INFLUENCE OF COMPOSITE RESIN PLACEMENT TECHNIQUES ON MICRO LEAKAGE AT THE GINGIVAL SEAT OF CLASS II CAVITY PREPARATION

(ln vitro study)

By

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بِسْمِ اللَّــهِ الرَّحْمَـٰنِ الرَّحِيمِ

يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ
وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ

"

سورة 58 المجادلة (الآية رقْم 11)

Dedication

I would like to dedicate my work to my beloved mother and the soul of my father, the light of my eyes. Whatever I have achieved is due to their hard work, prays and love. Thank you for teaching me to believe in myself, in Allah and in my dreams. You will always be in my prayers.

This dissertation is also dedicated to my loving husband, ***Abd alsalam alhaddar***, who experienced all the ups and downs of my research. All I have accomplished were only possible due to his endless support and encouragement. There are not enough words to express my appreciation.

It is also dedicated to my lovely kids, ***Aisha, Omran, Emad and Ghassan*** who did their best to make me feel better when I struggled during my stud.

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List of Abbreviations

Bis-GMA	Bisphenol Glycidyle Metha acrylate
UDMA	Urethan Di Metha Acrylate
TEGDMA	Tri Ethylene Glycol Di Metha Acrylate
DMAEM	dimethylaminoethyl methacrylate
PMMA	Poly(methyl methacrylate)
CEJ	Cemento-enamel junction
RBCs	Resin based composits
C- factor	Configuration factor
Mct	Micro-computed tomography
SAGs	Self-adhesive composites
LCU	Light curing unit
PS	polymerization shrinkage
OCT	Optical coherence tomography
FDI	World Dental Federation
MO	Mesio- occlusal
DO	Disto – occlusal
BFCs	Bulk fill composites
SEM	Scanning electron microscope

INFLUENCE OF COMPOSITE RESIN PLACEMENT TECHNIQUEs ON MICRO LEAKAGE AT THE GINGIVAL SEAT OF CLASS II CAVITY PREPARATION

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Abstract

Aim of the study: To evaluate the microleakage at the gingival seat of the proximal class II cavity prepared at 1mm distance above the cement enamel junction restored with bulk fill composite resin material using different placement techniques.

Materials and Methods: Forty sound extracted human permanent premolars used in the study. Standardized class II cavities (occluso-mesial and occluso- distal) were prepared in each tooth, with the cervical margin of the proximal box located 1 mm occlusal to the cemento-enamel junction (CEJ). The teeth were randomly distributed to four groups with 10 specimens each (n=20 cavities) according to packing techniques. In each group, a total-etch adhesive was applied, followed by composite resin that was applied according to; Group I: using bulk technique, Group II: horizontal layering technique, Group III: wedge - shaped layering technique, Group IV: vertical layering technique. All restored specimens were soaked in 2% methylene blue dye for 24 hours, and sectioned for microleakage evaluation using stereomicroscope. Data were collected and statistically analyzed. scanning electron microscope (SEM) for marginal adaptation and the presence or absence of gaps formed at the margins and of eight samples selected as two sample from each group in the study. The images were taken of the gingival margin at a magnification of1000x. **The result** : showed no statistical significant differences (p=.610) on comparison of microleakage score by different technique, but it was noticed that bulk technique had the highest mean and median for microleakage score (3.0+- 1.451 &4)and the horizontal, vertical and oblique techniques had the lowest mean scores.

Conclusions: Microleakage could not be completely eliminated by any of the testing packing techniques used in the study even with the newly developed Bulk-fill composite resin material. Horizontal packing technique showed the best results in terms of marginal seal with Bulk-fill composit. **Key words**: Microleakage, Class II, Bulk- fills composite, Composite placement Techniques.

