage. This may imply that these types of resin cements offer cariostatic potential [38].

Resin cements vary in curing mechanism (light-cured, self-cured, and dual-cured) [39]. Self-cured and dual-cured resin cements can be used for all cementation applications. Light-cured resin cements, however, should be limited to porcelain veneers and glass-ceramic restorations that allow the curing light to penetrate the porcelain. Some manufacturers claimed that light-cured resin cement had better long-term color stability. However, conflicting results have been reported in the literature [40,41]. It has been reported that dual-cured resin cement showed a reduced bonding strength and microhardness without curing light [42-44]. Therefore, it is important to light cure all dual-cured resin cements at all accessible restorative margins for enough time periods.

As mentioned previously, resin cements can be divided into 3 subtypes based on bonding mechanism (total-etch, self-etch, self-adhesive) [39]. The total-etch (etch-and-rinse) systems have 3 main steps: 1) acid etching, rinse, gently dried; 2) bonding agents applied, cured; 3) resin cement applied, cured. For the self-etch systems, the acid etching and bonding steps are replaced with the self-etch bonding agent application, which combines the conditioner, primer, and adhesive [7]. The total-etch and self-etch resin cements could be considered as "conventional resin cement". In order to improve the ease of use, the self-adhesive resin cements were developed and introduced in 2002. Although this subtype of resin cements does not

Table 1. *Overview of the representative contemporary definitive dental cements.*

Cement Type	Representative Product	Manufacturer
Conventional glass-ionomer cement	Ketac Cem	3M ESPE
	Fuji I	GC
	Meron	VOCO
	CX-Plus	Shofu
Resin-modified glass-ionomer cement	RelyX luting Plus	3M ESPE
	RelyX luting 2	3M ESPE
	Fuji Plus	GC
	Fuji Cem	GC
Conventional resin cement	RelyX ARC	3M ESPE
	Nexus 3	Kerr
	Panavia F 2.0	Kuraray
	Variolink 2	Ivoclar Vivadent
	Multilink	Ivoclar Vivadent
	C&B Cement	Bisco
Self-adhesive resin cement	RelyX Unicem	3M ESPE
	Clearfil SAC	Kuraray
	G-cem	GC
	BisCem	Bisco

have long-term clinical track record, it is already the most popular subtype of resin cements [45]. The first product, RelyX Unicem from 3M ESPE, has been well studied and widely used around the world. These cements do not require surface pretreatment and bonding agents to maximize their performance [46]. Therefore, the technique sensitivity of self-adhesive resin cement has been greatly reduced compared to the conventional resin cements [47]. However, that is not the case for bonding strength between self-adhesive resin cements and tooth structure/restoration.

All resin cements are relatively insoluble when compared to the dental cements mentioned previously. They have the highest mechanical and physical properties as well as the cost compared to other currently existing dental cements [2,48]. This class of cement has a more tooth-like translucency. In some cases, they are also available in tooth shades to best match the adjacent tooth. Importantly, for resin-containing dental cements (resin cement and resin-modified glass-ionomer cement), polymer degradation over time is still an issue. Mineralized dentin contains matrix metalloproteinases (MMPs) and MMPs are fossilized and activated during bonding procedure. The collagen fibers to be bonded might be slowly degraded by the activated MMPs, resulting in reduced bonding stability over time [49]. As a matter of fact, this action is far beyond the control of dentists. Pretreat dentin with chlorhexidine or combination of chlorhexidine and bonding agents might prevent this action of the endogenous enzymes [50,51]. However, further studies are needed to verify this hypothesis.

Application

Careless selection of the dental cement or improper manipulation of the chosen material significantly affects the longevity of a restoration. It is critical that the clinicians select the dental cements considering their physical, mechanical, esthetic, and handling properties as well as the costs and technique required. Currently resin cements have gained lots of popularity due to their versatility, performance and favorable esthetic properties. However, if adequate tooth preparation and resistance form exists or where moisture control may be problems, more conventional dental cements (e.g., conventional glass-ionomer cement, resin-modified glass-ionomer cement) might be a better choice compared to resin cement.

