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RESEARCH ARTICLE

RECENT ADVANCES IN COMPOSITE RESTORATIONS.

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Abstract

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Improvements in tooth-coloured restoratives and bonding technology have made dental procedures more palatable and feasible. Patients are attracted to a restoration that matches the color of natural teeth. Resin composites meet this demand and have become the most frequently used esthetic material in dentistry. In addition, resin composites avoid the mercury controversy, and bond to tooth structure by using adhesive systems.Composite restorative materials represent one of the many successes of modern biomaterials research, since they replace biological tissue in both appearance and function.

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Introduction:-

Dental caries is a disease that dates back to antiquity and is the most common disease affecting mankind making the restorative treatment, the focus of dentistry. Now a days restorative treatment is described as “secondary prophylaxis, ”because it is considered that once the inevitable dental caries occurs, it is to be treated to prevent further breakdown of teeth and the dentition.[1]

For this, various restorative materials have been used since years to preserve the lost tooth structure and to maintain form, function and esthetics.[2]

The concept of restoring the cavity dates back to the first century AD, where Celsus recommended lint, lead and other materials to fill cavities. Other early substances used to fill teeth included alum, honey and ground mastic.[1]In 1800, amalgam became the restorative material of choice due to its low cost, ease of application, strength, durability. However, due to lack of esthetics, and unavoidable use of mercury, it was regarded as harmful to the patients health. In 1803, gold was used as restorative material, but it was very technique sensitive. Guttapercha was then discovered in India in 1842, as a filling material, although mostly as a temporary one. [3]

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Most of the materials used until now was not esthetically compatible with the tooth. As the esthetic quality of a restoration is important to the mental health of the patient in the same manner as biological and technical qualities of the restoration are to his physical or dental health. Hence in an attempt to find materials which could match the tooth esthetically, silicate cement was introduced in 1903. This was the first direct semi-esthetic filling material. However, their shrinkage and subsequent marginal leakage was high, often leading to significant interfacial staining.[3]The search for an ideal esthetic restorative material thus continued. This search to overcome the shortcoming of the silicate materials led to a new turn when resin composites based on BISGMA were introduced in 1960.

With this concept stabilized, finally Composite resins were introduced into the field of conservative dentistry to minimize the drawbacks of the acrylic resins and silicate cement. Composite restorative materials represent one of the many successes of modern biomaterials research, since they replace biological tissue in both appearance and function[4]. These are tooth-colored restorative materials made of resin reinforced with silica or porcelain particles.[5]With the introduction of ultraviolet light-curing system, cosmetic dentistry became more convenient and efficient.[6]

Recently to further enhance the esthetics, strength, durability etc, various variants of composites have been introduced such as direct composite resin, flowable composite, indirect composite resin, nanocomposites, antimicrobial composite, stimuli responsive composite, fibre reinforced composite, self healing composite etc.

Definition:
Skinners (1991) defined composite as "a compound of two or more distinctly different materials with properties that are superior or intermediate to those of the individual constituents."[7]

Classification:[8]
Based on filler size
Lutz and philips(1983)
1. Macrofilled
2. Microfilled
3. Hybrid

Based on consistency
Marshall et al(1988)
1. Homogeneous filler(midifill, microfill, and hybrids) ,
2. Heterogeneous filler (microfill and hybrid)

Based On Viscosity
1. Flowable
2. Medium
3. Packable

Based On Density
A) Bog l et al(2007)
1. Low density (Fluid)
2. Medium density (Conventional)
3. High density (Packable)
4. Super high density (Ceromers)

Types of Composite Resin[9]
The most popular classification is based on filler particle size given by Lutz and Phillips in 1983.
According to this classification, composite resins were divided into
1. Macro filled composites,
2. Micro filled composites and
3. Hybrid composites.

	CONVENTIONAL	**MICRO FILLED**	**HYBRID**
Introduction	1960s	Late 1970s	1980s

Trade names	Adaptic(Johnson&Johnson) , Concise(3M)	Durafill VS(Kulzer) , Heliosit(vivadent) , silux plus, Heliomolar.	Command ultrafine(Sybron/kerr) , valuxOM, occlusion(ICI) , P-50(3M)
Composition	Quartz, strontium, barium glass	Colloidal silica	Glass and colloidal silica
Particle size	8-50 µm(75-80 wt%, 55-60 vol%)	0.01 µm to 0.04 µm(30-55wt%, 17-40vol%)	15-20 µm, 0.01-0.05µm(75-85wt%)
Indications	Stress bearing areas	Non stress bearing areas	ClassIII, IV, V, posterior restorations
Advantages	Excellent optical properties , Chemical inertness	Better esthetics and polishability	Less curing shrinkage, improved radioopacity, low water absorption, excellent polishing and texturing properties, abrasion and wear very similar to that of tooth structures
Disadvantages	Difficult to polish,surface roughness, staining, plaque occlusal wear, poor esthetics	Chip fractures	Mechanical properties are inferior to small particle filled resin
Compressive strength(MPa)	250-300	250-300	300-350
Tensile strength(MPa)	50-65	30-50	70-90
Elastic modulus(GPa)	8-15	3-6	7-12
Coefficient of thermal expansion($10^{-6}/^0C$)	25-35	50-60	30-40
Knoop Hardness number(KHN)	55	5-30	50-60

Table 1:-Classification of composite resins

Steps of Composite Restoration[10]

The steps involved in restoration of tooth with composite materials includes:

1. Preparation of the operative site
2. Shade selection
3. Isolation of the operating site
4. Tooth preparation
5. Acid etching
6. Bonding agent application.
7. Insertion of composite material
8. Curing
9. Finishing and poilishing

Preparation of the operative site:

The operating site is cleaned using pumice slurry to remove plaque, calculus and superficial stains to enhance bonding. Prophy pastes containing flavoring agents, glycerine or fluorides acts as contaminants and should be avoided. Local anesthesia can be given which makes the procedure pleasant, time saving and reduces salivation.