Chapter 1

1. Introduction

1. Introduction:

The general term of composite is defined as a physical mixture of at least two chemically different materials with a distinct interface separating the components in order to produce a material with different physical and mechanical properties better than if one of the components is used alone.[1]

Basically, dental resin composite is composed of a blend of three phases namely: the organic phase which represents the matrix; disperse phase includes the inorganic fillers; and the interfacial phase which consists of a coupling agent that promote adhesion between resin and filler beside other important ingredients such as initiators for the onset of polymerization reaction, inhibitors to prevent spontaneous polymerization of composite resin during storage and pigments for tooth-matching color range.[2]

Dental resin composites are widely used as direct tooth colored restorative materials in dentistry owing to their ability to replace the biological tissue in both appearance and function through their reinforcement of tooth structures and conservation of the tooth structures because they are retained by adhesive methods rather than depending on cavity design.[3,4]

The suitability of this type of restoration has been limited by the shrinkage inherent in its polymerization when the monomer is converted into polymer.[5] This volumetric contraction of the composite material compromises the integrity of the composite resin-tooth interface causing adhesive failure, and gap formation between the tooth and the Restoration.[6] In addition, Brännström and Vojinovic 1976 showed in their study the deleterious effect of irritation following infection by bacteria growing in the gap between the restoration and the cavity wall.[7] This implies a clinically undetectable passage of bacteria, fluids, molecules and/or ions from one structure to the other, known as marginal leakage causing secondary caries and failure of the restoration.[8, 9]

Hannig and Friedrichs 2001 reported in their study that the percentage of dentinal gaps in a composite restoration placed in vivo may vary between 14% and 54% of the total interface, depending on the materials and techniques used.[10]

Direct resin restorations in class II preparations are a great challenge for the dental surgeon, for the control of polymerization shrinkage of composite resin preparations with the cervical margin in dentin exhibit more susceptibility to the occurrence of leakage.[11]

Microleakage phenomena could be the end product of a number of clinical factors such as the cavity configuration (C-factor) which is defined as the ratio of bonded to unbounded surfaces where high ratio denotes high polymerization stresses, which are accompanied by increased shrinkage stresses.[12] Among many of other important factors contributing to the shrinkage stresses are the variety of composite placement techniques[13] and the light curing scenarios as well.[14]

Microleakage assays provide useful information on the performance of restorative materials. Different techniques for assessing microleakage have been developed and used. These tests which use dyes, radioactive isotopes, air pressure, bacterial activity, neutron activation analysis, scanning electron microscope, dye penetration, and microcomputed tomography (μCT) all come with both advantages and drawbacks.[15] The dye penetration assay has many advantages over other techniques. First, no reactive chemicals are used along with no radiation.[16] Second, different dye solutions are available; therefore, the technique is highly feasible and easily reproducible.[17]

It is necessary to overcome or reduce the polymerization shrinkage stress of composites in order to obtain adequate marginal integrity and increase the durability of composite restorations.[18,19]

However, at present, there is no technique or material that can provide complete marginal adaptation, and in spite of significant advances in dentin bonding technology, a complete prevention of microleakage specially at dentin or cemental margins of cavity has not yet been achieved.[20]

On other hands, attempts to minimize the shrinkage stress, to decrease the microleakage, improve the marginal integrity and the durability of direct composite restorations several approaches have been introduced such as modification in material's formulations for properties optimization and the development of new composite placement techniques.

Concerning material's formulations and modification, a new category resin based composites (RBCs) called ''Bulk-fill'' materials, which are claimed to offer a single increment placement thickness ranging from 4 to 6 mm, instead of the conventional 2 mm value due to their higher translucency which allowed a better light penetration in to the deeper layer and increases the depth of cure has been introduced to dental practitioners.[21]

Also, it is due to increase dimensions of the fillers, decreasing the total filler surface and having a different monomer, bulk fill composites produce less shrinkage stress \ and cuspal flexure in standard class II cavities.[22]

Several study revealed that the high-viscosity bulk-fill RBCs responded heterogeneously to variations in curing conditions and an exposure time of 20sec at moderate irradiance was recommended for all materials for a 4 mm bulk placement.[23] which make them suitable for use in uncooperative patients due to faster working time.[24] On the contrary, other study reported that increased polymerization shrinkage and failure of curing of the composite might occur during the polymerization of curing large increments over 2 mm-thick of composite resins.[25]

