MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

UNIVERSITY OF BABYLON / COLLEGE OF DENTISTRY

# BONDING SYSTEMS IN DENTISTRY

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بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

{هُوَ ٱلَّذِي بَعَثَ فِي ٱلۡأُمِّيِّـۧنَ رَسُولٗا مِّنۡهُمۡ يَتۡلُواْ عَلَيۡهِمۡ
ءَايَٰتِهِۦ وَيُزَكِّيهِمۡ وَيُعَلِّمُهُمُ ٱلۡكِتَٰبَ وَٱلۡحِكۡمَةَ وَإِن كَانُواْ مِن
قَبۡلُ لَفِي ضَلَٰلٖ مُّبِينٖ ﴿٢﴾}

صَدَقَ اللهُ العَظِيمُ

الجمعة / الاية ٢

# DEDICATION

To our parent's …

Whose love, support , encourgment and

prays of day and night That makes us able to get

such success and honor.

To our sisters and brothers ….

Your love and support made it all worth .

To our supervisor…

For his giudence and support that made

This project possible

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# INTRODUCTION

_*The main problem* of any restoration was and still the tooth/restoration interface discontinuity(fig.1), this is the weakest point of a restoration.

**ADHESION:_**It is tendency of dissimilar particles or materials to attach to one another.

Figure 1:-

Discontinuity (marginal gap)

**ADHESIVE:** this refers to the bonding agent that when applied to the surfaces or substances, can join them together, resist separation and transmit loads across the bond

**ADHEREND :** this refers to the surface or substrate that is adhered to

_*The basic advantage* of adhesion is to absence of the marginal gap between the restoration and tooth structure.

## Historical back ground

In the late 1940s, Oskar Hagger, developed the first bonding agent, Sevriton Cavity Seal.

This system was based  as a self-adhesive or self-etching component for both enamel and dentin bonding. However, this product had very limited clinical durability.

After that Michael Buonocore investigated stronger acids and discovered that **phosphoric acid** provides superior enamel  etching, and it is still in use today.

**dental bonding consisted of various methods such as:**

1. mechanical retention, such as forming undercuts in cavity preparations for amalgam restorations
2. Luting, using zinc phosphate

**Why the bonding is important?**

dental bonding system performs three essential functions:

1. provides resistance to separation of an adherend substrate (i.e., enamel, dentin, metal, composite, ceramic) from a restorative or cementing material.
2. distributes stress along bonded interfaces.
3. seals the interface via adhesive bonding between dentin and/or enamel and the bonded material, thus increasing resistance to microleakage and decreasing the risk for postoperative sensitivity, marginal staining, and secondary caries.

Microleakage—The flow of oral fluid and bacteria into the microscopic gap between a prepared tooth surface and a restorative material. [1]

# 1. MAJOR ROLES

## 1.1. Surface energy and wetting

**Wetting** is the essential first step for the success of all adhesion mechanisms. An adhesive cannot form micromechanical interlocks, chemical bonds, or interpenetrating networks with a surface unless it can form intimate contact with the surface,

spread over it and penetrate by capillary attraction into any microscopic and submicroscopic irregularities.

Figure 2:-

Wettability contact angle

These conditions are, by definition, achieved if the adhesive wets the surface.

wettability of a liquid on a solid can be characterized by the contact angle that forms between a liquid and solid, as measured within the liquid. Categories of wettability include “mostly nonwetting” (>90 degrees), “absolutely no wetting” (180 degrees), “mostly wetting” (<90 degrees), and absolute wetting (0 degrees

## 1.2. Interpenetration (formation of a hybrid zone)

The hybrid layer (adhesive–collagen composite) has been identified as the weakest link in the bond formed between the adhesive and However, many studies have shown that nanoleakages, which are only around 20–100 nm wide [39,40]compared to 10–20 µm wide microleakage gaps, occur within the hybrid layer even in the absence of gap formation. [2]

Figure3:-

Hybrid layer location

## 1.3. Micromechanical interlocking

resin tags are formed that micromechanically interlock or interpenetrate with the hard tissue

## 1.4_Other factor

is hydrolytic stability (resistance to chemical degradation by water).

# 2. SMEAR LAYER

Whenever both enamel and dentin tissues are mechanically cut, especially with a rotary instrument, a layer of adherent grinding debris and organic film known as a smear layer is left on their surfaces and prevents strong bonding prepared for a restoration.[3]

Figure 4:-

Smear layer

# 3. ACID-ETCH TECHNIQUE

**Why do we etch?**

If restorative materials were placed directly on the smear layer of the prepared tooth. It is evident that the apparent bond strength is the cohesive strength (5–10 MPa) of the smear layer, which is not sufficient to withstand the daily mechanical forces experienced in the mouth. As a result, **debonding** and leakage of oral fluids within the microscopic space between prepared teeth and restorative materials was an ongoing problem.

