Ministry of Higher education and Scientific researchUniversity of Babylon College of Dentistry

Cementation of Indirect Restoration

A Project

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Dedication

As well as everything that I do, I would be honoredto dedicate this Project to my parents and my grandmother. They supported me and

Encouraged me on every step in my life and they gaveme everything

Necessary to be who I am now. They always say thatI am going to be a Dentist since childhood so I am about to achieve our dream.

Last but not least I would like to thank my supervisor prof.

Ayat Salah to help me in this project and I am verylucky to be under his Supervision, he is an amazing person.

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Chapter 1

Introduction

Missing or damaged teeth are generally repaired by providing a restoration. Restoration provides a proper tooth function and form to the missing tooth structure while providing for the esthetics as well. Restorations on the basis of method of fabrication are classified as either direct restorations or indirect restorations. Direct restorations are fillings done directly onto the tooth, while indirect restorations are prepared outside the mouth and then cemented to either the tooth or the supporting tooth structure in a separate procedure. Extracoronal restorations cover the crown completely or partially. The retention and resistance form is provided by the external walls of the tooth and the overall surface area. Examples are partial/complete veneers crown, laminates.Intracoronal restorations are the restorations which are confined to the coronal aspect of the tooth gaining the resistance and retention form from the intimate fit of restoration to the opposing walls. Examples are inlays and onlay. Inlays and Onlay are generally practiced when a molar or premolar is too damaged to support a basic filling, but not so severely that they require a crown (Kurth and Kokich ,2001).

Dentists are often confused in various clinical scenarios as to which avenue they should pursue – whether direct or indirect restorations. Therefore, posterior teeth having large cavities showing failed direct restorations with multiple missing cusps; anterior teeth having large interproximal cavities including one or both mesial and distal incisal edges requiring replacement , are preferred examples for indirect restorations .In recent years, several new dental materials have been developed making the choice and the technique of restoration of which is relatively simple. The choice of material is usually depended upon the size of lesion, patients compliance, and esthetics. Up to the date gold is referred to as the standard material to be (Burke FJ and Watts ,1994).

Used in indirect restorations because of its excellent biocompatibility but due to high cost and technique sensitivity new material was introduced porcelain fused to metal (PFM) which also provided with strength but adaptation of base metal underlying the porcelain became the major issue of concern for dentist.Although the advent of all ceramic system has revolutionized the indirect restoration protocol, initially Empress (pressed ceramics) was used which had excellent surface texture and strength but

Later zirconia replaced the metal part of PFM and latest CAD/CAM technology has given promising result with decreased cost(Mohammadi et al.,2009).

Figure. **1** Posterior indirect adhesive restorations (PIAR) made with layered resin-based composite material. The buccal parts are for a cuspal cover- age only, and the palatal surfaces are for a more extended coverage (Ferraris, 2017)

1.1. History of indirect restoration

Indirect materials are generally prepared in a dental laboratory and then placed in or on the teeth; requiring two or more visits to complete the restoration . Later, Plaster of Paris came into use in dental profession after it had been discovered from Paris . John Greenwood was the first to use plaster of Paris as an impression material but was not able to produce appropriate impression because its inflexibility that caused fracture upon its removal (Chabouis et al.,2013).

in 1925, Alphons Poller introduced reversible hydrocolloid to dentistry to fabricate plaster reproductions Later, Sears used agar. type reversible hydrocolloids for taking impression in fixed partial denture . Japan provided for the major source of agar, so during world War II, the irreversible hydrocolloids (alginates) were invented to dental profession. In 1953, polysulfide impression materials were introduced to operative and prosthodontic dentistry Then, the discoveries of polyethers, condensation silicone, and addition silicone offered more stable and less messy materials to dentistry(Quinn ,2007).

The evidence for the use of cast restoration was first found in Mesopotamia (3000BC) where copper was being used to cast. The technique of casting was first introduced in Egypt (2500BC) where lost wax molding process was developed for gold casting. Etruscans (500BC) produced bridges made of soldered gold bands. Then, this technique was adapted by Romans and Europe until the 18th century. Lateron, Chinese developed specific bronze alloys and made elaborated use of lost wax process to produce castings (Weslcott,1870).

In 1937, Pincus developed thin facings made of air-fired porcelain. He attached these thin labial porcelain veneers temporarily with denture adhesive powder to enhance the appearance of the Hollywood actors for their close-up photographs. Pincus was aware of the importance of the ―Hollywood smile‖ as an integral part of the image and public opinion and provided a viable option to the full crown for the actors who needed to temporarily change their smile, yet they possessed very little strength, and the technology necessary to provide a permanent means of attaching the veneers to tooth structure was lacking. This reversible technique provided an alternate for those who wanted their smiles to improve without the need of more aggressive crown preparations. The gingival veneers were introduced in 1955 by Emslin and to mask the unesthetic appearance of gingival recession in a patient who underwent a gingivectomy. In 1990, Dr. Mat Carty introduced lumineers followed by Barnes Ian E who introduced porcelain laminate veneers for dentist and technicians in1999. The MAC (Micro Advanced Cosmetic division) veneer was introduced in 2005, by Micro Dental laboratory at Dublin, Dr. Joel. D. Gould in 2008 introduced The Vinci Veneers at the Da Vinci laboratory in California .Nowadays CAD/CAM system is being used for making indirect restorations providing high strength and accuracy. The First chairside ceramic inlay was made in 1985 using CAD/CAM device which was two dimensional, but Cerec was introduced in 2000 with three-dimensional graphics(Starcke,1975; Asgar ,1971;Ring,2001).

1.2. Indication of Indirect Restoration

- Medium to large-sized cavities where one or more cusps are missing.
- Cavities where the inclusion of at least one cusps is fitting to work on the guess of the complex re-established tooth (VAN DIJKEN and HASSELROT,2010).
- Morphological alteration or potentially raising of the back occlusal vertical dimensions (OVO) in instances of oral recoveries on components where a full-crown rebuilding would be excessively invasive (VAN DIJKEN and HASSELROT,2010).
- Cracked tooth syndrome, when the symptomatology should be man-matured fully intent on keeping up with the vitality of the tooth.
- Multiple medium- to large-sized cavities in the same quadrant (even if indirect inlay restorations are not the first choice

1.3. Contraindications

- ☒ Deep subgingival preparations this is certifiably not a flat out contraindication, deep subgingival preparations edges ought to be kept away from. These edges are hard to record with an impression and are challenging to finish. Moreover, attaching to enamel edges is enormously liked, particularly along gingival edges of proximal boxes (FASBINDER ,2010).
- ☒ Weighty occlusal forces Ceramic restoration efforts might break when they need adequate mass or are liable to exorbitant occlusal stress, as in patients who have bruxing or holding propensities(FASBINDER ,2010).
- ☒ Powerlessness to keep a dry field..

1.4. Advantage

- ☒ Making an optimal life structures of occlusal surfaces,with great control of contact focuses and development profiles (VENEZIANI,2017)
- ☒ The possible use of ceramic materials such as lithium desilicated-reinforced Glass-ceramics (VENEZIANI,2017).
- ☒ Photothermal treatment (130°C for 7 min) works on the level of change of the composite and the physiochemical properties of the reclamation
- ☒ The possibility of an occlusion evaluation with an articulator (MEYER et al.,2006).
- ☒ This strategy emphatically diminishes the restoring shrinkage that happens outside the cavity, working on the peripheral sealing. The last curing shrinkage is in the thin layer of resin cement (VENEZIANI,2017)
- ☒ Biocompatibility and great tissue reaction: Ceramic materials are thought of as the most synthetically dormant of all materials. They are biocompatible and generally related with a decent delicate tissue reaction.
- ☒ Most indirect strategies permit the manufacture of the rebuilding to be absolutely or to some extent appointed to dental lab technicians such delegation considers more effective utilization of the dental specialist's time (VENEZIANI,2017).

1.5 . material of indirect restorations

1.5.1 Complete coverage (full veneer crown): It covers all the coronal portion of the clinical crown such as full metal crown, porcelain fused to metal crown, Jacket crown that is fabricated entirely of plastic material.

1.5.1.1Full Metal Crown

A full metal crown is a dental restoration used to cover or cap a tooth that is extensively damaged or decayed. It is made up of a metal alloy, typically a combination of gold, silver, or other non-precious metals. Full metal crowns are known for their strength, durability, and high resistance to wear and tear. They are often used for molars or back teeth due to their ability to withstand heavy biting forces.