Shade selection:

Shade of the tooth should be determined before the teeth are subjected to any prolonged drying because dehydrated teeth become lighter in shade as a result of decrease in translucency. Most manufacturers provide shade guides for specific materials, which vary in number of shades available and among them VITA shade guide(figure 1) is the most acceptable one. Good lighting is necessary during selection of color. Natural light is preferred and if no windows are present, color corrected operating lights or ceiling lights are available to facilitate accurate shade selection. For more accuracy of shade selection, a small amount of material of selected shade can be placed directly in close proximity to the area to be restored and cured. If the shade is matched, an explorer is used to remove the cured material from the tooth surface.

Figure 1:-Vita shade guide

Isolation of the operating site:
Isolation can be achieved using rubberdam(figure 2), cotton rolls, with or without a retraction cord. Contamination of etched enamel or dentin by saliva results in significantly decreased bond and contamination of composite material leads to degradation of their physical properties.

Figure 2:-Rubberdam isolation

Tooth preparation:
Tooth preparation for a composite restoration includes the following:
1. Removing the fault, defect old material or friable tooth structure.
2. Creating prepared enamel margins of 90 degree or greater
3. Creating 90 degree cavosurface margins on root surface

Types of tooth preparation:
Tooth preparation for composite materials should be as conservative as possible. The extent of the preparation usually is determined by the size, shape and the location of the defect and whatever extensions are necessary to provide access for vision and instrumentation.

The designs of tooth preparations for composites are:
1. Conventional
2. Beveled conventional
3. Modified
4. Box only
5. Slot preparations

Conventional tooth preparation:
The primary indication for conventional tooth preparation(figure 3) in composite restoration are:
1. Preparations located on root surfaces (non enamel areas)
2. Moderate to large class I and class II restorations

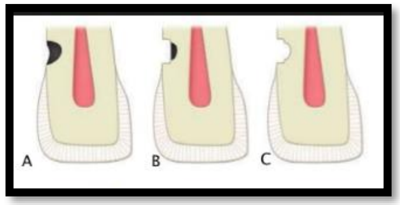


Figure 3:-Conventional tooth preparation

Beveled conventional:

The beveled conventional(figure 4) is typically indicated when a composite restoration is being used to replace an existing restoration exhibiting a conventional tooth preparation design with enamel margins or to restore a large area.

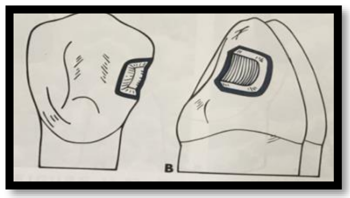
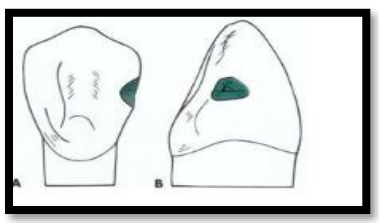


Figure 4:-Beveled conventional

Modified(Figure 5)

It is indicated primarily for the initial restoration of smaller cavitated carious lesions usually surrounded by enamel and for correcting enamel defects.



Figure(5) : Modified

d) Box only: (Figure 6)

This design is indicated when only the proximal surface is faulty with no lesions present on the occlusal surface.

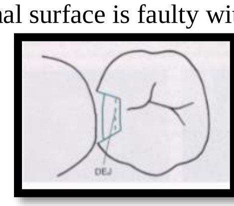


Figure 6:-Box only

Facial/lingual slot(**Figure 7)**

This is indicated for restoring proximal lesions on posterior teeth.

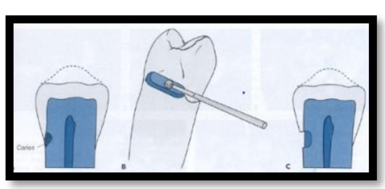


Figure 7:-Facial/lingual slot

Acid etching:
Introduction:
Etching is defined as the process of increasing the surface reactivity by demineralizing the superficial calcium layer and thus creating the enamel tags(figure 8) .

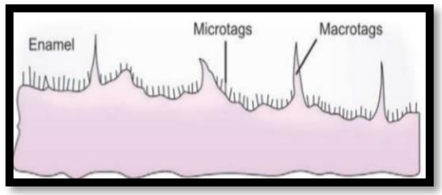


Figure 8:-Resin tag formation

Mechanism of action:
After tooth preparation, smear layer which constitutes hydroxyapatite ,altered collagen with an external surface formed by denatured collagen is formed on the surface of tooth. When an etchant is applied to the tooth surface(figure) , it dissolves the smear layer and penetrates it. There is preferential dissolution of hydroxyapatite crystals from enamel and dentin that results in microporous surface topography.[9]

Etching time:
Traditionally it is 60 seconds. Deborah A et al in 1986 revealed that 15 seconds etching time results inacceptable bond strength as 60 seconds. Hence 15 seconds is currently acceptable.