## 3.1 ENAMEL ETCHING

phosphoric acid removes the smear layer and about 10 microns of enamel to expose prisms of enamel rods to create a honeycomb-like, high energy retentive surface

## 3.2 DENTIN ETCHING

is more technique sensitive than enamel etching because of the complexity of the dentin structure. Unlike enamel, dentin is a living tissue.

## 3.3 ETCHING TECHNIQUES

_**Total etching** is the classic technique of utilizing a 30% to 40% phosphoric acid gel to prepare both the enamel and the dentin for adhesive procedures. One of the greatest advantages of this technique is its ability to prepare enamel, dentin, and sclerotic dentin for bonding, resulting in high bond strengths On the other side are the risks. Utilizing a total-etch system can be technique-sensitive

etching the enamel without over-etching the dentin. **Enamel** surfaces require 25 seconds of exposure to phosphoric acid. **Dentin** on the other hand should not be exposed to the gel for more than 15 seconds

Over-etching dentin results in postoperative sensitivity

_**Selective etch technique** apply phosphoric acid to enamel surface avoiding the dentine

## 3.4. RINSING AND DRYING STAGE (ENAMEL)

Once the tooth is etched, the acid should be rinsed away thoroughly with a stream of water for about 20 seconds, and the rinsed water must be removed. When enamel alone is etched and is to be bonded with a hydrophobic resin, it must be dried completely with warm air until it takes on a white, frosted appearance.

## 3.5. RINSING AND DRYING STAGE(DENTIN)

Dentin, in contrast,cannot withstand such aggressive drying, which would cause bond failure because of the formation of impermeable, collapsed collagen fibers. In the total-etch technique, a dentin bonding agent and primer must be used that are compatible with both moist dentin and moist enamel The etched surfaces must be kept clean (free of contaminants) and sufficiently dry until the resin is placed to form a sound mechanical bond.[3]

## 4. COMPOSITION OF BONDING AGENTS INCLUDE

a. Etchant-37% phosphoric acid.

b. Primers-HEMA (2-hydroxyethyl methacrylate) is a widely used primer monomer because of its high hydrophilicity and solvent like nature.

Figure 5:-

Dentinal tubules

c. Solvents-The most commonly used solvents are water, ethanol, and acetone. Solvent has a specific contribution to improve bond adhesion.

d. Adhesives- Adhesive resins mostly composed of mainly of hydrophobic dimethacrylates such as bis-GMA, TEGDMA, and urethane dimethacrylates (UDMA)

e. Initiators- Polymerization can be initiated through a photoinitiator system consisting of the photose-nsitizer (e,g., camphoroquinone) and an activator (e.g., tertiary amine) for a self-cure resin system with an initiator such as benzoyl peroxide.

f. Fillers-silica particles.

g. Other ingredients like glutaraldehyde act as desensitizer, paraben used as antimicrobials, fluoride to prevent secondary caries, and chlorhexidine to prevent collagen degradation.[4]

## 4.1. THE ETCHANT

Is composed of acidic molecules that alter or remove the smear layer and demineralize the enamel and dentin and prepare it for bonding. In total-etch technique the etchant used is 35-37% phosphoric acid. It prepares enamel and dentin to receive the primer. The etchant in self-etch bonding agents is typically an acidic monomer that also serves as the primer. (fig.6)

Figure 6:-

Acid etch

## 4.2. THE PRIMER

It serves as a type of molecule that helps make the dentin surface, which is very hydrophilic, become more hydrophobic in order to accept the very hydrophobic bonding resin. Thus, the primer typically contains a molecule or molecules with both hydrophilic and hydrophobic characteristics, i.e., amphiphilic. It functions by penetrating the demineralized dentin and preparing it for the bonding resin.

Priming is necessary to maintain an expanded collagen network (after acid etch of dentin) while removing residual water to allow for the infiltration of the hydrophobic adhesive monomer. Primers are solutions containing hydrophilic monomers dissolved in a solvent such as acetone, ethanol, or water. (fig.7)

## 4.3. SOLVENTS

Figure 7:-

HEME(2- hydroxyethyl methacrylate

To enhance the wetting, spreading, and penetration of the polymerizable monomers into the dentin substrate, solvents are always added to the mixture as “thinning” agents.

However, any solvent not displaced during the placement procedure, such as by drying appropriately, will be incorporated into the bonding layer and may serve as a weakening contaminant, such an agent is called a plasticizer.

In dentistry, the most common solvents are water, ethanol and acetone.

1. Water

Water is very important solvent because it is the only solvent that is capable of reexpanding the collagen fibers due to the high dielectric.

2. Alcohol (ethanol).

It has a lower dielectric and has a higher vapor pressure compared to water which facilitates its evaporation with air drying.

3. Acetone

One advantage of acetone is the evaporation time due to its relatively high evaporation pressure which is considered to be four times greater than ethanol. (fig.8

## 4.4 THE BONDING RESIN

Figure 8:-

Solvents

Unfilled fluid resins have been used as a bonding agent between the tooth and composite and are mostly light-cured.