The future outlook of the full metal crown market appears promising. The market is expected to experience steady growth with a projected compound annual growth rate (CAGR) of % during the forecasted period.

This growth can be attributed to several factors:

***Firstly**,* the increasing prevalence of dental diseases and disorders is driving the demand for dental restorations like full metal crowns. As the global population continues to age, the incidence of tooth decay, dental trauma, and tooth loss is expected to rise, fueling the demand for restorative dental treatments.

***Secondly**, t*he growing emphasis on aesthetic dentistry and patient preferences for metal-free or more natural-looking restorations may impact the demand for full metal crowns. While full metal crowns offer excellent strength and durability, their metallic appearance may not appeal to patients seeking a more esthetically pleasing option. This could lead to a shift towards alternative restorative materials such as ceramic or zirconia crowns.

However, despite the potential challenge from aesthetic preferences, the ongoing advancements in dental materials and technologies are expected to help sustain the full metal crown market. Manufacturers are continually improving the alloy compositions to enhance the biocompatibility, corrosion resistance, and esthetics of full metal crowns, thereby expanding their potential patient base.

Overall, the full metal crown market is projected to witness steady growth in the coming years, driven by the increasing need for dental restorations and ongoing innovations in materials and technologies .

Full Metal Crown types is segmented into:

- Noble Metal Alloy
- Base-Metal Alloy
- Titanium

1.5.1.1.1.Noble Metal Alloys

Noble alloys, specifically gold, have had the longest use in dental history, and are often referred to as the standard by which other dental materials are judged.Typically, for dental applications, the metals that are considered to be noble are gold and the platinum-group metals (platinum, palladium, iridium, rhodium, osmium, and ruthenium).Noble metals are comparatively thermodynamically stable and thus inert in a moist environment, making them ideal for use as dental material (although titanium and CrCo alloys provide a kinetic barrier to oxidation;).As dental materials, noble metals must typically be mixed with additional elements to make alloys with increased strength that are useable as indirect restorations. Because gold is so soft and malleable, it must be hardened with copper, silver, platinum, or another hard, durable metal.Adding 10% by weight of copper to gold, for instance, increases tensile strength from 104 MPa to 395 MPa.

- **Gold Crowns**

  When exploring different types of permanent dental crowns, it's important to acknowledge gold crowns as a time-tested option known for their exceptional strength and durability. Gold crowns offer longevity and can withstand the forces of biting and chewing exceptionally well, making them a reliable choice for long-lasting dental restorations.

Figure 2 : Gold Crowns

Advantages

1. Minimal Tooth Preparation: Compared to all-porcelain crowns, gold restorations require less tooth reduction during the preparation process. This preserves more of the natural tooth structure, promoting better long-term oral health.

2. More Affordable: Gold crowns tend to be cheaper than other crown options, but this depends on many factors such as your geographical location and the type of gold crown selected by your dentist.

Disadvantages

1. Appearance: Gold crowns may not be the preferred choice for those seeking a natural appearance due to their visible metallic appearance in the mouth.
2. Back Teeth Only: Unless requested, these crowns are never used for front tooth restorations.
3. They are commonly used for posterior teeth restorations (back teeth), prioritizing strength and functionality over aesthetics. Your dentist will consider factors like tooth location and personal preferences to recommend the most suitable crown type for you

1.5.1.1.2. Base Metal Alloys

By 1980 the increasing price of gold led to the development and increasing use of base metals.However, as noted above, unlike the noble metal alloys that get their corrosion resistance from their relative inertness in the oral environment, base metals used for dental applications can attribute their corrosion resistance to the existence of passive oxide layers. These oxide layers, such as titanium oxide and

Figure 3 :Base Metal Alloys

corrosion to extremely low values under typical oral conditions. The hardness of base alloys compared to gold complicates adjustments,1and base metals are more likely

Common base-metal alloys used in dentistry are:

- Silver-palladium
- Silver-palladium-copper
- Nickel-chromium
- Nickel-chromium-beryllium
- Cobalt-chromium

- **Nickel-Chromium and Cobalt-Chromium** are the most common base alloys, although a number of base elements may be added, including aluminum, molybdenum, manganese, and silicon, to increase strength, castability, and/or resistance to corrosion.

- **Nickel-Chromium alloys** are generally used for crowns and fixed partial dentures.More elastic Cobalt-Chromium alloys have yield strengths from around 240 MPa to 650 MPa,and are used primarily for removable partial dentures.

1.5.1.1.3. Titanium and Titanium Alloys

Titanium has been popular in the medical and dental fields due to its low weight-to-strength, corrosion resistance, and biocompatibility.In contrast to the thermodynamic stability of noble metals, the reaction of titanium with its environment is limited by a tenacious oxide layer (titanium oxide) that controls the rate of corrosion, reducing it to extremely low rates under typical oral conditions.Titanium can be used as a restorative material in its unalloyed form, commercially pure titanium, with yield strengths ranging from 240 MPa to 550 MPa depending on grade. Titanium can be alloyed for higher strengths with aluminum and niobium (Ti-6Al-7Nb, 795 MPa) or vanadium (Ti-6AL-4V, 860 MPa),although there are some biocompatibility concerns with the potential release of toxic vanadium. Titanium and its alloys may be used for crowns, implants, and partial dental . (Jones, 1998, Sharkey, 2011)

1.5.1.2. All-ceramic restorations

Ceramics are biocompatible and inert materials and have a high degree of intra-oral stability. Therefore, they can be safely used in the oral cavity. However, ceramics are brittle materials that can be easily fractured (Jones, 1998, Sharkey, 2011). To combat this weakness, ceramics are usually reinforced with particles, supported by metal, or made purely of polycrystalline material.

When aesthetics are of utmost importance, dental ceramics are the material of choice because they can visually simulate the character of the tooth substance successfully (Contrepois et al., 2013). For instance, the use of all-ceramic restorations has increased in recent years Nevertheless, there is a wide range of ceramic materials and systems on the market that are available for use in dentistry .

All-ceramic restorations can be used as a bi-layered restoration in which a core or framework is veneered by more aesthetic ceramics. They can also be used as full-contour (monolithic) restorations, which can be stained when required.

In general, monolithic restorations have good mechanical properties but may not always provide the required aesthetic requirements. Monolithic restorations are more commonly used in the posterior region of the mouth because the aesthetic is less critical. On the other hand, bi-layered, all-ceramic restorations provide outstanding aesthetic results and may be used in the aesthetic areas (Hermann et al., 2006).The predominantly glass-based ceramics such as feldspathic ceramics are used as veneers to cover the metal coping and framework.

They are also used in the bi-layered, all-ceramic restoration method when the aesthetic is considered a dominant factor (Stappert et al., 2005). Although the predominantly glass-based ceramic restorations are the most aesthetic, they are also the weakest (Castelnuovo et al., 2000). The improved strength of highly filled glass-based ceramics such as leucite- and lithium disilicate–based types are considered for use as inlays and onlays, anterior and posterior crowns, and veneers. They can also be used as a short-span, three-unit, fixed partial denture (FPD). In addition, they can be used as monolithic or bi-layer restorations. Polycrystalline ceramics such as zirconia are more commonly used as monolithic restorations in posterior regions, but they can also be used as cores or frameworks for bi-layer restorations.
Generally, the success of ceramic restorations depends on several factors such as material selection, restoration design, and cementation media (Mizrahi, 2008, Sharkey, 2010, Rekow et al., 2011).

- Materials

1.5.1.2.1 <u>Porcelain fused to metal restorations</u>

A porcelain fused to metal (PFM) restoration is composed of a metal coping that supports overlying ceramic (Fig. 1). PFM restorations have a long clinical track record (Denry and Holloway, 2010). However, failure rates of the PFM fixed partial denture was 4% after five years, 12% after 10 years, and 32% after 15years(Valderhaug,1991).

Figure 4: Porcelain fused to metal restorations

Requirements for the metal alloys used with PFM restorations.

- The melting temperature of the metal alloy is greater than that of the firing temperature of the ceramic (greater than 100OC) to avoid melting and sagging of metal
- The metal's coefficient of thermal expansion (CTE) is slightly greater than that of ceramic veneer to put the ceramic in slight compression and prevent crack propagation on cooling
- Metal alloy has the ability to make a strong bond with the ceramic:
  - hrough the chemical reaction between the metal surface and the ceramic (Chemically)
  - through metal alloy surface roughness which can be achieved after metal surface treatment such as Air-borne abrasion (Mechanically)
  - by the intentional mismatch in the CTEs between the metal alloy and ceramic
- Metal alloy should be stiffand strong enough to withstand imposed forces and resist distortion and bending

- Metal alloys should be thin enough to allow sufficient placement of the ceramic so as to mask it but still be able to resist deformation and distortion during firing and when it is used.