Greater etching time is required for fluorosed teeth(Gordon J et al, 1992) and primary teeth because fluorosed teeth has increased mineral content and primary teeth has aprismatic enamel.

Procedure of acid etching:
Cleaning of tooth surface using pumice paste
⇩
Acid etched for 15 seconds
⇩
Rinsed with water for 20seconds and dried

Bonding Agent Application:[10]
The adhesive material can interact with dentin in different ways- mechanically, chemically or both. However, importance of micromechanical bonding, similar to what occurs in enamel bonding, has become accepted. Studies have shown that dentin adhesion relies primarily on the penetration of adhesive monomers into the filigree of collagen fibres left exposed by acid etching.

Development Of Dentin Bonding Systems:[9]
Based on chronology of development, dentin bonding agents were classified into seven generations(Table 2).They are as follows.

GENERATION	NUMBER OF STEPS	STEPS DESCRIPTION	EXAMPLES
First	2	Etch enamel+ apply adhesive	Crevident-SS White Cosmic bond.
Second	2	Etch enamel+ apply adhesive	ScotchBond(3M Dental) Clearfil bond
Third	3	Etch enamel+apply primer+apply bonding agent	Scotch bond 2 XR bonding system Gluma bonding system Tenure dentin bonding system Prisma universal bond 2 and 3 Clearfil liner bond 160
Fourth	3	Total etch+apply primer+apply bonding	All Bond 2 Optibond Probond

		agent	Scotchbond multipurpose Clearfil liner bond.
Fifth	2	Total etch	Prime and bond Single bond Optibond Solo Optibond Solo plus
Sixth	1 or 2	Apply self etch adhesive	Self etching primer-clearfil SEbond Self etching adhesives-Adper Prompt L-Pop, Xeno III
Seventh	1	Apply self etch adhesive	Ibond Gbond
Eigth	1	Apply self etch adhesive	Future bond dc

Table(2) :Generations of bonding agents

Placement of composite material:
Composite resins can be inserted in the prepared cavities either in a bulk(figure) or incremental pattern depending on the site of restoration.

Bulk-Fill Placement:[8](Figure 9)
The composite resin was placed in a single increment into the prepared cavity and allowed to set. Composite materials tends to shrink during polymerization which thus leads to bond failure, leading to marginal discoloration, secondary caries and postoperative sensitivity.This was the main drawback and it may be due to polymerization shrinkage of about 1.5-5% volumetric shrinkage.

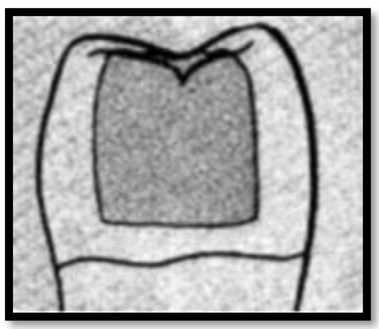


Figure 9:-Bulk-fill

Incremental Layering:[11]
To reduce the volume of the resin and the stress generated on the cavity walls, incremental layering was introduced by **Lutz et al in 1986**.It is also called as horizontal incremental layering technique(figure 10) .Composite material can be placed in small increments, each increment is less than 1 to 1.5mm thickness and is allowed to set before the next one is added. This thickness has been decided according to the curing capability of curing lights. In incremental pattern, there is minimal contact of the material with the cavity walls during setting. By utilizing the technique of placing a small amount of composite, a low configuration factor can be achieved.The advantage to having a low configuration factor is a reduction of the amount of shrinkage in the composite while it is being polymerized. Before light curing, as much surface area of the composite was made free as possible to allow for the composite to flow, thus decreasing the amount of shrinkage and this reduces shrinkage and gap formation which is responsible for post-operative sensitivity, microleakage etc which eventually lead to failure of restoration.

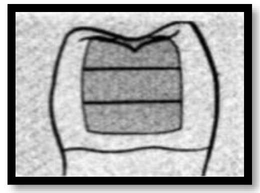


Figure 10:-Horizontal incremental technique

To further reduce polymerization shrinkage of composite resins, incremental layering was modified into different techniques to obtain better clinical efficiency.[12]

The modifications were as follows:

1. Oblique incremental technique
2. Vertical layering technique
3. Split-increment horizontal layering technique
4. Successive cusp buildup technique
5. Separate dentine and enamel buildup
6. Mat horizontal technique.

Oblique incremental technique(Figure 11)

Also known as Z-technique. The composite resin is placed inside the cavity in multiple increments so that each increment is in contact only with the bottom and one side wall of the cavity. This results in a relative increase in the free surface of the filling material, and a decrease in the extent of polymerization shrinkage.

Advantages:

1. Enhanced adaptation
2. Decreased polymerization shrinkage

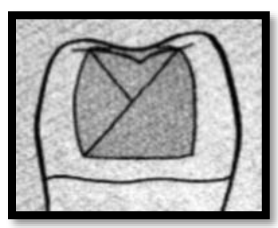


Figure 11:-Oblique incremental technique

Vertical layering technique:

Small increments can be placed in vertical(figure 12) pattern starting from one wall, i.e., buccal or lingual and carried to another wall followed by the polymerization from behind the wall, i.e,if buccal increment is placed on the lingual wall, it is cured from outside of the lingual wall. This reduces gap at gingival wall which is formed due to polymerization shrinkage, hence there can be less postoperative sensitivity and secondary caries formation.