A variety of restorative techniques have been recommended to reduce polymerization stress. One such strategies includes the use of liners/bases in the preparation.[25] Other strategy depends on the use of the incremental layering technique which has been accepted as the gold standard for placement of RBC restorations.[26] This technique has widely known as a technique that is used to outgrow the polymerization contraction process that has high C-factor. This technique is used by placing the composite resin incrementally into the cavity with 2 mm maximum thickness for every increment so the contraction stress that happened on one increment could be compensated by the next increment and at the end only the polymerization contraction from the last increment will destruct the bond.[27]

Various studies reported that the direction of the composite increment placed in the cavity showed great influences on the shrinkage stresses and microleakage.[25,26,27] The horizontal placement technique has been reported to increase the C-factor, and thereupon increases the shrinkage stresses between the opposing cavity walls.[25]

The oblique technique is accomplished by placing a series of wedge-shaped composite increments which in turn it reduces the C-factor and prevents the distortion of cavity walls.[28]

Vertical layering technique which is accomplished by placement of small increments in vertical pattern starting from one wall and carried to another wall to reduce the gap at gingival wall which is formed due to polymerization shrinkage, hence postoperative sensitivity and secondary caries.[29]

Santhosh *et al.*, 2008, and Usha *et al.*, 2011 found that there were no influence of different composite placement techniques on microleakage,[30,31] while other observation made by Eakle and Ito 1990 found that the diagonal insertion or oblique placement technique had the most leak-free margins when the proximal box ended on enamel.[32] Other study showed better results with vertical layering technique compared to oblique layering for enamel margin.[33]

So, this study was conducted to evaluate the microleakage at the gingival seat of proximal class II cavity prepared at 1mm from cementoenamel junction (CEJ) restored with Bulk fill composite resin material using different composite placement techniques.

Chapter 2

2. Literature review

2. Over review of dental composite resin.

2.1. Historical background of dental composite.

Dental composites made its entrance as direct tooth colored restorative materials in the early 1960s when Bowen developed bisphenol A- diglycidyl methacrylate resin (Bis-GMA) as an attempt to improve the physical properties and to minimize the drawbacks of the acrylic resins.(34)

It was reported that Bis-GMA is able to form a resistant cross linked matrix and many desirable properties could be achieved on using it including less shrinkage, higher modulus and low toxicity due to its lower volatility and diffusivity into tissues and hence, Bis-GMA is still used as the dimethacrylate monomer to create dental composite materials today.(34) These early, chemically cured composites required, a base paste to be mixed with a catalyst, leading to problems with the proportions, mixing process and color stability.(35)

In 1977, light-activated initiators were incorporated in the resin matrix and this gave the birth of light-cured composites which polymerized by electromagnetic radiation and eliminated the drawback of the paste mixing system and gave the dentist more control over the placement and setting of the material.(36) At first, an ultraviolet light source (365 nm) was used to provide the required light energy, but its shallow polymerization and iatrogenic side-effects led to its replacement by visible light (427-491 nm), which is currently in use and undergoing further development.(36) Since then, composite resin has undergone a lot of research along with a great development which has been to be unceasing in order to obtain better products.

2.2. Chemical composition of dental composite:

PHILLIPS defined a composite as a "three-dimensional combination of at least two chemically different materials with a distinct interface separating the components.[1] Composite resins used in dentistry is basically composed of three distinct phases: the polymer resin matrix, the inorganic filler (mostly) and the filler resin interface.[2] Other components such as accelerators, inhibitors and pigments are incorporated in the formulation of composition in order to control or modified certain properties of the composites.[37] This system is versatile, and different type of composites can be derived by modifying the resin formulation and/or the resin-to-filler ratio.[37]

- In general, restorative resin composite encompasses three phases, namely:

2.2.1. The organic phase (matrix):

The organic matrix is composed initially of a monomer system which is viewed as the backbone of the composite resin as it converts to a highly cross linked polymer upon initiation polymerization, whether chemically or using light.[2]

Bisphenol A and glycidylmethacrylate Bis-GMA continues to be the most-used monomer for manufacturing present-day composites; whether alone or in conjunction with urethane dimethacrylate (UDM). However, this monomer is very viscous so, in order to facilitate the manufacturing process and to obtain a reasonable consistency for proper clinical handling, it is diluted by other methacrylate monomers of low molecular weight and low viscosity such as triethyleneglycol dimethacrylate (TEGDMA).[38]