It becomes, after priming, incorporated into the primed substrate and, once cured, forms the structural support of the bonded interface between the tooth and the subsequently placed restorative material. The entire process forms a zone of material that consists of components of both the dentin and the resin and is called the hybrid layer or interdifusion zone.

The ideal adhesive would have a hydrophilic nature during placement and would become much more hydrophobic after curing. (fig.9)

Figure 9:- adhesive resins

## 4.5. INHIBITOR

They are added to prevent the initiators from auto reaction specially in hard storage condition as during shipping and transporting and as a result increase the shelf life of adhesive (Odian, 2004) (fig.10)

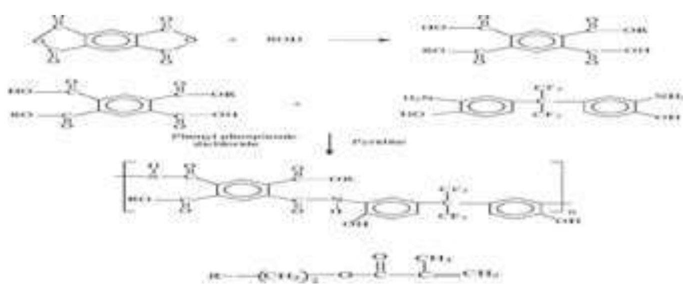

Figure 10:-

Initiaters

## 4.6. FILLER

Recently nanofillers have been added ranging from 0.5% to 40% by weight in the 8th generation adhesive systems. Its advantages:

1. Fillers control handling and may improve strength.

2. Fillers may increase film thickness of the adhesive layer.

3. In the new agents, the addition of nano-fillers with an average particle size of 12 nm increases the penetration of resin monomers and the hybrid layer thickness, which in turn improves the mechanical properties of the bonding systems. (fig.11)

Figure 11:-

Silica particles

## 4.7. OTHER INGREDIENTS

Fluoride is added to prevent secondary caries.
Chlorhexidine are used to prevent collagen degradation, recently been shown in laboratory studies to prevent protease enzymes (matrix metalloprotease enzymes - MMPs) from being activated and subsequently denaturing the hybrid layer collagen.[5] [6]

# 5. CLASSIFICATION OF MODERN ADHESIVES [7]

## 5.1. BASED ON GENERATIONS

i. First generation bonding agent
ii. Second generation bonding agent
iii. Third generation bonding agent
iv. Fourth generation bonding agent
v. Fifth generation bonding agent
vi. Sixth generation bonding agent
vii. Seventh generation bonding agent
viii. Eighth generation bonding agent
ix. Ninth generation bonding agent

## 5.2. BASED ON SMEAR LAYER TREATMENT

1. Smear layer modifying agents.
2. Smear layer removing agents.
3. Smear layer dissolving agents.

## 5.3. BASED ON NUMBER OF STEPS

1. Three steps.
2. Two steps.
3. Single step .

# 6. EVOLUTION DENTIN-BONDING AGENTS

## 6.1. First Generation Dentin-Bonding Systems

Development of NPG-GMA (N-phenylglycine-glycidyl methacrylate) a surface active co monomer was the basis of commercially available DBA.In this, NPG-GMA was supposed to chelate with calcium of dentin to form water resistant chemical bond to dentin. First step to achieve bonding to dentin was done by application of a coupling agent such as glycerolphosphoric acid dimethacrylate as a primer and N- 2-hydroxy-3- methacryloxypropyl and N-phenylglycine (NPG-GMA) and silane coupling agents. The first bonding agent to appear on the market was Cervident (SS White Co, King of Prussia, PA) [8]

These products ignored the smear layer. Mechanism adhesion was deep penetration of the resin tags into the exposed dentinal tubules after etching and the chelating component which could bond to the calcium component of dentin. Since they could chelate with calcium ions of the tooth structure, they formed stronger bonds with enamel than dentin.

❖ **Disadvantages :**

1. Low bond strength (2-3 MPa)
2. Loss in bond strength over time.
3. Instability of NPG - GMA in solution.
4. Hydrolysis of glycerophosphoric acid dimethacrylate in oral environment [7].

## 6.2 Second Generation Dentin-bonding Systems

These were introduced in 1970s. In these, bonding agents were attempted to bond chemically to either organic or inorganic components of dentin. Phosphate groups, amino acid groups or carboxylic acid groups present in bonding agents affect the bond to calcium or collagen of dentin but not much success was achieved. Examples; Scotchbond (3M), Prisma universal bond (Dentsply).

❖ **Disadvantages:**

1. Low bond strength (1-5 MPa)
2. Unstable interface between dentin and resin because of hydrolysis of phosphate calcium bond [9].