The high demand for esthetically pleasing restorations has resulted in the development and introduction of various ceramics. Among all the available ceramics, the polycrystalline ceramics (aluminum oxide and zirconia oxide) are the most popular materials due to their superior performance. Although polycrystalline ceramics are often cemented conventionally using glass-ionomer cement or zinc phosphate cement, they can benefit from adhesive cementation with resin cements. In those circumstances application of a primer containing 10-methacryloyloxydecyldihydrogen phosphate (MDP) (eg. DC Bond, Kuraray) before application of the resin cement has been recommended in instances where better retention is required [52].

Regarding selection of dental cements for implant-supported restorations, the practitioners have a broad choice of many different dental cements, each with advantages and disadvantages. Before making decision, the dentists should answer the questions how much and how long retention is needed for this particular restoration. As soon as the answers to these questions are clarified, the decision-making process could be simplified. In general, if an implant is ideally placed and the occlusion is optimal, the implant-supported restoration should be cemented with definitive dental cements such as glass-ionomer cement and resin cement.

Although some materials are contraindicated for certain circumstances, the best choice is not always clear. *Table 2* lists the recommended indications for the mentioned dental cements, which may serve as a guide for the practitioner in the selection of contemporary dental cement. The recommendation is based on clinical observation, research, and the literature.

Concluding Remarks

With an increase in the types of indirect restorations, the choice of dental cement has become more and more difficult and confusing to the clinicians. Either definitive or provisional dental cement has its unique drawbacks that may prevent their universal usage. Thus, understanding the differences between each class of dental cements will greatly contribute to clinical success of the restoration.

Although zinc phosphate cement is still used in clinical practice and even considered the “gold” standard, advances in dental technology over the last decade have produced new materials, which might eventually replace zinc phosphate cement in the near future. In recent years, with the increase in ceramic restoration types, there has been a shift in the types of cements being used. Resin cements (especially the self-adhesive resin cement) have become increasingly popular, primarily because they are indicated for the widest variety of uses in daily practice. Although self-adhesive resin cements

Table 2. *Recommended types of dental cements for indirect restorations.*

Restoration type	Indicated	Contraindicated
All-metal/PFM crowns	1,2,3	4,5
Short span fixed partial denture	1,2,3,4,5	-
Long span fixed partial denture	3,4,5	1,2
Traditional feldspathic or pressable all-ceramic restorations	4,5	1,2,3
Almuina/Zirconium-based all-ceramic restorations	1,2,3,4,5	-
Metal post and core	1,2,3	4,5
Fiber post	4,5	1,2,3
Maryland bridge	4,5	1,2,3
Composite/porcelain veneer	4,5	1,2,3

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

significantly improve the ease of use, they should not be considered a substitute for conventional resin cements in all situations.

The clinician should give special consideration to the advantages and disadvantages of any dental cement and select them scientifically, and of utmost importance, adhere strictly to manufacturers' instructions.

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Authors' contributions

HY conceived, contributed and wrote the major portion of the manuscript. MZ and RC reviewed and edited the manuscript and compiled the references. HC contributed to all portions of the manuscript and provide personal clinical experiences. All the authors have read and approved the final version of the manuscript.

Conflict of interest statement

The authors declare that there is no conflict regarding this article.

References

1. Hill EE. Dental cements for definitive luting: a review and practical clinical considerations. *Dental Clinics of North America*. 2007; **51**: 643-658.

2. Hill EE, Lott J. A clinically focused discussion of luting materials. *Australian Dental Journal*. 2011; **56** (Suppl 1): 67-76.

3. Walton JN, Gardner FM, Agar JR. A survey of crown and fixed partial denture failures: length of service and reasons for replacement. *Journal of Prosthetic Dentistry*. 1986; **56**: 416-421.

4. Simon JF, de Rijk WG. Dental cements. *Inside Dentistry*. 2006; **2**: 42-47.

5. Attar N, Tam LE, McComb D. Mechanical and physical properties of contemporary dental luting agents. *Journal of Prosthetic Dentistry*. 2003; **89**: 127-134.

6. de la Macorra JC, Pradies G. Conventional and adhesive luting cements. *Clinical Oral Investigations*. 2002; **6**: 198-204.

7. Pegoraro TA, da Silva NR, Carvalho RM. Cements for use in esthetic dentistry. *Dental Clinics of North America*. 2007; 51: 453-471.

8. Shillingburg HT, Hobo S, Whitsett LD. Fundamentals of Fixed Prosthodontics. (3rd edn.) Chicago: Quintessence Publishing; 1997.