PFM ceramic veneers consist of an opaque ceramic (e.g., a titanium oxide glass) that is required to mask the color of the underlying metal and provides the bond with the metal alloy (Terada et al., 1989). The opaque ceramic bonds to the metal alloy by an oxide layer that is created on the metal surface in a process known as degassing. The degassing process also removes the contaminants from the alloy be polished.surface. A dentine/body ceramic is applied over the opaque ceramic. The dentine ceramics simulate natural dentine. An incisal ceramic is then applied to the incisal third over the dentine/body ceramic. The restoration is also glazed either by the use of a low-fusing glazing ceramic or self-glazed, and it can One of the main **disadvantages** of a PFM restoration is its inability to transmit light, thus having a negative effect on the aesthetic outcome of the restoration because it may appear dark in color (Sharkey, 2010, Sharkey, 2011). This drawback is more noticeable at the cervical area of the restoration where it is sometimes not possible to get enough room. To mitigate this effect, an adequate amount of the tooth structure should be removed to accommodate a ceramic material that can mask the underlying metal without over-contouring the restoration. In addition, the metal coping should stop 1 mm short of the buccal finish line, and a ceramic margin (shoulder ceramic) should be used (O'Boyle et al., 1997, Sharkey, 2011).

Another disadvantage of a PFM restoration is allergic reactions in some patients to metal elements such as nickel in the metal alloy.

Examples of ceramics used in PFM restorations include VM15® (Vita), and IPS InLine (Ivoclar Vivadent) represent powder ceramics, whereas PM9® (Vita) and IPS InLine POM® (Ivoclar Vivadent) represent pressed ceramics.

1.5.1.2.2 All-ceramic restorations

When a ceramic restoration is made completely of ceramic material, it is known as an all-ceramic restoration. In an all-ceramic restoration, the ceramic material may be monolithic (uni-layer) and consist of a single ceramic material, or it may consist of a ceramic core material that is covered with a ceramic veneer (Beuer et al., 2009, Sharkey, 2010) and is known as a bi-layered, all-ceramic restoration. The introduction of newer all-ceramic crowns has increased the popularity of restorations. Now they are stronger, more reliable and more aesthetically-pleasing than ever before. Choices include IPS Empress, a leucite-reinforced pressable porcelain that was one of the first of the newer all-ceramic crowns to be introduced to the market. Lithium disilicate crowns are even stronger and the market leader is IPS e.max. Considerably stronger than PFMs, zirconia crowns are also extremely popular, and choices include solid or monolithic zirconia and high-translucent zirconia, both of which provide excellent aesthetics.

1.5.1.2.3 **Glass-based Systems**

Leucite Reinforced Pressable Porcelain Crowns

Originally introduced 15 years ago, IPS Empress pressable crowns have a flexural strength of 160MPa and have proven to be durable and to provide excellent aesthetics. With this system, it is possible for clinicians to achieve restorations that closely replicate natural teeth. A die-shade guide is used to determine the shade of the tooth preparation, helping to decide the right tooth shade. This information allows the technician to select the correct ingot when pressing the crown. IPS Empress crowns have a high translucency which helps to transmit the shade from adjacent teeth so it is possible to obtain an exact shade match even for more difficult cases.

Lithium Disilicate Porcelain Crowns
Made from biocompatible lithium disilicate ceramic glass ingots, IPS e.max crowns are resilient to fracturing with a flexural strength of 400MPa, which is three times stronger than Empress. Crowns can be pressed or milled to offer good fit and function. With e.max, it is possible to create full-contour restorations, or to layer enamel porcelain using IPS e.max Ceram, a comprehensive layering ceramic capable of achieving highly aesthetic results

1.5.1.2.4.**Resin-matrix Composites**

Resin-matrix materials as indirect restorations have the advantage of being easy to manipulate.12, 30, 31 Resin-matrix composites are capable of higher degrees of filler loading and polymerization than direct composites and, because they are cured outside the mouth, polymerization shrinkage does not occur as it does in direct resin-matrix composite restorations.12 CAD/CAM resin-matrix composite blocks for indirect restorations can be more biocompatible than direct composite counterparts, often made with alternative, non-toxic resins and more resistance to degradation and leakage (see Biocompatibility Concerns section, below).30 They generally consist of a urethane dimethacrylate (UDMA), triethylene glycol dimethacrylate (TEGMDA), and/or bisphenol A-glycidyl methacrylate (Bis-GMA) matrix with silica, silica-based glasses, glass-ceramics, zirconia, and/or zirconia-silica ceramic fillers.30, 31 Resin-matrix composites in the form of composite blocks have more flexibility to masticatory stress, with lower abrasivity to opposing teeth, but lower flexural strength (100 - 200 MPa) and fracture toughness (0.8 - 1.2 MPam1/2) than typical CAD/CAM blocks. Due to their lower strength, they are primarily indicated as an alternative for inlays, onlays, and single unit crowns

1.5.1.2.5 Zirconia crowns

Patients need crowns that look great, work well, and aren't toxic to their body. Dentists want those things, too, and they want them made out of material strong enough to hold up to bite forces without fracturing. Zirconia crowns live up to these demands in many cases.
Zirconia was around for a long time before it became a material in dentistry. A German chemist Martin Heinrich Klapropse first introduced the idea of zirconium dioxide as a bioceramic in the 18thcentury. However, it didn't start serving dentists as a restorative material until the late 20th century (1995).

Today, zirconia is a popular crown material in today's dental operatories, often replacing materials like porcelain-fused-to-metal or even gold crowns. However, like any material, zirconia crowns have problems sometimes. In this article, we look at the advantages and disadvantages of zirconia crowns.

The three types of zirconia crowns

There are several types of zirconia materials. Each of them has different features and benefits that contribute to patient outcomes, which can affect what you want to choose for your case.

Zirconia has varying structures at different temperatures. It is monoclinic (i.e., the crystals have three axes of uneven length, and two of them are perpendicular to each other) at room temperature. However, mixing it with elements like yttrium, calcium,

magnesium, or cerium, changes the structure as it stabilizes at room temperature.

For example, adding 8% yttrium (Y_2O_3) transforms the structure to cubic at room temperature, referred to as cubic-stabilized zirconia (CSZ). With 3-to-8% yttrium, it's a mix of tetragonal and cubic phases at room temperature, called partially stabilized zirconia (PSZ). When it's around 3% yttrium, it's mostly tetragonal at room temperature and is called tetragonal zirconia polycrystal (TZP) or toughened zirconia. This TZP material was one of the early types of zirconia used in dentistry. Similarly, cerium-stabilized zirconia (Ce-TZP) also has a tetragonal structure when cerium is added.

To clarify the significance of the amount of yttrium in zirconia, it affects how strong and clear it is. It's usually given as a percentage, like 3%, 4%, or 5%. However, it is critical to note that these percentages are actually in tenths, so a small change can make a big difference in the properties of the material.For example, zirconia with about 3% yttrium is very strong, with mostly a tetragonal structure. On the other hand, zirconia with about 5% yttrium is more translucent, with about half of its structure being cubic. So, the amount of yttrium makes zirconia stronger or clearer

.

The three types of zirconia used in dental crowns are:

- Solid or monolithic zirconia
- Layered zirconia
- High translucent zirconia

1.5.1.2.5.1 Solid or monolithic zirconia

Solid or monolithic zirconia, also called Full-Contour, is the most opaque of zirconia styles. Solid zirconia crowns are a popular choice because of their durability and because they require less occlusal clearance than other crown materials.

As a single material, monolithic zirconia has several advantages. First, it has flexural strength like its metal counterparts. It is also multichromatic. Since it is one single material, it has a manufactured consistency. Plus, it has great aesthetics with multi-layered color.

However, it also has a disadvantage. If you use it below the minimum thickness, it doesn’t perform.

Generally, monolithic zirconia is recommended for posterior crowns. There are two primary reasons for this:

- **Monolithic zirconia is opaque.** Monolithic zirconia lacks the translucency of other zirconia types, and the opaque color can be difficult to match teeth that are situated at visible points of the mouth.
- **Monolithic zirconia contains many stabilizers.** Oxide additives are used in zirconia to add strength and durability. Solid zirconia contains more of these stabilizers than other kinds of zirconia, making them perfect for the primary job of the molars at the back of the mouth—aka, chewing. Patients who tend to grind their teeth may also be better served by the durability of monolithic zirconia.
-

So, how long do zirconia crowns last? It depends on many things, but when you have a monolithic zirconia crown, chances are they will hold up for a long time. Also, in addition to their durability, monolithic zirconia crowns cause less wear to neighboring teeth.