Advantages:

Decreased polymerization shrinkage

Disadvantages:

Time consuming

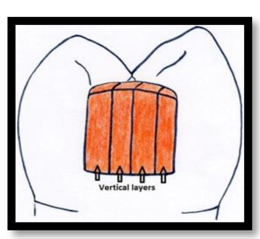


Figure 12:-Vertical layering technique

Split-increment horizontal layering technique(Figure 13)
Each horizontal increment was split, before curing, into four triangle-shaped portions with each portion placed against only one cavity wall and part of the floor one diagonal cut was filled completely with dentin shade composite and photocured. At this point, the other diagonal cut was filled and photocured, one half at a time. The same technique is followed until dentin-enamel junction and later enamel shade composite followed by translucent shade are placed and shaped to establish occlusal morphology. This sequence would prevent composite resin from connecting two opposing cavity walls simultaneously, minimizing the negative effects of polymerization shrinkage on the cavity walls and adhesive interfaces. This would even reduce the configuration-factor ratio from 5, which is the highest and the most unfavorable, to the second most favorable configuration-factor ratio of 0.5. Such small increment portions with a low configuration -factor ratio would relieve the shrinkage stress by the free composite surface flowing at the diagonal cuts and not at the bonded interfaces, minimizing the adverse effects of polymerization shrinkage stresses.

Advantages:
1. Decreased polymerization shrinkage
2. Better contour and esthetics.
3. Decreased finishing time

Disadvantages:
Time consuming

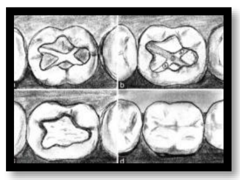


Figure 13:-Split-increment technique

Successive cusp buildup technique(Figure14)
Here, individual cusps are restored one at a time up to the level of the occlusal enamel. Small sloping increments are applied to each corner of the cavity in turn and manipulation is kept to a minimum, to avoid folding voids into the material. Initially it was time consuming, but it can greatly reduce finishing time by precise attention to progressive reconstruction of natural morphology.

Advantages:
Bettercontour can be obtained

Disadvantage:
Time consuming

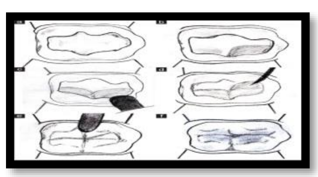


Figure 14:-Successive cusp buildup technique

Separate dentine and enamel buildup(Figure 15)
Here, sloping increments are again applied to cavity walls but only till the level of the dentinoenamel junction. Final "enamel" increments are then applied. Prudent control of the final layer will again reduce the finishing time. An alternative method of achieving a more natural appearance is to use a dark shade of composite for the bulk of the restoration and a translucent or light shade for the "enamel" increment.

Advantages:
1. Better esthetics
2. Reduces finishing time

Disadvantages:
Time consuming

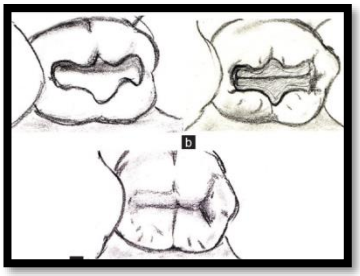


Figure 15:-Separate dentine and enamel buildup

Mat horizontal incremental technique:
The Mat horizontal incremental technique showed the lowest microleakage as the mat cutting of the flat uncured composite increment into six square shaped composite portions has created new unbonded composite surfaces, thereby configuration-factor was reduced further resulting in less polymerization shrinkage due to lesser stress developed at the bonded cavity walls and margins.

Advantages:
Decreased polymerization shrinkage.

Curing:[13]
Photopolymerization is a technique that uses light (visible or ultraviolet) to initiate and propagate a polymerization reaction to form alinear or crosslinked polymer structure.
The four main types of photopolymerization sources currently available are visible lights such as quartz tungsten halogen lamps, plasma arc lamps, argon ion lasers, and light emitting diodes.

Quartz Tungsten Halogen (Qth) Lamps
These were introduced in early 1976 to overcome the drawbacks of UV lamps.These have been the standard curing units for several years, despite a remarkably low efficiency compared to heat generation. Since these lamps(figure 16) emit a rather wide range of wavelengths, band-pass filters are required to limit the wavelength between 370 and 550 nm in order to fit the peak absorption of camphorquinone(400-500nm) . With these lamps, 5% of the total energy is visible light, 12% heat, and 80% light emitted in the infrared spectrum.

Advantages:
1. Better output stability
2. Smooth spectral curve.
3. Considered as broad banded in spectral emission capacity to activate a wide range of photoinitiators

Drawbacks:
1. Heat generation is a major disadvantage which increases with increasing radiation time.
2. Limited lifetime of the bulb and degradation of the reflector and filter over time.
3. Less irradiance
4. Short curing depth

Figure 16:-Quartz tungsten halogen (qth) lamp

Plasma Arc Curing (Pac) Lamps:
These were introduced in mid 1990s in Europe to enhance the rate at which the peroxide gel break down intra orally, by exposing it to high intensity visible light and were primarily designed to save irradiation time as an economic factor and without affecting mechanical properties. Plasma arc curing lamps(figure 17) emit light from glowing plasma being composed of a gaseous mixture of ionized molecules such as xenon molecules and electrons. These are characterized by high intensities in a narrow range of wavelengths around 470 nm. Due to the described high energy output of plasma arc systems, 3 seconds of irradiation would achieve similar material properties compared to 40 seconds curing with quartz tungsten lamps. The current recommendations for plasma arc lights are based on 3x3 seconds.