Also the matrix incorporates other components such as a free radical polymerization initiation system, which in photocurable composite resins is an alpha diketone (camphoroquinone) used in combination with a tertiary aliphatic amine reducing agent while in chemically-curable ones is, benzoyl peroxide, used in combination with an aromatic tertiary amine; an acceleration system such as dimethylaminoethyl methacrylate or DMAEM, which acts on the initiator, allowing curing to take place in a clinically acceptable time; a stabilizer or inhibitor system such as hydroquinone to maximize the product's storage life prior to curing and its chemical stability thereaf-ter; and, lastly, absorbers of ultra-violet wavelengths below 350 nm, such as 2-hydroxy-4-methoxybenzophenone, to provide colour stability and eliminate the effects of UV light on the amine compounds in the initiator system.(39)

2.2.2 The dispersed phase (fillers):

Hard filler particles were dispersed in the resin matrix to enhance the mechanical and physical properties and to reduce polymerization shrinkage, the coefficient of thermal expansion and the fraction of resin in the final restoration. The filler particles used vary widely in their chemical composition, morphology and dimensions. The most common types of inorganic fillers used in dental composite are silicon dioxide (Silica); boron silicates and lithium aluminum silicates, with various other ions such as barium, zinc, boron, zirconium, and yttrium are added to produce radio opacity in the filler particles.(40)

Fillers used in dental composites may be produced by grinding and milling, precipitation or by condensation. The particle size may vary, depending on the method of manufacture, from 10 nm for some of the pyrolytic silica fillers to 100 μ for some quartz or glass fillers. There is a trend towards the use of blends of fillers having different particle sizes in order to maximize the filler content.[41]

2.2.3 The interfacial phase (coupling agent):

This phase consists of a bipolar coupling agent which is usually an organo-silane, connecting the organic resin matrix and the inorganic filler, or a co-polymeric or homopolymeric bond between the organic matrix and partially organic filler. The strength and durability of the composite depending on the adhesive bonding between fillers and resin, dislodgment of the filler from the surface lead to penetration of water along the filler-matrix interface. Thus, the manufacturer coats the surface of the filler with a suitable 'coupling agent', normally 3-methacryloxy propyl trimethoxy silane which, act as a stress absorber at the filler-resin interface.[42]

2.3. Classification of restorative resin composites:

Different classifications of the composite resin have been introduced depending on different strategies to simplify their identifications and uses for therapeutic purposes.

Lutz and Phillips 1983 provided a classification for composite resin which is still valid, based on the filler particle size and in which the composites were divided into macro filler composites, microfiller composites and hybrid composites.[43]

Willems *et al.,* 1992 laid out a more detailed categorization based on several parameters including morphological , mechanical and physical characteristics of composite resin in which the composites divided into densified composites which contain < 60% by volume inorganic filler, Compact-filled > 60% by volume, Microfine composites, Miscellaneous composites which composed of blends of densified and microfine composites, Traditional composites, and finally, Fiber-reinforced composites.[44]

More recently, Zhou *et al.*, 2019 addressed new classification of dental composites based on their different compositions and performance characteristics into four categories.[45] :

1. According to Filler Particle Size: into macrofilled, microfilled, hybrid, moden hybrid, and nanohybrid.
2. According to Curing mode into: chemically activated, light activated, heat-curd, and dual-cured.
3. According to restorative procedure: into direct and indirect.
4. According to clinical application into: packable, flowable, polyacid modified, self-adhesive, osmotic and finally Bulk-fill.

2.4. Evaluation of dental composite

The composition of resin-based dental composites has evolved significantly since the materials were first introduced to dentistry more than 50 years ago. It appears that a significant transition in the filler particle size and modification in the resin formula have been made in order to improve the clinical performance of RBCs.