1.5.1.2.5.2 Layered zirconia

The idea behind using multi-layered zirconia in dental work is to make artificial teeth look more like real ones. Natural teeth have a gradient in color, with the outer being more see-through and getting darker and less translucent towards the gumline. Various types of this layered zirconia are recommended for different dental procedures based on how they look and work.

Layered zirconia is coated with a special ceramic where the teeth are visible. However, only the visible surfaces are layered; the occlusal surfaces remain full zirconia to ensure durability.

With this modification, the answer to the question, “How long will this type of zirconia crown last?” will still be a satisfying answer.
The ceramic layering is why layered zirconia a popular choice for anterior crowns. There are a couple of reasons for this, which include:

- **Layered zirconia creates a more realistic-looking smile**. Compared to full zirconia, layered zirconia is more translucent and opalescent.

- **Layered zirconia allows you to skip the extra layer if you want**. The improved aesthetics mean you can use it in the visible zone with or without porcelain layering.

Another significant advantage of layered zirconia is that the color variation you see in the finished tooth is part of the zirconia itself. With older types of zirconia, the coloring was added to the outside of the restoration with special stains. However, if the patient brushed their teeth vigorously or had an acidic oral environment, those added colors could wear off, and the tooth would look the same color all over. With layered zirconia, even if the added color on the surface wears off, the tooth keeps its color variation because it’s built into the material.
Although layered zirconia is perfect for anterior crowns, it can also be used for posterior crowns, provided there’s room for the amount of clearance layered zirconia crowns require. However, when you are using it in the posterior, recognize that layered zirconia is weaker than monolithic zirconia, if only slightly.

1.5.1.2.5.3 High translucent zirconia

High translucent zirconia is considered the most natural-looking of all zirconia types. Its heightened translucency allows it to reflect the color of the teeth surrounding it, leading to crowns that blend in more with the rest of the teeth in the mouth.
The further individual benefits of high translucent zirconia may include:

- **Enhanced durability** – High translucent zirconia is sturdier than other kinds and far stronger than traditional porcelain crowns.
- **A quicker implant procedure** – High translucent zirconia doesn’t require any of the fine-tuning that other crowns need, like color shadings or glazes. This can also cut back on the time it takes for those kinds of additions to dry.

1.5.1.2.5.4 Zirconia crowns advantages

- No matter what type of zirconia you and your patient decide on for their crowns, there are many ways this dental option can elevate their smile. Here are the three top advantages of zirconia crowns:
- **Zirconia crowns are biocompatible.** Biocompatibility means your patients don't have to worry about their zirconia crowns negatively interacting with the living tissue in their mouth. Zirconia is non-toxic and naturally hypoallergenic.
- **Zirconia crowns are customizable.** Zirconia is an incredibly customizable material, thanks to its chemical composition and the range of technologies that have been developed to work with the material. When it comes to zirconia crowns, that means designing for the needs of specific patients is more feasible than ever. For your patients, this helps ensure a perfect fit and long-lasting comfort.
- **Zirconia crowns are metal-free.** Zirconia crowns contain zero metal, which makes them the obvious choice for people with nickel allergies or other metal sensitivities.
- **Zirconia crowns are digital friendly.** Due to new dental technology, zirconia crowns can be fabricated 100% digitally. You can start by taking a digital impression. The crowns are then digitally designed with CAD/CAM technology and are precisely milled so that seating requires fewer chairside adjustments.
- **Zirconia crown cementation is easy**. Zirconia crowns are cemented differently; however, the process can be simpler and more efficient than their other ceramic counterparts.

1.5.1.2.5.5 Zirconia crowns disadvantages

The disadvantages of zirconia crowns are essential to understand, also. For example, the opaque appearance of some zirconia types can make the restoration look less natural than other crown materials. Also, they can be pricier than crowns of other materials, which makes them less accessible for patients. (VENEZIANI,2017)
Furthermore, it is essential to remember that while zirconia crowns can be an excellent option for many patients, a few potential challenges associated with zirconia crowns could present. Let's examine a couple of possible zirconia crown problems—and how innovative technology can help to mitigate them:

- **Discoloration** – In the past, it could be difficult and time-consuming to match zirconia crowns to the color of neighboring teeth. However, digital options like Dandy's intraoral scanning technology nullify this problem with zirconia crowns; shade matching workflows help to ensure that digitally produced zirconia teeth are the perfect shade, creating a seamless aesthetic.

- **Potential damage to neighboring teeth** – Some members of the dental community have raised concerns that a hard, durable material like zirconia might wear away the comparatively soft texture of natural enamel in the neighboring teeth. To address this common issue, Dandy's dedicated CAD design team places a special emphasis on proper spacing and alignment of zirconia teeth. Such digital workflows help to prevent any deterioration caused by wear and tear.

In addition, some contraindications for zirconia crowns can also occur. A zirconia crown is not recommended when the:

- Preparations have very little reduction (less than 0.6 mm) and thin walls.
- Strong biting forces occur where the opposing contact is zirconia also (as microscopic breakdown can occur)
- Opposing contact is made of cast gold or polymer (to prevent excessive wear)
- Case requires precision attachments
- Aesthetics are paramount (unless the dental lab can apply the right stains, fire it correctly, and polish it without making it look gray or shiny and without using a glaze

1.5.2. Partial coverage(partial veneer Crown)

An extracoronal metal restoration that covers only part of the clinical crown is considered to be a partial veneer crown. It can also be referred to as a *partial-coverage restoration.* An intracoronal cast metal restoration is called an *inlay* or an *onlay* if one or more cusps are restored. Examples of these restorations are presented in Figure 10-1. Partial veneer crowns generally include all tooth surfaces except the buccal or labial wall in the preparation. Whenever feasible, a partial-coverage restoration should be selected, rather than a complete veneer, because it preserves more of the tooth's coronal surface. However, the preparation is more demanding and is not routinely provided by practitioners. Buccolingual displacement of the restoration is prevented by internal features (e.g., proximal boxes and grooves). The partial veneer can be used as a single-tooth restoration, or it may serve as a retainer for a fixed dental prosthesis (FDP). It can be used on both anterior and posterior teeth. Because it does not cover the entire coronal surface, it tends to be less retentive than a complete crown and is less resistant to displacement. Unless the partial veneer is very carefully prepared, the reduced retention may contraindicate its use. Inlays and onlays are even less retentive than partial veneer crowns and are not recommended for FDP retainers. However, they provide the advantages of a casting, with less enamel removal than for a crown. When carefully prepared, they can produce an exceptionally long-lasting restoration.

1.5.2.1 Indications

Partial veneer crowns often can be used to restore posterior teeth that have lost moderate amounts of tooth structure, if the buccal wall is intact and well supported by sound tooth structure. They are also commonly used as retainers for an FDP or where restoration or alteration of the occlusal surface is needed. Anterior partial veneers are rarely suitable for restoring damaged teeth, but they can be used as retainers, to reestablish anterior guidance, and to splint teeth. They are particularly suitable for teeth with sufficient bulk because they can accommodate the necessary retentive features.

1.5.2.2 Contraindications

Partial veneer restorations are contraindicated on teeth that have a short clinical crown because retention may not be adequate. They are also contraindicated as retainers for long-span FDPs. They are rarely suitable for endodontically treated teeth, especially anterior teeth, because insufficient supporting tooth structure remains for the retentive features. Likewise, they should not be used on endodontically treated posterior teeth if the buccal cusps are weakened by the access cavity or on teeth with an extensively damaged crown. As is true of all cast restorations, partial veneer restorations are contraindicated in dentitions with active caries or periodontal disease.

The shape and alignment of teeth are important determinants of the feasibility of partial veneer crowns. The alignment of axial surfaces should be evaluated, and partial veneer crowns should not be placed on teeth that are proximally bulbous. Making the necessary proximal grooves on these teeth is likely to leave unsupported enamel. It may be similarly impossible to prepare adequate grooves on thin teeth of restricted faciolingual dimension.

Partial veneer crowns are usually prepared parallel to the long axis of the tooth, and poorly aligned abutment teeth may not be suitable. When poorly aligned teeth are being prepared for a partial-coverage restoration, problems with unsupported enamel often result.