## 6.3 Third Generation Dentin-bonding Systems

Third generation bonding systems were introduced in 1979, which were designed not to remove the entire smear layer but to modify it to allow penetration of acidic monomer. These were applied for total etching of dentin was avoided in these bonding agents to avoid pulp inflammation. Mild acids employed in 3rd generation were 10% citric acid, 10% phosphoric acid, 2% nitric acid, 3% ferric chloride, etc. Examples; Scotch Bond II (3M), GLUMA (KULZER) [10].

❖ **Advantages:**

1. Higher bond strengths (8-15 MPa)
2. Reduced microleakage.
3. Form a strong bond to both sclerotic and moist dentin.
4. Reduced need for a retentive tooth preparation.
5. Can be used for porcelain and composite repairs.

❖ **Disadvantages:**

Since bonding agents have hydrophobic nature, mild acid etching didn't much improve dentin bond strength:

1. Decrease in bond strength with time.
2. More chair side time.
3. Technique sensitive.

## 6.4. Fourth Generation Dentin-bonding Agents

These were developed in early to mid-1990s. These bonding agents applied concept of total etching of enamel and dentin simultaneously using (37%) phosphoric acid. Smear layer is considered as obstacle which should be removed so that resin can be bonded to underlying dentin surface .

### 6.4.1.Fourth generation DBA consists :

- An acid etchant to remove smear layer which is washed off.
- Solution of primers which contains monomers like HEMA (2- hydroxyethyl methacrylate) and 4-META (4-methacryloxyethyl trimellitate anhydride) dissolved in acetone or ethanol.
- Bonding agent which combines with monomers to form resin reinforced hybrid layer and resin tags seat the dentinal tubules (Fig. 12).

Figure 12 : Fourth and fifth generation dentin-bonding agents.

### 6.4.2. 4th generation Dentin-bonding system is characterized by :

1. Complete removal of smear layer.
2. Total etch technique.
3. Hybrid layer formation.
4. Wet bonding.

❖ **Mechanism of Bonding**

Concept of hybridization comes with fourth generation bonding agents. It was given by Nakabayashi in 1982. This is the zone where resin of bonding agent micromechanically interlocks with intertubular dentin and surrounding collagen fibers. It is also known resin-dentin inter-penetration/ inter-diffusion zone (Fig. 13).

Figure 13: Mechanism of bonding in fourth generation bonding agents.

### 6.4.3.

### Examples of the fourth generation DBA :

- All Bond - 2 (Bisco)
- Scotchbond Multipurpose (3M)

❖ **Advantages:**

1. Ability to form a strong bond with both enamel and dentin High bond strength to dentin (17-30 MPa)
2. Ability to bond strongly to moist dentin.
3. It can also be used for bonding to substrates such as porcelain and alloys (including amalgam) [11].

❖ **Disadvantages:**

1. Time consuming.
2. More number of steps.
3. Technique sensitive.

## 6.5. Fifth Generation Dentin-bonding Agents

Fifth generation BAs were made available in the mid-1990s. They are also known as “one-bottle “or” one-component " bonding agents. In these agents the primer and adhesive resin are combined in one bottle. Basic differences between fourth and fifth generation is the number of basic components of bottles. Fourth generation bonding system is available in two bottles, one primer and other adhesive, fifth generation bonding agents are available in one bottle only.

❖ **Advantages:**

1. High bond strength, almost equal to that of fourth generation adhesives.
2. Easy to use and predictable.

3. Little technique sensitivity.
4. Reduced number of steps.
5. Bonding agent is applied directly to the prepared tooth surface.
6. Reduced postoperative sensitivity [12].

❖ **Disadvantages :**

Lesser bond strength than fourth generation bonding agents.

**Examples of fifth generation DBA :**

- Prime and Bond (Dentsply).
- Optibond Solo (Kerr).
- Single Bond (3M) (Fig.14).

## 6.6. Sixth Generation Dentin-bonding Agents / Self-etch Primers

Figure 14: Fifth generation dentin-bonding agent (single bond).

These were made available in 2000. In fifth-generation primer and adhesive are available in single bottle, and etchant in separate bottle. In sixth generation etching step is eliminated, because in sixth generation etchant، primer and bonding are available in single solution. Most self-etching primers are moderately acidic with a pH that ranges between 1.8 and 2.5. Because of the presence of an acidic primer, sixth generation bonding agents do not have a long shelf-life and thus have to be refreshed frequently.

### 6.6.1.Types of Sixth Generation Bonding Agents (Fig. 15)

1. Self-etching Primer and Adhesive / Two Step / Non-rinsing Conditioner

- Available in two bottles; primer and adhesive.

- Primer is applied prior to the adhesive.
- Water is the solvent in these systems.

2. Self-etching Adhesive / All-in-One System

- Available in two bottles; primer and adhesive.
- A drop from each bottle is taken, mixed and applied to the tooth surface; for example, Prompt L-Pop and Xero III [13].

Figure 15: Sixth generation dentin-bonding agent.

## ❖ Mechanism of Bonding

In these agents as soon as the decalcification process starts, infiltration of the empty spaces by the bonding agent is initiated (Fig. 16).