Advantages:
Saves irradiation time

Drawbacks:
1. 3 seconds cure was far too short to obtain good conversion of monomers to polymers**.**
2. Compromised mechanical properties of cured restoration.
3. Lower hardness values were obtained.

Figure 17:-Plasma arc curing (pac) lamps

Argon-Ion Lasers (Al)
These were first introduced in Europe in 1962 which emit blue-green light of activated argon ions in selected wavelengths (between 450 and 500 nm) and are therefore suitable for light-curing of resin-based composites. Argon-ion lasers(figure 18) operates with 250 ± 50 mW/cm^2 for 10 seconds

Advantages:
1. Higher conversion rates within a shorter period.
2. Polymerization depths

Drawback:
1. High cost
2. Heat generation
3. High initial shrinkage stresses

Figure 18:-Argon-ion lasers (al)

Light Emitting Diodes (Led) :
To solve the problems associated with conventional quartz tungsten halogen technology, Mills introduced these diodes in 1995. While the halogen bulbs operate with a hot filament, these diodes use junctions of doped semiconductors (p-n junctions) for the generation of light. The spectral emittance of gallium nitride blue light

emitting diodes cover the absorption spectrum of camphorquinone so that no filters are required in light emitting diode(figure 19) curing units. These are less energy-consuming compared to conventional quartz tungsten halogen and do not require external cooling in the majority of products on the market. Moreover, light emitting diode lamps have a lifetime of several thousands of hours without a significant intensity loss. These diodes emit approximately 15% visible light and 85% heat. In the direction of the curing tip, these are mainly not emitting heat,however, 85% heat is produced in a backward direction which has a inbuilt mechanism of dissipating heat that is why these diodes do not heat up easily.

Advantages:
1. No filters are required
2. Less energy consuming
3. Increased life time.
4. Highest polymerization efficiency.

Figure 19:-Light emitting diodes (led)

Contouring ,Finishing and Polishing:-
This is one of the most important steps for the success of composite restorations as it improves patients esthetics,maximize patients oral health and increase the longevity of the restoration. The key to beauty and biologic integrity of these longterm restorations lies in the final steps of the procedure.

Finishing refers to the process of adapting the restorative material to the tooth such as removing overhangs and shaping occlusal surfaces,whereas polishing refers to removing surface irregularities to achieve smoothest possible surface.

The commonly used finishing systems included fluted carbide burs(figure 20), diamond burs, stones, abrasive discs(figure 21) and strips(figure 22), polishing pastes, rubber cups(figure 23 and abrasive wheels (various grits).

Figure 20:-Flame shaped carbide finishing bur

Figure 21:-Aluminium oxide disc

Figure 22:-Aluminium oxide strips

Figure 23:-Composite polishing cup

Advantages of proper finishing and polishing:
1. Greatly enhances longevity,durability and longterm wear resistance of restoration.
2. Polishing the interproximal surfaces will significantly lowers patients risk for secondary caries and periodontal disease.
3. A smooth tooth surface minimizes gingival irritation and surface discoloration.
4. A polished tooth is more biologically compatible with the gingival tissue,so the health of gingival tissue is maintained.
5. A smooth surface reduces the accumulation of plaque on tooth surfaces.
6. A highly polished tooth surfaces increases the reflective and refractive index of restoration to create more natural and esthetic smiles.
7. Enhances patient comfort and satisfaction.

Failure of composite restorations[10]
polymerization shrinkage:
Polymerization shrinkage is a major problem with composite resins. The polymerization reaction of light cured composites induces polymerization contraction stress on tooth structures when a composite resin is bonded to cavity walls. This creates contraction stress, which has the potential to initiate the failure of the composite tooth interface if the forces of polymerization contraction exceed dentin bond strength. As the configuration factor(ratio of bonded to unbounded surfaces) increases, shrinkage increases. If this occurs, adverse consequences such as postoperative sensitivity, microleakage, secondary caries, and microcracking of the restorative material can result.

Methods to overcome:
1. Increase in filler content
2. Silorane system that provides a high performance bond to the tooth.
3. Use of incremental layering technique
4. Use of a flowable resin composite as an intermediate thin layer

White line or halo around enamel margin:
It represents the microfracture of marginal enamel. This appearance may be due to traumatic contouring or finishing techniques, inadequate etching and bonding of that area, high intensity light curing which results in excessive polymerization stresses**.**

Methods to overcome:
1. Re-etch, prime and bond the area
2. Removal of fault conservatively and re-restore.
3. Use of atraumatic finishing techniques with light intermittent pressure

Voids:
Voids in composite restoration may be due to inadequate mixing of self cured composites, spaces left between increments during insertion of light cured composites**,** tacky composite pulling away from site of prepared tooth during insertion due to improper isolation during the procedure.

Methods to overcome:
1. More careful technique.
2. Repair of marginal voids by preparing the area and re-restoring.
3. Proper isolation of operating area.

Weak or missing proximal contacts:
Weak or missing proximal contacts like in GV BLACKS class II, III, IV cavities.These may be due to inadequately contoured matrix band which is too thick and its movement during composite insertion, inadequate wedging preoperatively and during the composite insertion, tacky composite pulling away from matrix contact area during insertion due to saliva contamination.