1.5.2.3 Advantages

The primary advantage associated with partial veneer crowns is conservation of tooth structure. Another advantage is reduced pulpal and periodontal insult during tooth preparation. Access to supragingival margins is rather easy and allows the operator to perform selected finishing procedures that are more difficult or impossible with complete coverage restorations. Access is also better for oral hygiene. Because less of the margin approximates the soft tissues subgingivally, there is less gingival involvement than with complete coverage.

During cementation of a partial veneer, the luting agent can escape more easily, which produces relatively good seating of the restoration. Because of direct visibility, verification of seating and cement removal are simple. When the restoration is in service, the remaining intact facial or buccal tooth structure permits electric vitality testing.

1.5.2.4 Disadvantages

Partial veneer restorations have less retention and resistance than do complete cast crowns. Preparing the tooth for this type of coverage is difficult, primarily because only limited adjustments can be made in the path of placement. The preparation of grooves, boxes, and pinholes requires dexterity of the operator. Some metal is displayed in the completed restoration, which may be unacceptable to patients with high cosmetic expectations.

1.5.2.5 inlays and onlay

In dentistry, **inlays and onlays** are used to fill cavities,and then cemented in place in the tooth. This is an alternative to a direct restoration, made out of composite, amalgam or glass ionomer, that is built up within the mouth.

Inlays and onlays are used in molars or premolars, when the tooth has experienced too much damage to support a basic filling, but not so much damage that a crown is necessary. The key comparison between them is the amount and part of the tooth that they cover. An inlay will incorporate the pits and fissures of a tooth, mainly encompassing the chewing surface between the cusps. An onlay will involve one or more cusps being covered. If all cusps and the entire surface of the tooth is covered this is then known as a crown.(*Dr. Jennifer Dean* 2018-10-25.)

Figure 5:inlay and onlay

Historically inlays and onlays will have been made from gold and this material is still commonly used today. Alternative materials such as porcelain were first described being used for inlays back in 1857.(Due to its tooth like colour, porcelain provides better aesthetic value for the patient. In more recent years, inlays and onlays have increasingly been made out of ceramic materials. In 1985, the first ceramic inlay created by a chair-side CAD-CAM device was used for a patient. More recently, in 2000, the CEREC 3 was introduced. This allows for inlays and onlays to be created and fitted all within one appointment.Furthermore, no impression taking is needed due to the 3D scanning capabilities of the machine.

inlays

Inlays are indirect restorations which do not have cuspal coverage and are within the body of the tooth.Sometimes, a tooth is planned to be restored with an intracoronal restoration, but the decay or fracture is so extensive that a direct restoration, such as amalgam or composite, would compromise the structural integrity of the restored tooth or provide substandard opposition to occlusal (i.e., biting) forces. In such situations, an indirect gold or porcelain inlay restoration may be indicated.

Onlays

Onlays are indirect restorations that cover both body and cusps of teeth.When decay or fracture incorporate areas of a tooth that make amalgam or composite restorations inadequate, such as cuspal fracture or remaining tooth structure that undermines perimeter walls of a tooth, an onlay might be indicated.Similar to an inlay, an onlay is an indirect restoration which incorporates a cusp or cusps by covering or *onlaying* the missing cusps. All of the benefits of an inlay are present in the onlay restoration. The onlay allows for conservation of tooth structure when the only alternative is to totally eliminate cusps and perimeter walls for restoration with a crown. A systemic review found that the most common cause of onlay failure is ceramic fracture, followed by ceramic de-bonding from the tooth structure, and the occurrence of secondary caries which is seen as a discolouration at the margins of the restoration. High failure rates were associated with teeth that had previous root canal treatment, and with patients who exhibit para-functional habits such as bruxism, or teeth clenching Just as inlays, onlays are fabricated outside of the mouth and are typically made out of gold or porcelain. Gold restorations have been around for many years and have an excellent track record. In recent years, newer types of porcelains have been developed that seem to rival the longevity of gold. If the onlay or inlay is made in a dental laboratory, a temporary is fabricated while the restoration is custom-made for the patient. A return visit is then required to fit the final prosthesis. Inlays and onlays may also be fabricated out of porcelain and delivered the same day utilizing techniques and technologies relating to CAD/CAM dentistry.

1.5.2.6 Occlusal-veneer (or "table-top"):

This is a thin (1 to 1.2 mm) bonded posterior occlusal partialcoverage preparation with a non-retentive design. It is indicated, above all, in advance erosion of the occlusal surface or in clinical restorative cases where the vertical dimension needs to be increased.An in vitro fatigue study concluded that CAD/CAM superthin (0.6 mm) composite resin occlusal veneers had significantly higher fatigue resistance when compared to ceramic occlusal veneers.

Figure 6: Detail of minimally invasive preparations,,The ultra-thin Lithium disilicate pressed occlusal veneer (IPS e.max Press) of quadrant4 after adhesive cementation.

1.5.2.7 Overlay-veneer (or "veneerlay")

This is used in the case of a restoration that involves the occlusal surface that extends to the entire buccal surface due to either esthetic or functional considerations. It is indicated in teeth positioned in esthetic areas (typically maxillary premolars) with significant loss of hard tissue, heavily discolored, and resistant to bleaching.The gold standard material is ceramic(lithium disilicate).

1.5.2.8 Materials

1.5.2.8.1 Gold

The use of gold as a restorative material for the production of inlays and onlays is fading due to the increase in usage of more aesthetically pleasing tooth coloured materials. Gold has many advantages as a restorative material, including high strength and ductility, making it ideal to withstand the masticatory forces put upon the teeth. It is strong, ductile, can be cast accurately and not abrasive to opposing dentition. This property allows gold to be used in thinner cross sections, meaning less tooth tissue needs to be removed during tooth preparation compared to other restorative materials, to achieve the same strength. The tooth preparation needs near parallel wall and an absence of undercut, hence less occlusal and axial reduction. When the patient is not concerned with aesthetics, such as in posterior teeth, gold can provide the properties needed.(Santamaria, Ruth M. (2015-12-31)).

1.5.2.8.2 Ceramice Materials

Ceramic materials began being used in restorative dentistry in the 1900s. Ceramic offers a more aesthetically pleasing restoration colour than previous gold and amalgam restorations. It is aesthetic and has high wear resistance.[33]However, ceramic used as a restorative material without metal reinforcement have reduced strength and are more prone to failure.

This is because conventional ceramics have a higher fracture risk and fractures can propagate easily under cyclical loading causing marginal ridge or bulk fracture.To compensate for this, ceramic is placed in a thicker cross-section of at least 2mm for stress bearing areas. This reduces flexure under loading and prevents crack formation.Ceramic can also be abrasive to opposing tooth surfaces upon mastication. More tapered walls are needed in tooth preparation. Undercuts can be eliminated by further tooth preparation or be blocked out with an adhesive tooth - coloured material. (Santamaria, Ruth M. (2015-12-31)).

1.5.2.8.3 Composite

Resin composite is widely used in dentistry as a direct and indirect restorative material. It comes in different compositions, variable in content and size of filler particles. Composite inlays and onlays offer great aesthetics, as a combination of different shades and opacities can be used in a layering technique, equalling or surpassing the aesthetically pleasing all-ceramic restoration. It can be easily repaired or modified as composite can bond to existing material. Using composite as a direct restoration can have a relatively high polymerisation shrinkage, but this can be avoided by using a laboratory indirect composite restoration. Due to the more in-depth curing method, using heat, pressure or strong light, this can have a lower polymerisation shrinkage. Lab made composite has reduction in polymerisation shrinkage as there is higher degree of curing in lab as compared to chair-side curing. However, fewer reactive resin groups are available to bond to the resin luting cement indicating lower accuracy in fitting compared to the other materials.However, using this indirect laboratory method demands more skill and time, and is more destructive as tooth preparation is needed prior to taking an impression. Compared to ceramic and gold inlays and onlays, composite can provide similar advantages, but a comparison of the longevity of composite is unknown. (Santamaria, Ruth M. (2015-12-31)).

1.5.2.8.4 Metal-ceramic

Metal-ceramic inlays were developed to see if the aesthetic advantages of an all-ceramic inlay restoration could be replicated, whilst improving the strength and stability of the restoration. A study showed that the fracture resistance of all-ceramic inlays was greater than that of these metal-ceramic inlays. It went on further to find that it was the taper of the inlay preparation that affected the fracture resistance more so than the choice of restoration material. (Santamaria, Ruth M. (2015-12-31)).