Figure 16: Mechanism of bonding in 6th generation dentin-bonding agent.

## ❖ Advantages

1. Comparable adhesion and bond strengths to enamel and dentin.
2. It etches the dentin less aggressively than total etch products.
3. Demineralized dentin is infiltrated by resin during the etching process
4. Since they do not remove the smear layer, the tubules remain sealed، resulting in less sensitivity.
5. Less technique sensitive as fewer number of steps are involved for selfetch system.

## ❖ Disadvantages

1. PH is inadequate to etch enamel, hence bond to enamel is weaker as compared to dentin.
2. Sufficient bond strength to dentin but poor strength to enamel.
3. Since they consist of an acidic solution, they cannot be stored and have to be refreshed.
4. May require refrigeration.
5. High hydrophilicity due to acidic primers.

## 6.7. Seventh Generation Dentin-bonding Agents All-in-One System

They are truly all-in-one self-etch adhesives that require no mixing، thus avoiding any mistakes in mixing (Fig. 17). Seventh generation DBAs have shown very little or no postoperative sensitivity. However, due to complex mixed solution, they are prone to phase separation and formation of droplets within their adhesive layers. Example of a seventh generation bonding agent is Xeno IV, G-Bond and I-Bond [7]

Figure 17: Seventh generation dentin-bonding agent.

### ❖ Advantages

1. Simple to use Less technique sensitive.
2. Less postoperative sensitivity.

### ❖ Disadvantage

Complex nature of mixed solutions, thus more prone phase separation

## 6.8. Eighth Generation Bonding Agent

It was developed as time saving product for direct and indirect restorations. These bonding agents combine etching, priming, and bonding in one bottle. In 2010, 8th generation bonding agent was developed VOCO America, Futurabond DC (self-etching, dual cured dental adhesive) (Fig. 18A). Futurabond DC contains polyfunctional adhesive monomers, i.e. phosphoric acid modified methacrylate esters. These acidic esters, when combined with water, produce a pH value of 1.4 . This lower pH favors the complete removal of smear layer and dissolution of hydroxyapatite creating a deeper retentive pattern on tooth surface. Moreover, it contains nanofillers with average particle size 12 nm which increase the penetration of resin monomers and thickness hybrid layer, thus increasing the mechanical properties of bonding systems and better marginal integrity It can achieve the bond strength of 30 MPa. This bonding agent contains fluorides, so has anticariogenic effect .

GC G-Premio BOND is a universal, 8th generation bonding agent which is compatible with total-etch, self etch and selective etch techniques providing excellent versatility (Fig. 18B). It has high bond strength and is used for direct restorations, repair indirect restorations without the use of primer and in combination with a silane when repairing glass or hybrid ceramic. It consists of combination of three functional monomers (4-MET، MDP and MDTP) [14][15].

# 7. CLINICAL USES OF BONDING SYSTEMS IN DENTISTRY

## 7.1 BONDING OF DIRECTLY PLACED RESIN BASED RESTORATIVE MATERIALS [16]

Figure 18: Eighth generation dentin-bonding agent: (A) Futurabond dc (Voco india); (B) G-premio bond (gc india).

There are some general guidelines to improve clinical success with direct restorative material include:

1. Excellent isolation with a dental dam or other isolating devices
2. Right-angled enamel margins in stress-bearing areas
3. To minimize postoperative sensitivity, use an SE adhesive and a low-shrink composite .
4. Adequate light curing in the proximal box of a Class II (at least 10-20 seconds with a high-intensity light [greater than 1100 mW/cm2) for the adhesive and first increment of composite resin placed in the proximal box to ensure polymerization of the adhesive and composite resin over the distance to the end of the gingival margin. (fig.19

**Procedure :-**

- A minimally invasive preventive resin cavity preparation done with a fissurotomy bur .
- Etching of enamel surface for 15 seconds.
- Application of a previously selected generation of bonding agent .

Figure 19:

Application of bonding agent

- blow the cavity with air to remove the excess material of bonding agent and create a thin layer.
- 10 - 20 seconds light curing with high-intensity LED curing light .
- Application of direct based resin restorative material .
- 20 seconds of light curing with high-intensity LED curing light .

## 7.2 BONDING OF INDIRECTLY PLACED RESTORATIVE MATERIAL[17] :- (fig.20)

**Procedure** :-

- **Tooth Preparation**:-
  decreasing grift with cylindrical round –ended diamond bur .
  slightly occlusal divergent walls .
  round internal angels .
  Butt joint preparation margins .
  Blocking out defect-related undercut .
  Finishing with diamond bur and silicone point .
- **Dentin surface treatment :-**
  Immediate dentin sealing using a three-step , total etch dentin-bonding agent with a fill adhesive resin and rubber dam isolation .
- **Treatment for the Internal Surfaces of Indirect Restorations:-**
  The internal surfaces of indirect restorations can be abraded with aluminum oxide, using an intraoral sandblasting device .
- **CEMENTATION:-**
  Constantly using rubber dam isolation with three-step total-etching , light cure cement systems.
  Applying the resin cement and insertion of the indirect restoration ,
  Removing the residual cement using explorer , scalpel and floss before complete polymerization .
  Dual-cured resin cements have the advantages of controlled working time and adequate polymerization in areas that are inaccessible to light. Curing should be calibrated for each material to address high degrees of conversion. Preheating light-cured filled composites allows the

Figure 20: preparation of veneers surface

materials to reach optimal fluidity. Optimal luting of indirect restorations is dependent on the light source power, irradiation time, and dual-cure luting cement or light-curing composite chosen.