Methods to overcome:
1. Properly contour the matrix band and make it in contact with adjacent tooth
2. Use of firm preoperative and insertion wedging technique.
3. Hand instrument to be used to hold matrix against adjacent tooth when curing incremental placements of composite.

Incorrect shade:
The incorrect shade of composite may be due to inappropriate operating light while selecting the shade, selecting the shade after the tooth is dried, shade tab not matching the actual composite shade, wrong shade selection.

Methods to overcome:
1. Use of natural light if possible
2. Shade selection to be done before isolating the tooth.
3. Preoperatively place some of the selected shade on tooth, cure it and evaluate the shade matching.
4. Do not use operating light directly on area during shade selection.

Poor retention:
Inadequate tooth preparation form, contamination of operating area, poor bonding technique, intermingling of bonding materials from different systems may result in poor retention of composite restoration.

Methods to overcome:
1. Prepare the tooth with proper bevels or flares and secondary retention features when necessary.
2. keep area isolated during bonding
3. Do not intermingle bonding materials from different systems.

Contouring and finishing problems:
Injury to the adjacent unprepared tooth structure, overcontouring the restoration, ditch created in cementum during cervical margin contouring result in problems with finishing and polishing.

Methods to overcome:
1. Careful use of rotary instruments to avoid adversely affecting adjacent tooth structure or teeth.
2. Use of proper matrix with appropriate axial and line angle contours.
3. Create embrasures to match adjacent tooth embrasure form
4. Do not use rotary instruments that leave roughened surfaces
5. Use a properly shaped contouring instrument for area being contoured.
6. Remember the outline form of preparation.
7. View restoration from all angles after contouring.

Recent Advances In Composites

Recent advances in the field of dentistry has given a wide variety of composites available today in the market. But the right material for each clinical situations should be selected based on the requirement of individual case. Every method has its merits and demerits,these should be considered while they are selected for clinical purposes.[14]

Self-Repairing Materials:[15]

These materials were introduced by **Wool and O'Connor (1981) .**One of the first self-repairing synthetic materials reported, interestingly showed some similarities to resin-based dental materials. Brittle polymers and the structural composites made from them are susceptible to microcracking when subjected to repeated thermo mechanical loading. For structural composites, these matrix microcracks coalesce and lead to other damage modes that includes fiber/matrix debonding .These self repairing materials(figure 27) has a inbuilt intrinsic mechanism to manage the microcracking before it starts affecting the integrity of the material.

Indications:

GV BLACKS Class I, II cavities.

Contraindications:

GV BLACKS Class III, IV V cavities.

Composition:

These materials significantly extends the life of polymeric components by autonomic healing microcracks whenever and wherever they develop.This was an epoxy system which contained resin filled microcapsules.

Mechanism of action:

If a crack occurs in the epoxy composite material, some of the microcapsules are destroyed near the crack and release the resin. The resin subsequently fills the crack and reacts with a catalytic chemical trigger catalyst which is dispersed in the epoxy composite, resulting in a polymerization of the resin and repair of the crack.

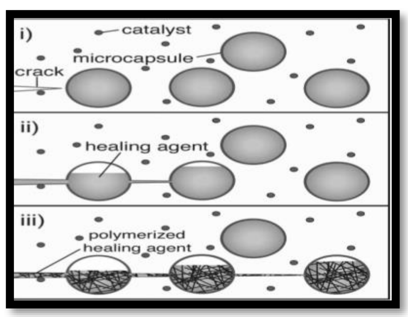


Figure 27:-Structure of self healing composite

Advantages:

1. Reduces polymerization shrinkage
2. Increased resistance to fracture.
3. Increased flexural strength and wear resistance
4. Better durability and toughness as compared to conventional composites

Disadvantages:

Technique sensitive.

Ormocer:[16]

These materials were introduced in 1991 in order to overcome various limitations and concerns associated with the traditional composites when used as a posterior composite material. A new packable restorative material was introduced which is called ormocer which is an acronym for organically modified ceramic technology **(Cunha et al., 2003) .**

Indications:
1. Restoration of GV BLACKS class I, II, V cavities
2. As a liner of class I and II cavities
3. Reconstruction of traumatically damaged anteriors
4. Splinting of loose teeth
5. As a extended fissure sealant
6. Core build up
7. Fabrication of composite inlay

Contraindications:
In areas where esthetics is of prime importance.

Composition:
Ormocers basically consist of three components – organic, inorganic portions and the polysiloxanes. The proportions of those components can affect the mechanical, thermal and optical qualities of the material.

The inorganic components are bound to the organic polymers by multifunctional coupling agent silane molecules. After polymerisation the organic portion of the methacrylate groups form a three-dimensional network.

Advantages:
1. Better marginal seal
2. Large size of monomer molecule minimizes polymerization shrinkage(**rosin et al 2002**) .

Disadvantage:
1. Highest cytotoxicity
2. Tendency to discolor.
3. Lower wear resistance.

Antimicrobial Composite:[17]
These were introduced in 1998. Antimicrobial properties of composites may be accomplished by introducing agents such as silver(**Peng et al., 2012)**, titanium particles, immobilized antibacterial components(**Xie et al., 2011; Imazato et al., 2012)**or one or more antibiotics into the material. Microbes are subsequently killed on contact with the materials or through leaching of the antimicrobial agents into the body environment.The method of immobilization has the advantage of long lasting antibacterial properties **(Imazato et al., 2012) ,**however they lack strong and remote antibacterial action.