Table 1-1: Differentce between partial and full veneers

Key Differences between Partial and Full Veneers

Differences	Partial Veneers	Full Veneers
Tooth Preparation	No or minor tooth reduction needed for veneer application	A portion of the enamel needs to be removed for fitting of the veneer
Coverage Area	Only covers discoloured or damaged areas of the tooth	Full tooth coverage of the front, sides, and biting portion
Thickness	Thin shell	Thicker shell
Reversibility	Removeable if need be	Permanent as a portion of the enamel is removed
Durability/Longevity	Susceptible to damage	Extremely durable
Costs	Affordably lower cost (dependent on material and number needed)	Higher cost ranging up to $2,000 per tooth (dependent on the material and number needed)
When Needed	Eroded tooth enamel, tiny cracks, cavities, slight discolouration	Large chips/cracks, gaps, misalignment, severe discolouration

1.5.3. Complete replacement (Post crown)

The use of posts to retain indirect restorations in structurally compromised teeth is a technique that has been used for many years. There are many factors that need to be considered prior to the provision of post- and core-retained crowns to reduce the risk of failure. This includes case selection and an understanding of the cumulative prognostic endodontic, periodontal and prosthodontic factors .

Post and core restorations have been used as a treatment modality for structurally compromised teeth since 1728, when Pierre Fauchard described the use of metal screws in the roots of maxillary anterior teeth to retain crowns made from ivory and bone. (D. Non metal post systems.. 2001) Since then, posts and cores have been widely used to provide retention on teeth that would otherwise have had insufficient coronal tissue to retain a crown. There has been much advancement since 1728 in the characteristics and materials of post systems, meaning that clinicians have a plethora of options from which to choose.

Although it has been suggested that there is a high failure rate associated with post- and core-retained crowns, a clinical study by Sorensen and Martinoffdemonstrated that, although posts may not reinforce teeth, success with this treatment modality is possible, with success rates of 87.3% and 100% for tapered cast posts and parallel-sided posts, respectively, when the length of the post was greater than the length of the crown. (Lewis R, Smith BG1988;)

Furthermore, a study by Valderhaug *et al* reported that crowned teeth with good quality endodontic treatment and a post and core with optimal morphology had a similar 25-year survival rate to that of crowned teeth with a vital pulp. These studies demonstrate that clinical success is significantly reliant on operator skill and appropriate case and material selection .

Chapter 2

Cementation

Cementation is a crucial step in the process of ensuring the retention, marginal seal, and durability of indirect restorations. Since the introduction of the first all-porcelain crown in the early 1900s, various cements have been used to adhere porcelain crowns to tooth structure. Initially, only luting cements were available for use, which led to many failures.Presently, another category has been added—the adhesive cements. Resin cements fall into this category of adhesive cements. Adhesive cements must bond to a variety of different substrates, including dentin and enamel, porcelain and other ceramics, gold and other metal alloys, and indirect resin composites(White et al.,1995).

There are several characteristics of resin cements that make them clinically superior luting agents. Resin cements may have high bond strengths both to tooth structure and porcelain, high tensile and compressive strengths, and the lowest solubility of the available cements. Flexural properties—including modulus and strength—are important to prevent de-bonding during function, and resin cements have both a high modulus and strength. In fact, they have the highest strength of the cements currently in use(White et al.,1995).

The disadvantages of resin cements are associated with their technique sensitivity and difficulty with clean-up. Resin cements may change shade during curing and can darken during their lifetime. This can be a crucial factor, especially since esthetics is a particularly important characteristic for all-ceramic restorations. Because these materials depend upon bonding, the operator must be careful to follow all steps in proper order and with the recommended time for each step(White et al.,1995).

2.1.Materials

Selection of a luting agent options for luting agents today are zinc phosphate, glass-ionomer, polycarboxylate, resin, and resin-modified glass-ionomer cements. Resin cements and resin modified glass-ionomer cements have gained popularity in recent years, with much of the current research in the area of cements focused on these two materials. According to surveys, there has been a significant shift in routine cement use from zinc phosphate, zinc polycarboxylate, and conventional glass ionomer to resin and resin-modified glass-ionomer cements. More than two-thirds of North American practices have elected resin cements and resin-modified

glass-ionomer cements as their first choice. Purportedly, they are superiorto zinc phosphate in terms of retention, strength, and solubility and are comparable in terms of film thickness. The type of cement used does not seem to influence the final marginal adaptation. The ease of manipulation and strict adherence to the protocol for each specific luting agent have a more significant impact on the ultimate strength and solubility properties, which, in turn, affect the clinical performance of the definitiverestoration. Because the indications and procedures for each luting agent are different, they are discussed separately(Christensen and Christensen 2004; Piwowarczyk A, Lauer.,2003).

2.1.1 Zinc phosphate cement

Zinc phosphate cement consists of a powder containing 90% zinc oxide and 10% magnesium oxide that is incorporated into a liquid containing approximately 67% phosphoric acid.Among the many luting agents available, zinc phosphate has the longest record (more than 100 years) of successful use.It has good compressive strength and low film thickness, and it is relatively easy to manipulate. Excess cement is easily removed after it has set. Relatively high compressive and tensile strengths make it a good choice for long-span fixed partial dentures.In a study of Zinc phosphate cement samples taken from castings that had been in servicefor up to 48 years, the cement was found to have maintained a stable chemical structure(Johnson et al.,2009).

Zinc phosphate cement is slightly soluble in oral fluids, allows relatively high levels of microleakage, and is sometimes associated with postoperative sensitivity. Despite these drawbacks, it is not unusual to seepatients with gold castings that were cemented more than 30 years ago with zinc phosphate cement. In a study of eight restorations that had been in service for 22 years despite positive microleakage tests, no evidence of carious tooth structure, sensitivity, or pulpal degeneration was observed. Zinc phosphate cement should be mixed on a glass slab that has been chilled, preferably to just above the dew point to avoid water condensation that could contaminate the mix and weaken the set cement. Powder should be mixed into the liquid in small increments over a large area of the glass slab. This method dissipates the heat released during the exothermic setting reaction and provides a longer working time. The slower the mix and cooler the glass slab, the longer the working time. A cool glass slab also allows more powder to be incorporated into the liquid, resulting in improved mechanical properties. From a practical standpoint, refrigerated glass slabs (4şC) always induce water condensation, but the coldness of the slab still allows the incorporation of more powder to the mix, which compensates for the water contamination and leads to improved compressive strength. Powder is added until the mixed material adheres to the spatula to form a 1-inch string when the spatula is lifted from the glass slab. The mixing should be completed within 90 seconds after initiation. If the mixing is prolonged beyond approximately90 seconds, the hardening of the cement

caused by the setting reaction may be confused with having

Figure 7:Zinc phosphate cement

achieved the proper powder-liquid ratio. Its relatively long working time makes zincphosphate cement a good choice when multiple castings are luted at the same time. However, because of a lack of a bond to tooth structure and the mixing-technique sensitivity, zinc phosphate is used less frequently now(Johnson et al.,2009)

2.1.2.Glass-ionomer cement

Traditional glass-ionomer luting cement is a modification of the glass- ionomer restorative material. It consists of a powder containing aluminum fluorosilicate glass particles that are incorporated into a liquid containing polyalkenoic acids. In some products, these acids are freeze-dried and included in the powder that is mixed with water.It bonds to tooth structure by formation of ionic bonds to hydroxyapatite crystals in enameland dentin.It is speculated that glass ionomers have the potential to inhibit caries because of fluoride release, but the critical level of fluoride release over time to prevent caries is well beyond the release rate of current glass-ionomer luting cements.

Figure 8: GIC

Glass-ionomer luting cement has a low film thickness (20 to 25 µm) and better mechanical properties than zinc phosphate cement. However, a glass ionomer may take a significant amount of time before reaching ultimate strength(Johnson et al.,1993).

Glass-ionomer cements may be hand-mixed but are also available inreweighed capsules that allow mixing in an amalgamator. Empirical reports of excessive postoperative sensitivity associated with glass ionomer luting agents have not been borne out in clinical studies. Glass ionomer cements appear to be more technique sensitive than zinc phosphate cements because the surface of the preparation needs to remain moist before cementation and the cement at the margin of the restoration must be isolated from moisture but not desiccated after cementation (Mojon et al.,1992).