## 7.3 BONDING OF CERAMIC RESTORATION[18] :-

The resin cement is the material of choice for bonding ceramics to dental substrate, Basically, two techniques can be used to achieve this purpose: the conventional technique based on etching and rinse protocol, and the self-etching technique**.**

**Clinical procedure:-** (fig.21)

The preparation should be done using Index silicone guide in order to control the reduction and prevent over contours.

The full arch impression was made with a combination of heavy and light silicon, or a secure bonding, the use of rubber dam is necessary.

The treatment of ceramic surfaces starts with the etching of internal surface of the veneer with hydro fluoric acid after waxing the external surface in order to protect it from acid action. Silane coupling agent was then applied.

Figure 21: ceramic crowns

he prepared surfaces were first cleaned using chlorhexidine, then etched for 15 sec using 37% phosphoric acid and then rinsed off , then it was coated with bonding agent in thin layer and polymerized for 15sec.

## 7.4 BONDING OF AMALGAM RESTORATION[19] :-

Amalgam can be bonded to the tooth using an adhesive system. Potential benefits include:

- Decreased microleakage
- Decreased incidence of recurrent caries
- Decreased pulpal inflammation
- Decreased post-operative sensitivity
- Increased fracture resistance of the tooth
- Decreased cuspal deflection
- Treatment of cracked cusp
- Conservation of tooth substance
- Increased retention

### Technique

Bonding amalgam to tooth structure with a partial- or total-etch technique and placement of a resin adhesive is making the traditional amalgam cavity preparation obsolete. Cavity preparations for bonded amalgam restorations may, however, still require an adequate form of resistance. Fragile cusps and walls should be reduced and protected with amalgam. For wide and complex cavities, the lack of clinical data should temper the dentist's enthusiasm for establishing retention with the adhesive only. In such cases, we believe it to be of fundamental importance to establish some mechanical retention in the remaining dental tissue. However, combining pins with adhesive may be contraindicated"" because catastrophic tooth failure has been observed in laboratory tests.

## 7.5 BONDING OF PREFABRICATED AND CAST POSTS [20]:-

The need for the adhesive luting of GFPs has engendered debates . It has been reported that the bonding of GFPs to the dental structure may be related more to the friction of the post along the canal walls than to the adhesive bonding to root dentin . The use of resin cements, however, has been found to significantly increase the retention of fiber posts and improve the fracture resistance of the bonded structures when compared to other cements . Adhesive cementation has also been shown to better withstand functional forces . improve marginal adaption with better apical sealing . increase retention with reduced post length . and optimize the fracture patterns in case of failures . Therefore, the adhesive cementation of GFPs is preferred over non-adhesive luting. (fig.22

Figure 22: bonding of GFPs to root dentin

**Post surface treatments:-** Various pretreatment procedures, such as silanization, acid etching, sandblasting, tribochemical silica coating, and the application of bonding agents for enhancing the bond strength of GFPs to the luting cement . Other treatments as plasma and dopamine treatment have also been described, with varying results.

## 7.6 BONDING OF ORTHODONTIC BRACKETS [21]:-

### 7.6.1 TYPES OF BONDING:-

There are two main types of orthodontic bonding: direct and indirect. Direct bonding involves correctly attaching and positioning metal brackets right onto your teeth the first time. Indirect bonding is when the orthodontist first uses a plaster model of your teeth to position the brackets, and then transfers them to your actual teeth.

### 7.6.2 TOOTH PREPARATION :-

Braces can't work unless your brackets stay where they are. To make sure that happens, the surface of your teeth have to be completely dry. This ensures that the bond between your tooth's surface and the metal bracket will be strong enough to keep brackets where they are in the long-term. Etching the teeth using an acidic etching agent. Etching will make your tooth's enamel rough so that the bonding agent will have a better hold.

### 7.6.3 BONDING SYSTEMS:- (fig.23,24)

- **No Mix:-** The no mix system consists of a liquid primer and paste. The primer is placed on the etched surface of the tooth and on the base of the bracket. The paste is then applied to the bracket base, and the bracket placed onto the tooth.

- **Two-Paste Mix:-** In the two-paste mix system, two bonding resin liquids are mixed and applied to etched tooth enamel, and two pastes are mixed and applied to the base of the metal bracket before placing it onto the tooth.