9. Erkut S, Kucukesmen HC, Eminkahyagil N, Imirzalioglu P, Karabulut E. Influence of previous provisional cementation on the bond strength between two definitive resin-based luting and dentin bonding agents and human dentin. *Operative Dentistry*. 2007; **32**: 84-93.

10. Ribeiro JC, Coelho PG, Janal MN, Silva NR, Monteiro AJ, et al. The influence of temporary cements on dental adhesive systems for luting cementation. *Journal of Dentistry*. 2011; 39: 255-262.

11. Silva JP, Queiroz DM, Azevedo LH, Leal LC, Rodrigues JL, et al. Effect of eugenol exposure time and post-removal delay on the bond strength of a self-etching adhesive to dentin. *Operative Dentistry*. 2011; **36**: 66-71.

12. Altintas SH, Tak O, Secilmis A, Usumez A. Effect of provisional cements on shear bond strength of porcelain laminate veneers. European *Journal of Dentistry*. 2011; 5: 373-379.

13. Pameijer CH. A review of luting agents. International *Journal of Dentistry*. **2012**: 752861.

14. Sailer I, Oendra AE, Stawarczyk B, Hammerle CH. The effects of desensitizing resin, resin sealing, and provisional cement on the bond strength of dentin luted with self-adhesive and conventional resincements. *Journal of Prosthetic Dentistry*. 2012; **107**: 252-260.

15. Bagis B, Bagis YH, Hasanreisoglu U. Bonding effectiveness of a self-adhesive resin-based luting cement to dentin after provisional cement contamination. *Journal of Adhesive Dentistry*. 2011; **13**: 543-550.

16. Ames WB. A new oxyphosphate for crown seating. *Dental Cosmos*. 1892; **34**: 392-393.

17. Rosenstiel SF, Land MF, Crispin BJ. Dental luting agents: A review of the current literature. *Journal of Prosthetic Dentistry*. 1998; **80**: 280-301.

18. Brannstrom M, Nyborg H. Pulpal reaction to polycarboxylate and zinc phosphate cements used with inlays in deep cavity preparations. *Journal of American Dental Association*. 1977; **94**: 308-310.

19. Donovan TE, Cho GC. Contemporary evaluation of dental cements. *Compendium of Continuing Education in Dentistry*. 1999; **20**: 197-199, 202-198, 210 passim; quiz 220.

20. Smith DC. A new dental cement. *British Dental Journal*. 1968; **124**: 381-384.

21. Craig RG, Powers JM. Restorative *Dental Materials*. (11th edn). St Louis: Mosby; 2002.

22. Charlton DG, Moore BK, Swartz ML (1991) Direct surface pH determinations of setting cements. *Operative Dentistry*. 1991; **16**: 231-238.

23. Christensen GJ. Why is glass ionomer cement so popular? *Journal of American Dental Association*. 1994; **125**: 1257-1258.

24. Habib B, von Fraunhofer JA, Driscoll CF. Comparison of two luting agents used for the retention of cast dowel and cores. *Journal of Prosthodontics*. 2005; **14**: 164-169.

25. Rosenstiel SF, Rashid RG. Postcementation hypersensitivity: scientific data versus dentists' perceptions. *Journal of Prosthodontics*. 2003; **12**: 73-81.

26. Um CM, Oilo G. The effect of early water contact on glass-ionomer cements. *Quintessence International*. 1992; **23**: 209-214.

27. Mojon P, Kaltio R, Feduik D, Hawbolt EB, MacEntee MI. Short-term contamination of luting cements by water and saliva. *Dental Materials*. 1996; **12**: 83-87.

28. Johnson GH, Hazelton LR, Bales DJ, Lepe X. The effect of a resin-based sealer on crown retention for three types of cement. *Journal of Prosthetic Dentistry*. 2004; **91**: 428-435.

29. Yu H, Li Q, Cheng H, Wang Y. The effects of temperature and bleaching gels on the properties of tooth-colored restorative materials. *Journal of Prosthetic Dentistry*. 2011; **105**: 100-107.

30. Yu H, Buchalla W, Cheng H, Wiegand A, Attin T. Topical fluoride application is able to reduce acid susceptibility of restorative materials. *Dental Materials Journal*. 2012; **31**: 433-442.

31. Peutzfeldt A. Compomers and glass ionomers: bond strength to dentin and mechanical properties. *American Journal of Dentistry*. 1996; **9**: 259-263.