Composition:
Very often antibacterial materials with immobilized agents consists of polymers containing quaternary ammonium or phosphonium salts or a combined incorporation of quaternary ammonium and polyethylenimine nanoparticles **(Rolland et al., 2011**) .New dental composites incorporating quaternary ammonium dimethacrylate (QADM)and silver nanoparticles (AgNP)have been manufactured and observed to inhibit Streptococcus mutans (S. mutans)**(Zhang et al., 2013; Cheng et al., 2018**) .

Several reports have described the incorporation of a methacryloyloxydodecyl pyridinium bromide monomer in composite resins that showed no release of the incorporated monomer but still exhibited antibacterial properties. Alkylated ammonium chloride derivatives and chlorhexidine diacetate have also been introduced as an antimicrobial agent into dental composites.Calcium phosphate nanoparticles have been incorporated into composites in addition to QADM(quaternary ammonium dimethacrylate)and AgNP(silver nanoparticles)to induce regenerative properties **(Cheng et al., 2012**) . Calcium-fluoride and chlorhexidine or a new sol-gel derived Ag-doped bioactive glass, are also some of the new components in novel dental materials development aiming to enhance remineralization, regeneration and bactericidal properties**(Cheng et al., 2012b**; **Chatzistavrou et al., 2015) .**

Advantages:
1. Enhanced biocompatibility
2. Reduces formation of secondary caries near margin of restorations due to inhibition of bacterial growth
3. Reduced demineralization and buffering of acids produced by cariogenic microbes.

Disadvantage:
1. Deterioration of physical and mechanical properties of the material
2. Toxic effects of released materials
3. Short lived antibacterial activity

Stimuli Responsive Composite:[18]
Stimuli-responsive materials also known as smart composites and were introduced in 1998.These materials possess properties that may be considerably changed in a controlled fashion by external stimuli. A stable polymer network and a reversible switching transition of the polymer are the two pre-requites for the shape memory effect (SME) .

Mechanism of action:
The stable network of SMPs determines the original shape, which can be formed by molecule entanglement, crystalline phase, chemical cross-linking, or interpenetrated network. Stimuli-responsive polymers significantly change their properties such as shape, mechanical properties, phase separation, surface, permeability, optical properties, and electrical properties upon small variation of environmental conditions such as temperature, electric field, pH, light, magnetic field, electrical field, sonic field, solvent, ions, enzymes, and glucose.

Shape memory polymers (SMPs)as a type of important stimuli-responsive polymers, can recover their original (or permanent)shape upon exposure to external stimuli.The lock in the network represents the reversible switching transition responsible for fixing the temporary shape, which can be crystallization/melting transition , vitrification/glass transition, liquid crystal anisotropic/isotropic transition , reversible molecule cross-linking, and supramolecular association/disassociation. Such stimuli may be for example changes of temperature, mechanical stress, pH, moisture, or electric or magnetic fields. Stimuli-responsive dental composites may be quite useful for example for “release-on-command” of antimicrobial compounds or fluoride to fight microbes or secondary caries, respectively.

Advantages:
Reduces risk of secondary caries.

Giomer:[19]
To overcome the disadvantages of compomers like no fluoride recharge capacity, recently a new category of hybrid aesthetic restorative material which differs from both resin modified glass ionomer and composites has been introduced by Shofu Inc. **(Kyoto, Japan 2000** known as GIOMERS, in which they created a Stable Glass-ionomer phase on a glass core in which they induced an acid-base reaction between fluoride containing glass and polycarboxylic acid in the presence of water developed as Pre-Reacted Glass-ionomer (PRG)filler.

Indications:
1. GV BLACKS III, IV V cavities.
2. Restorations of deciduous teeth.
3. As a base/liner under restorations.
4. As a fissure sealant
5. Restoration of fractured composites and porcelain
6. Repair of fractured incisal edges
7. Cervical erosion and root caries
8. Venneers and post

Contraindications:
In areas where esthetics is of prime concern.

Composition:
Giomer is a fluoride-releasing, resin-based dental adhesive material that comprises Pre-Reacted Glass-ionomer fillers**.**Glass inomers are easy to place, fast-setting, have high fluoride release, low polymerisation shrinkage, hydrophilicity and bonding ability to enamel and dentin. Light activated glass ionomer in particular have the added benefits of reduction in microleakage and immediate finishing and polishing .

The difference between giomer(figure 28)and other fluoride-releasing restorative materials is that giomer includes a surface prereacted glass (S-PRG)filler to the resin matrix. These filler allows the material to release fluoride and they can be recharged with fluoride even on a daily basis by means of fluoride dentrifices.,which in theory makes it able to release fluoride over the long term. It also contains BISGMA(Bisphenol-A glycidyl dimethacrylate), UDMA(urethane dimethacrylate), BISMPEPP(2, 2 bis(4-2 methacrlyloxy)ethoxy)phenyl propane), TEGDMA(triethylene glycol dimethacrylate)in organic matrix.

Advantages:
1. Better esthetics
2. Improved handling and physical properties compared to conventional composites
3. Increased radioopacity compared to conventional composites.
4. High fluoride release and recharge capability.
5. Shade stability before and after curing.
6. Low shrinkage stress

Disadvantage:
1. Rough surface resulting in tooth discoloration
2. Vickers hardness value are less than composite
3. Long term fluoride release is questionable.
4. Not beneficial in high recurrent caries lesions as release of fluoride is less than that of GIC.