### 7.6.4. CURING:-

Once the brackets are placed on your teeth with the one or two mix bonding systems, that bond has to be hardened or cured with a curing lamp. This will be done either by using a halogen or an LED curing lamp, placing it as close as possible to your metal brackets. The higher the intensity of the light, the less time it will take to harden the bonding agent.

Figure 23:

Bonding of orthodontic brackets to tooth surface

## 7.7 BONDING OF PERIODONTAL SPLINTS [22]:-

Teeth become loose because of lost gum tissue, injury, orthodontic treatment, or pressure caused by tooth misalignment. A technique called periodontal splinting attaches loose teeth together, turning them into a singl and stronger than the single teeth by themselves.

Figure 24:-

Direct bonding of periodontal

### 7.7.1TECHNIQUE:-

There are two techniques for bonding periodontal splint :-

The first technique done by direct application of the periodontal splint to the acid etched and bonded Enamel surface and then splints by composite and light cured for 10-20 sec.

This technique is easy and require less time .

The second technique is done by cutting a channel in the teeth at the level of the interproximal contacts and placing the periodontal splint at the base of the channel. This will make it more resistant to debonding and will maximize the longevity, esthetics and comfort of the splint.

### 7.7.2TOOTH PREPARATION :-

After cutting the channel in the teeth, Prepare lingual surfaces and labial interproximals for bonding. Prepare the teeth for bonding in the standard manner (clean, acid-etch, apply a thin layer of bonding adhesive, remove excess adhesive, and cure) .then Wet the splint with resin and blot off excess.

Apply filled composite to the teeth. Adapt the splint against the composite , Remove excess composite with a composite instrument. Tack-cure the splint for 5 sec per tooth . Cover the splint with a flowable composite. Remove the excess and Light-cure the covering layer of composite for 30 sec per tooth , Check occlusion, finish and polish.

## 7.8 SEALING OF PIT AND FISSURES OF POSTERIOR TEETH[23]

The preventive function of pit and fissure sealant is achieved by the adherence of the material to the acid etched enamel surface thus physically occluding the pits and fissure from the rest of the oral environment. The clinical success of adhesives allows for more conservative preparation when using composite restorative materials. (fig.25)

Dentin bonding systems consist of bifunctional molecules: (1) A methacrylate group that bonds to the restorative resin by chemical interaction and (2) a functional group that is able to penetrate wet dentin surface. The use of dentin bonding agents between the tooth and fissure sealant can be beneficial for reducing microleakage when there is contamination of the enamel.

Retention rates are of interest as sealant effectiveness is directly related to its retention and completely sealed fissures should not develop caries. Studies have shown improved results when an intermediate bonding layer is applied between enamel and sealant which increases, bond strength, reduce microleakage and enhances flow of resins into fissures.

Figure 25:

Pit and fissure sealing

# 7.9. TREATMENT OF CERVICAL SENSITIVE DENTIN [24]

## 7.9.1. PURPOSE:

investigated the ability of a dentine bonding agent (DBA) to reduce cervical dentine sensitivity.

## 7.9.2. MATERIALS AND METHODS:

Following stimulation of pairs of teeth by conventional tactile and air blast stimuli, together with controlled evaporative and cold fluid stimuli, sensitivity was recorded using tactile threshold, visual-analogue scale (VAS) and short-form McGill pain questionnaire (SFMPQ), prior to and 1 week following treatment with DBA. Prior to assessment, subjects recorded their perceived overall sensitivity using VAS and SFMPQ. Application of each stimulus was separated by 10 min. Sensitivity was recorded by a clinician blinded to the treatment status of each tooth. The control tooth was treated by applying DBA to coronal enamel.

## 7.9.3. RESULTS:

Dietary information was collected after the post-treatment assessment. There was a significant ($p<0.05$) improvement in tactile threshold and air flow and air blast VAS scores, together with reductions in sensitivity to evaporative stimuli when assessed by SFMPQ. Treatment response was not influenced by the subjects' age, gender, diet, use of fluoride-containing or silica-based toothpastes or fluoride mouthwashes, or a history of previous sensitivity treatment. It is concluded that topical application of DBA is an effective way to reduce cervical dentine sensitivity. (fig.26)

Figure 26:

Effect of DBA on dentin tubules

## 7.10. TOOTH FRAGMENT REATTACHMENT[25]

The remarkable advancement of adhesive systems and resin composites has made reattachment of tooth fragments a procedure that is no longer a provisional restoration, but rather a restorative treatment offering a favorable prognosis. However, this technique can be used only when the intact tooth fragment is available.