Glass-ionomer cement is very sensitive to early moisture contamination. If exposed to external moisture during the setting reaction (usually 5 minutes), the setting reaction is interrupted, resulting in a cement with high solubility and poor mechanical properties(Musa et al.,1996).

Therefore, glass-ionomer cement should not be used unless contamination can be prevented. As with glass-ionomer restorative materials, dehydration is also a problem. Excess cement should not be removed from the margins for at least 5 minutes after the crown is seated. Leaving a bead of excess cement in place protects the underlying layersof cement from moisture contamination(Musa et al.,1996).

Because glass-ionomer cement bonds to the tooth surface, excess cement is somewhat difficult to remove once set, particularly in the interproximal areas.When glass-ionomer cement is mixed by hand, the pre-measured powder is incorporated into the premeasured liquid in bulk as quickly as possible. A chilled slab has been shown to significantly increase the working time for glass-ionomer cements, as it has for zinc phosphate cements.Most manufacturers now offer an encapsulated form of glass- ionomer luting cement; this results in properlyproportioned cement that isthoroughly mixed in a few seconds. Glass-ionomer cement has a relatively short working time, so a single mix should be limited to luting no more than two or three units. If additional units have to be luted, a new mix of cement should be used(Matsuya et al.,1996).

2.1.3 Polycarboxylate and zinc oxide–eugenol cements

Polycarboxylate and zinc oxide–eugenol cements are no longer widely used with cast restorations. Their properties are generally inferior to those of the cements previously discussed. Historically, some clinicians have used them if a tooth has had a history of sensitivity. They have also been used as temporary luting agents and with stainless steel crowns.

2.1.4 Resin luting cements

Resin cements patented since 2002 come either with a separate self- etching bonding agent, such as Panavia F (Kuraray) and Multilink Automix (Ivoclar Vivadent), or with an incorporated self-etching primer, such as RelyX Unicem (3M ESPE) and Maxcem (Kerr). These cements have shown low microleakage, high shear bond strength, and adhesive properties to tooth structure. However, they have other additional challenges. First, they are significantly more technique sensitive tha traditional luting agents. Most require multiple time-consuming steps and strict moisture control. In addition, resin cements are very difficult to remove from crown margins once they are completely set. Removal of cement flash is made difficult by the relative inaccessibility of crown margins, irregular root topography, and the clear or tooth-colored nature

of many resin cements. For these reasons, many clinicians do not use resin cements routinely for posterior applications. However, some circumstances dictate the use of resin cement. Because of their adhesive properties, a resin cement is the material of choice when luting a crown with minimal retention and resistance features. In addition, resin cements must be used when bonding all-ceramic etchable, noncore crowns. (Blair et al.,1993).

Figure 9 :Resin luting cement

Resin cements are especially designed for use with bonded ceramic restorations, but they may also be used with cast restorations. They are generally supplied as a dual-paste system in which the two parts are mixed just prior to the cementation process. Polymerization may be initiated by a chemical catalyst or by a combination of a chemical catalyst and a light-activated catalyst, but for cast restorations, chemically cured cements are indicated. Resin cements differ from resin composite restorative materials primarily in their reduced filler content reduction of the filler content leads to better flow and reduced film thickness, which are desirable properties for a luting cement. Some resin cements contain fillers that are capable of providing fluoride release, although there is questionable therapeutic effect because of the low levels and short duration of fluoride release. Resin cements have the best mechanical properties of all of the cements. They are virtually insoluble in oral fluids and have the highest compressive and tensile strengths of all the cements. They also exhibit less microleakage than other luting agents. If used in combination with a dentin adhesive system, they bond to tooth structure and to some metals. For this reason, as previously stated, they are often recommended for less-retentive preparations. There are several potential problems associated with resin cements. There is great variation in the mechanical properties and handling characteristics among resin cements, which can cause confusion for clinicians. The film thickness tends to be greater than that of other cements, so incomplete seating of the casting could be a problem. This is especially true when a dentin adhesive is used, because without due care, it can pool in the internal angles of the preparation. Resin cements require the most clinical steps if used with an adhesive system, so there is more chance for an error in technique to occur. There are no long-term clinical studies to determine if the high retention values and low microleakage are long lasting in castings cemented with resin cements (Jacobson and Rees,1992;Burgess et al.,1996).

2.2 Resin Cement Classifications

Resin cements may be classified according to their polymerization mechanisms into light-cured, chemical-cured, and dual-cured . They can also be classified by their adhesive scheme: total-etch, self-etching, and self-adhesive . The self-adhesive resin cements may be referred to as "all-in-one" resin cements or universal cements.

The curing methods are a factor in dictating the potential uses of the cements. For example, in cases where very little or no light-cure is possible, chemical-cure cement is a better choice than either a dual-cure or, of course, a light-cure cement(Hunsaker et al.,1993).

2.2.1Classification by Polymerization Mechanism

2.2.1.1 Light-Cure Resin Cements

Light-cure resin cements utilize photo-initiators, which are activated by light. The ability of light to penetrate all areas and activate the photo-initiators is important with this type of cement. An advantage of light-curing cements is that there can be an increased working time compared to the other cure types. The clinician has the ability to remove excess cement before curing, and thus the finishing time required is decreased.
Another advantage of light-cure cements is their color stability compared to dual-cure or chemical-cure resin cements.These cements are, therefore, suitable for esthetic restorations and metal-free restorations. Light polymerized resins are recommended when cementing ceramic that is thin and fairly translucent, allowing the transmission of light through it to reach the resin cement.
Examples of light-polymerized cements include: RelyX™ Veneer Cement (3M ESPE,); Variolink® Veneer (Ivoclar Vivadent Inc.,); and Choice™ 2 Light-Cured Veneer Cement (BISCO, Inc.) (Vargas et al.,2011) .

2.2.1.2 Dual-Cure Resin Cements

Dual-cure resin cements are capable of being cured by means of both chemicals and light. Self-cure initiators that can cure the cement are present. In addition, a curing light can be used to activate the photo-initiators that are present in the cement.[6] Dual-polymerized resin cements are indicated when the ceramic is too thick or too opaque to allow transmission of light through it. Studies have shown that these dual-cure resin cements still require light-curing to reach a high degree of polymerization.These cements are used for metal-free restorations where light-curing may be performed to quickly seal margins.
Examples include: NX3 Nexus® Third Generation (Kerr Corporation,); RelyX™ ARC Adhesive Resin Cement (3M ESPE); and Variolink® II (Ivoclar Vivadent Inc.)(Pegoraro et al.,2007).

2.2.1.3 Chemical-Cure Resin Cements

Chemical-cure resin cements polymerize with a chemical reaction and are referred to as “self-curing.” This means that two materials must be mixed together to initiate this reaction.These cements are especially useful in areas where light-curing is difficult. Some examples include metal restorations, endodontic posts, and ceramic restorations that prohibit the curing unit from adequately polymerizing the resin cement. Chemically polymerized resin cements do not offer much selection in terms of shade and translucency; therefore, dual-polymerized resin cements can be beneficial. Additionally, accessible areas benefit from light polymerization with dual-polymerized resin cements.
Examples include: Panavia™ (Kuraray Dental,); and C&B™ Cement (BISCO, Inc.) (Vrochari et al.,2009; Simon and Darnell,2012).

2.3 Classification by Adhesive Scheme

2.3.1 Total-Etch Resin Cements

Total-etch resin cements use a 30% to 40% phosphoric acid-etch to etch dentin and enamel. This etching procedure removes the smear layer, and dentinal tubules are opened.After etching, the adhesive is then applied to the preparation to bond the cement to the tooth.These cements and the adhesives used with them can be light- or dual-cured. Total-etch resin cements have increased the bond strengths of resin-based cements to nearly that of enamel bonding and have significantly reduced microleakage. This category provides the highest cement-to-tooth bond but also requires the most steps to bond ceramic, composite resin, or metal to the tooth. This multi-step application technique is complex and consequently might compromise bonding effectiveness,because each step represents a possible contamination point(Ferracane et al.,2011).
Examples include: RelyX ARC (3M ESPE); Variolink II (Ivoclar Vivadent Inc.); Choice 2 (BISCO, Inc.); and Calibra® (DENTSPLY Caulk)(Burgess et al.,2010).

2.3.2 Self-Etch Resin Cements

Self-etch systems apply a self-etching primer to prepare the tooth surface, and mixed cement is applied over the primer. Bonds to tooth structure using this category of cements are almost as high as those of the total-etch cements.