Figure 28:-Giomer

Nanocomposites:[18]
These materials were introduced in 2002 and is constituted by a matrix and a reinforcement consisting of fibers.

Composition:
The matrix itself comprises a resin and filler, the goal of which is to improve the characteristics of the resin while reducing the production cost. From a mechanical point of view the filler-resin system behaves as a homogeneous material mainly because of the nano particle size of the fillers . The composite is considered as being made of a matrix and filler reinforcement. The filler reinforcement brings to the composite material its greater mechanical performance, whereas the role of the matrix is to transmit the external mechanical load and to protect the composite restoration against external attack.

Nanocomposites nanotechnology may provide composite resins with a dramatically smaller filler particle size that can be dissolved in higher concentrations and polymerized into the resin system. The molecules in these materials can be designed to be compatible when coupled with a polymer and provide unique characteristics (i.e., physical, mechanical, optical) .

Advantages:
1. Improved mechanical characteristics
2. Good thermal stability
3. High cost
4. Resistance to corrosion
5. Increased transulency leading to surface gloss
6. Improved handling properties

Conclusion:-
Many advancements were made in these resin compositions to achieve better clinical efficiency and patient comfort such as compomer, giomer, self healing composites ,antibacterial composites etc, which thus revolutionized esthetic

dentistry. Compomer, which had the benefits of fluoride release and ease of use of glass ionomers and esthetic qualities of composite materials. Giomer, a unique class of restorative material has the distinguishing feature of a stable S-PRG(prereacted glass fillers), which is coated with an ionomer lining incorporated in a resin matrix. This arrangement aids in the protection of the glass core from moisture, adding to long-standing esthetics, and durability of the conventional composites with ion release and recharge property whereas self healing composites had the property of autonomous repair of the composite material.Antibacterial composites releases antibacterial monomers into the restoration.

Furthermore, improvements in formulations, optimization of properties and the development of new techniques for placement have made the restoration of direct composite more reliable and predictable.

References:-

1. Kidd Ea, Fejerskov o. essentials of dental caries. oxford university press; 2016 jun 16.
2. Manuja n, Pandit ik, Srivastava N, Gugnani N, Nagpal R. Comparative evaluation of shear bond strength of various esthetic restorative materials to dentin: an in vitro study. Journal of indian society of pedodontics and preventive dentistry. 2011 Jan 1;29(1):7.
3. Schulein TM. Significant events in the history of operative dentistry. J Hist dent. 2005 jul;53(2):63-72.
4. Cramer N B , Stansbury JW, Bowman C N .Recent advances and developments in composite dental restorative materials.Journal of dental research. 2011 Apr;90(4):402-16.
5. Ferracane J . Current trends in dental composites. Critical reviews in oral biology & medicine. 1995 Oct;6(4):302-18.
6. Singh H, Kaur M, Dhillon J S , Mann J S , Kumar A. Evolution of restorative dentistry from past to present. indian journal of dental sciences. 2017 Jan 1;9(1):38.
7. Phillips R W . Skinner's science of dental materials. Philadelphia: Saunders; 1973.
8. Wei S H , Tang el. Composite resins: a review of the types, properties and restoration techniques. Annals of dentistry university of malaya. 1994 Dec 30;1(1):28-33.
9. Vijay prakash ,Ruchi gupta. Textbook of dental materials 1 st edition 2018.
10. Roberson T, Heymann H O , Swift J R E J . Sturdevant's art and science of operative dentistry. Elsevier health sciences; 2006 Apr 13.
11. Asghar S,Aali A, Rashid S, Hosein T. Assessment of post-operative sensitivity in posterior resin-based composite restorations with two placement techniques. JPDA. 2013 Apr;22(02):98.
12. Chandrasekhar V, Rudrapati , Badami V, Tummala M. Incremental techniques in direct composite restoration. journal of conservative dentistry: JCD. 2017 Nov;20(6):386.
13. Singh TK, Ataide I, Fernandes M, Lambor R T . Light curing devices-a clinical review. Journal of orofacial research volume. 2011;1(1).
14. Aïssa B, Therriault D, Haddad E, Jamroz W. Self-healing materials systems: overview of major approaches and recent developed technologies. Advances in materials science and engineering. 2012.
15. Singh, et al.Recent advances in composite resin. international journal of scientific study. 2015 Dec;3 (9)
16. Chatzistavrou X, Lefkelidou A, Papadopoulou , Pavlidou E, Paraskevopoulos KM, Fenno J C , Flannagan S, González-cabezas C, Kotsanos N, Papagerakis P. Bactericidal and bioactive dental composites.frontiers in physiology. 2018 Feb 16;9:103.
17. Zhang JF , Wu r, Fan y, Liao S, Wang y, Wen ZT , Xu X. Antibacterial dental composites with chlorhexidine and mesoporous silica. Journal of dental research. 2014 Dec;93(12):1283-9.
18. Singh P, Kumar N, Singh r, Kiran k, Kumar s. Overview and recent advances in composite resin: a review. Int j sci stud. 2015;3(9):169-72.
19. Meena n. Giomer-the intelligent particle (new generation glass ionomer cement). Int j dent oral health. 2015;2(4).