### 7.10.1 CASE REPORT

A 22-year-old male patient reported to the Department of Conservative Dentistry and Endodontics at Mahatma Gandhi Dental College with the chief complaint of fractured upper anterior tooth due to a road traffic accident, 3 hours before. Patient's medical history was noncontributory. Clinical and radiographic examination revealed horizontal fractures (Ellis class III) in the gingival third regions of the crowns of maxillary left lateral incisor. Patient was in acute pain and coronal tooth fragment was mobile. No mobility of the remaining tooth was recorded and surrounding intraoral soft tissues were normal. The fractured fragment was removed and washed thoroughly under running water and stored in sterile normal saline to prevent dehydration and discoloratio. The patient expressed the desire to maintain teeth and restore them. It was planned to reattach the fractured fragment to the remaining tooth and patient's consent was obtained. Root canal treatment was carried out immediately and obturation was done by sectional method maintaining 5 mm apical seal.

## 7.10.1.1. PROCEDURES:

1-After preparing the post space with pesso reamer, prefabricated metal post was luted in the canal with glass ionomer cement.

2- A hole was prepared on palatal side of fractured tooth fragment and then etched with 37% orthophosphoric acid, rinsed, blot dried with paper points, and bonding agent (Prime and Bond NT, Dentsply) was applied.

3-Subsequently, flowable composite (Grandio Flow, Voco) was used to fill the access cavity and hole in the tooth and the prepared grooves into the coronal fragment.

4- The fragment was carefully seated on the remaining tooth and light cured. During curing, firm and stable finger pressure was applied to the coronal fragment to closely oppose it to the tooth.

5-After curing, excess composite was removed with a diamond finishing bur. Afterwards, final polishing was done with Enhance Dentsply.

6- Follow-up examinations were carried out at 20 months interval. The tooth remained normal in esthetics and function. (fig.27)

Figure 27:

Steps of tooth fragment reattachment

## 7.11. DIRECT PULP CAPING[26] :

Calcium hydroxide (CH) is generally the material of choice for the capping of vital pulp that has been accidentally injured However, in the last few years, the possibility of direct pulp capping with adhesive systems has been advocated. Preliminary clinical and histological experiments have revealed that resin-based composite systems may be as effective as calcium hydroxide . Both CH and dentinal adhesives have their proponents and adversaries. CH is unable to provide a long-term seal against microleakage .

## 7.11.1. PROCUDURES:

1- After local anesthesia with 3% prilocaine containing 0.03 UI/ml felipressin, the teeth were isolated with a rubber dam and polished with a rubber cup and a low abrasion prophylactic paste.

2-Finally, the operating field was cleaned with 70% isopropyl alcohol.

3-Class I cavities were prepared as deeply as possible without exposing the underlying pulp tissue using a sterile cylindrical #2068 diamond point (KG Sorensen ISO size 014; Ind.e Com Ltda, SP, Brazil) in an air turbine with distilled water spray.

4- An exposure approximately 1 mm in diameter was made in the coronal pulp chamber using a sterile round #1010 diamond bur (KG Sorensen, ISO size 010) under air-water spray, applied with a gentle technique to avoid deep penetration into the pulp tissue.

5- Bleeding was arrested by rinsing with physiological saline, along with the application of dry sterile cotton pellets or pellets moistened with saline solution kept in place for 10 to 20 seconds.

6- acid etching and adhesive application.

**Moreover, the precarious clinical conditions during DPC procedures, such as bleeding and difficulty with hemostasis maintenance, may contribute to capping failures**

## 7.12. REINFORCE FRAGILE ROOTS INTERNALLY[27] :

### 7.12.1. PURPOSE

This study evaluated the ability of resin-bonded posts to reinforce teeth that are structurally weak in the cervical area against fracture.

### 7.12.2. MATERIAL AND METHODS:

Forty canine roots were endodontically treated and randomly distributed into four groups of 10. Parallel-sided preformed posts were cemented into the roots of these teeth after their crowns were removed. The cervical third of the canals were flared to simulate teeth weakened in this area as a result of caries or endodontic therapy. Three resin cements and a zine-phosphate cement, which was used as the control, were used to secure the posts into the roots. Cemented posts were loaded in an Instron testing machine with a gradually increasing force at a 60-degree angle to the long axis of the root until the root fractured.

### 7.12.3. RESULTS

Roots in which the posts were cemented with Panavia were significantly more resistant to fracture than those where zinc phosphate was used ($p < 0.05$). Because of the inability to determine exactly the point of failure of the zinc-phosphate cement, no statistically significant difference was found when compared with the other two resin cements (ANOVA and Student-Newman-Keuls test).

## 7.13. REPAIR EXISTING RESTORATION [28]:

The results of this study therefore indicate that the use of bonding agents significantly improves the quality of composite repair . It has been shown that the success of repair is higher for newer composite than older composite . The advantages of not replacing the entire restoration due to minor flaws are several; tooth structure and strength are preserved. When deciding to repair RC restorations, strategies for pretreatment of the restoration to be repaired are important. Different additives to bonding systems, such as silanising agents and phosphates have been shown to improve bond strength. (fig.28)

Theoretically, macro mechanical retention should also be beneficial as it firmly locks the restoration in place and reduces direct stress on the repair interface.

Old Restotation Using Bonding Agent

New Restoration

Figure 28:-

Steps of repair existing restoration