32. Xu X, Burgess JO. Compressive strength, fluoride release and recharge of fluoride-releasing materials. *Biomaterials*. 2003; **24**: 2451-2461.

33. Chandrasekhar V. Post cementation sensitivity evaluation of glass Ionomer, zinc phosphate and resin modified glass Ionomer luting cements under class II inlays: An *in vivo* comparative study. *Journal of Conservative Dentistry*. 2010; **13**: 23-27.

34. McCabe JF, Walls AWG. Applied *Dental Materials*. (8th edn). Oxford: Blackwell Publishing Company; 2005.

35. Bowen RL. Properties of a silica-reinforced polymer for dental restorations. *Journal of American Dental Association*. 1963; **66**: 57-64.

36. O'Brien W. *Dental Materials* and their selection. (3rd edn.). Chicago: Quintessence International; 2002,.

37. Kious AR, Roberts HW, Brackett WW. Film thicknesses of recently introduced luting cements. *Journal of Prosthetic Dentistry*. 2009; **101**: 189-192.

38. Diaz-Arnold AM, Vargas MA, Haselton DR. Current status of luting agents for fixed prosthodontics. *Journal of Prosthetic Dentistry*. 1999; **81**: 135-141.

39. Ladha K, Verma M. Conventional and contemporary luting cements: an overview. *Journal of Indian Prosthodontic Society*. 2010; **10**: 79-88.

40. Hekimoglu C, Anil N, Etikan I. Effect of accelerated aging on the color stability of cemented laminate veneers. *International Journal of Prosthodontics*. 2000; **13**: 29-33.

41. Turgut S, Bagis B. Colour stability of laminate veneers: an in vitro study. *Journal of Dentistry*. 2011; **39**: e57-e64.

42. Pereira SG, Fulgencio R, Nunes TG, Toledano M, Osorio R, et al. Effect of curing protocol on the polymerization of dual-cured resin cements. *Dental Materials*. 2010; **26**: 710-718.

43. Aguiar TR, Di Francescantonio M, Ambrosano GM, Giannini M. Effect of curing mode on bond strength of self-adhesive resin luting cements to dentin. *Journal of Biomedical Materials Research Part B: Applied Biomaterials*. 2010; **93**: 122-127.

44. Cadenaro M, Navarra CO, Antoniolli F, Mazzoni A, Di Lenarda R, et al. The effect of curing mode on extent of polymerization and microhardness of dual-cured, self-adhesive resin cements. American *Journal of Dentistry*. 2010; **23**: 14-18.

45. Behr M, Rosentritt M, Wimmer J, Lang R, Kolbeck C, et al. Self-adhesive resin cement versus zinc phosphate luting material: a prospective clinical trial begun 2003. *Dental Materials*. 2009; **25**: 601-604.

46. Radovic I, Monticelli F, Goracci C, Vulicevic ZR, Ferrari M. Self-adhesive resin cements: a literature review. *Journal of Adhesive Dentistry*. 2008; **10**: 251-258.

47. Gomes G, Gomes O, Reis A, Gomes J, Loguercio A, et al. Effect of operator experience on the outcome of fiber post cementation with different resin cements. *Operative Dentistry*. 2013; **38**: 555-564.

48. Yu H, Wegehaupt FJ, Wiegand A, Roos M, Attin T, et al. Erosion and abrasion of tooth-colored restorative materials and human enamel. *Journal of Dentistry*. 2009; **37**: 913-922.

49. Pashley DH, Tay FR, Yiu C, Hashimoto M, Breschi L, et al. Collagen degradation by host-derived enzymes during aging. Journal of Dental Research. 2004; **83**: 216-221.

50. Ricci HA, Sanabe ME, de Souza Costa CA, Pashley DH, Hebling J. Chlorhexidine increases the longevity of *in vivo* resin-dentin bonds. *European Journal of Oral Sciences*. 2010; **118**: 411-416.

51. Zhou J, Tan J, Yang X, Xu X, Li D, et al. MMP-inhibitory effect of chlorhexidine applied in a self-etching adhesive. *Journal of Adhesive Dentistry*. 2011; **13**: 111-115.

52. Valandro LF, Ozcan M, Bottino MC, Bottino MA, Scotti R, et al. Bond strength of a resin cement to high-alumina and zirconia-reinforced ceramics: the effect of surface conditioning. *Journal of Adhesive Dentistry*. 2006; **8**: 175-181.