Self-etching systems are popular among dentists because they are easy to use, but as a general category they have demonstrated bond strength to enamel that is weaker than that of total-etch systems. Therefore, the total-etch, three-step adhesive system of some 30 years ago still sets the standard in terms of versatility and long-term predictability.

Resin cements that incorporate self-etching primers eliminate steps during application with the goal of reducing operator errors and technique sensitivity and increasing ease of use. However, it is imperative to follow the manufacturer's instructions during adhesive cementation, including use of the manufacturer's adhesive and resin cement combination, because investigators have found incompatibilities between some dual-cure resin cements and simplified adhesive systems(FERRARI et al.,1999).

2.3.3 Self-Adhesive Resin Cements

A number of resin cements have been introduced as one-component "universal adhesive cements"; they are said to have good bond strengths to dentin, enamel, and porcelains without the need for separate bonding agents. These self-adhesive cements can bond to an untreated tooth surface that has not been micro-abraded or pretreated with an etchant, primer, or bonding agent; thus, cementation is accomplished in a single step. These cements contain phosphoric acid, which is grafted into the resin. Once mixing is initiated, the phosphoric acid reacts with filler particles and dentin in the presence of water, forming a bond. The resin is polymerized into a cross-linked polymer, as is the case with composite resin bonding(FERRARI et al.,1999).

Data from Burgess et al (2010)shows that most of these cements bond better to dentin than to enamel. With most of the cements in this category, the bond to enamel is improved when an etchant and bonding agent are applied.This "selective-etch" approach uses an etchant or a self-etching primer before applying the self-adhesive resin cement. In other words, “selectively etching” enamel and/or dentin surfaces and indirect restorations may be incorporated to improve the bond of these self-adhesive resin cements. However, a lower bond strength to dentin was shown when the phosphoric acid pre-etch was applied.In contrast to enamel, when dentin is etched with phosphoric acid and a bonding agent is applied with one of these cements, the bond decreases.This negative effect of pre-etching of dentin for self-etch adhesives has been shown many times in the literature.When tested without the pre-etch, self-adhesive resin cements have been shown to produce fairly strong bonds to dentin.Examples include: RelyX™ Unicem (3M ESPE), BisCem® (BISCO, Inc.) ,Maxcem Elite™ (Kerr Corporation), SpeedCEM™ (Ivoclar Vivadent Inc.)(NG et al.,2010).

2.3.4. Clinical Considerations and Advantages

- When using resin-based cements, the internal surface of the restoration must be treated differently than the surface of the tooth, because the surface treatment depends upon the type of material (metal, ceramic, or zirconia) used for the restoration. The surfaceof the tooth may need to be treated with phosphoric acid, while the surface of the restoration may need to be treated with hydrofluoric acid, sandblasting, and silanization (NG et al.,2010).
- The efficiency by which the self-adhesive resin cements adapt to and seal margins is critical for their success. Studies have found conflicting results when analyzing the marginal seal and microleakage of resin cements. However, self-etch and total-etch resin cements tend to have adequate marginal adaptation compared to glass ionomers, resin-modified glass ionomers (RMGIs), and zinc phosphate cements(NG et al.,2010).
- Because self-adhesive cements bond to tooth structure, excess cement should be removed before setting to avoid damaging the weaker early bond. Self-adhesive cements are dual-cured, and like all dual-cured cements, have reduced bond strengths, color stability, and wear resistance in the self-cure-only mode. Therefore, the clinician should light-activate all dual-curing cements at accessible restorative margins to improve marginal integrity and wear resistance and to reduce staining(NG et al.,2010)

2.4 Surface Treatment

Preparing the tooth for cementation although some materials are more adversely affected by the presence of contaminants than others, no material fares well if used in the presence of oils, debris, saliva, blood, or other significant contamination.It is important to ensure that the area is cleaned, free of excess moisture, and well isolated. Bleeding and other significant sources of contamination must be well controlled. Temporary cements leave a layer of debris on the dentin ssurface that should be removed before cementation. This may be accomplished with hand instruments, pumice,detergents, and/or cleaning agents.Some clinicians recommend the additional step of disinfecting the preparation with chlorhexidine,ethylenediaminetetraacetic acid (EDTA), or benzylkonium. The rationale is that bacteria are a primary cause of postoperative sensitivity, so disinfection of the dentin surface will lower the number of microbes and thus reduce one cause of sensitivity. Another approach is to use desensitizing agents, usually including hydroxyethyl methacrylate (HEMA). These agents can be applied immediately before the final impression. They essentially disinfect the dentin and seal the tubules. Their use does not seem to interfere with crown retention, regardless of the type of luting cement used. In addition to cleaning and isolating the preparation, specific additional steps are recommended to prepare the tooth to receive certain cements. Preparation surface texturing obtained either by rotary instruments or sandblasting with 50-µm aluminum Oxide has been shown to increase crown retention significantly, regardless of the choice of cement(Christensen ,2012).

2.4.1 Zinc phosphate cement

Because zinc phosphate cement exhibits the most microleakage of any cement190 and has been associated with postcemen-tation sensitivity, several methods have been recommended to prevent sensitivity by “sealing” the dentin prior to cementation.Copal varnish has a long history of use for this purpose, with anecdotal reports of success. However, copal varnish does not disinfect the dentin, and its effectiveness has limited duration.More recently, use of dentin primers and adhesives to seal the dentin before cementation has resulted in reports of decreased sensitivity.

However, a study has noted a marked (42%) decrease in retention with the application of a resin-based sealer prior to cementation.

2.4.2 Glass-ionomer cements

For glass-ionomer cements, the tooth should be clean and slightly moist.No cavity varnish should be placed that might prevent bonding of this luting agent to the tooth surface. The area should be well isolated to prevent moisture contamination during the luting process and for several minutes following the seating of the restoration (Christensen ,2012).

2.4.3 Resin-modified glass-ionomer cements

One of the advantages of resin-modified glass-ionomer cements is that the cementation procedure is fairly simple. Multiple bonding steps are not necessary, and no special preparation of the tooth surface is performed, other than to make it clean and slightly moist. Removal of excess cement is relatively easy(Christensen ,2012).

2.4.4 Resin cements

Most resin cements have corresponding dentin adhesive systems that are applied immediately before cementation. In most cases, the preparation is etched and a primer and adhesive are placed. Each adhesive system has specific instructions for its use that must be followed precisely to obtain the best results. Failure to follow the specific directions for both the adhesive and the luting difference between success and failure. It must be emphasized that excellent isolation is a necessity when a resin cement is used.A small amount of the cement should be mixed and observed before cementation procedures are started to confirm that the cement will set. Some self-curing resin cements have short shelf lives and lose their ability to polymerize(Hitz et al.,2012).

Conclusion

The key points for clinicians to bear in mind regarding resin-based cements are:

Bond strengths vary among specific cements, but total-etch cements generally provide the greatest retention; self-etching systems are intermediate; and self-adhesive cements can provide bond strength nearly equal to self-etching systems.Self-adhesive resin cements can create bond strengths to dentin that exceed the strength of the ceramic material.High bond strengths can be achieved with self-adhesive resin cements on non-retentive teeth.Large coefficients of variation indicate that the bond strength cannot consistently be achieved.

While in vitro data may show some cement bond differences among investigators, self-adhesive cements perform well clinically.Although clinical evaluations are few and short-term, the result of this review of self-adhesive resin cements would suggest that these materials may be expected to show clinical performance similar to that of other resin-based and nonresin-based dental cements.The handling properties of these materials appear to be excellent, and their acceptance by the profession is increasing

Discussion

New technologies are changing the therapeutical options to do indirect restorations and new adhesive systems are continuously introduced to be used by clinicians. Different interactions between restorations, adhesive systems components, enamel and dentin require having criteria based on the selection of the adhesive system, ensuring the longevity of the restorations and the preservation of the biological remnant. The adhesion force to the dental tissue is one of the indicatives of the behavior of the adhesive systems and influences the behavior of the treatments with direct and indirect restorations.

The self-etched adhesive systems reduce the time spent in clinical practice. However, at the interface they behave as permeable membranes, which facilitates the passage of fluids from oral environment to dentin and vice versa (dentine–intraoral environment), being more susceptible to degradation. Furthermore, its use is limited when using dual and self-curing cements, as its components can interfere with the polymerization process. They are also prone to form a discontinuous, irregular ,and shallow hybrid layer associated with low wettability, viscosity of the system, and low infiltration into the dental tissues. More clinical studies with a low level of methodological bias that analyze the adhesive systems and their clinical protocol for cementing indirect restorations are required.

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