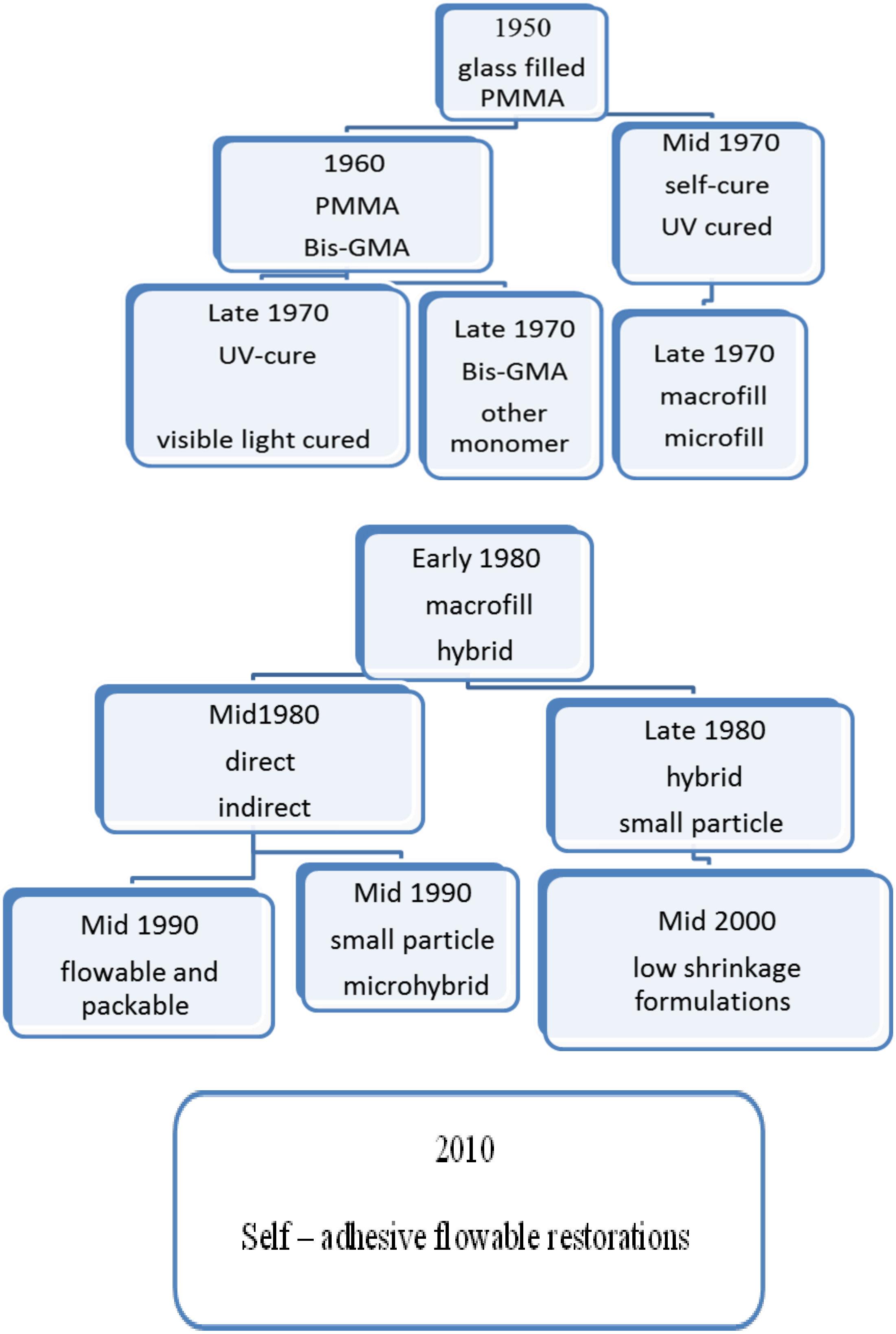


Figure1: Evaluation of dental composite.

2.4.1. Macrofilled Composites:

Macrofilled composite resins are considered as the first generation of composites which developed in late 1970's, as they contain relatively large filler particle size (macrofiller) ranging from 10 to 100 μm of ground quartz with a l high filler loading about (55–65 % vol.).[46]

The major disadvantages of traditional RBCs included insufficient wear resistance, high surface roughness which made them more susceptible to stain and plaque deposition.[47] Therefore, researchers developed smaller and rounded fillers with a suitable particle size distribution, which attempted to avoid the fore mentioned problems.[47]

2.4.2. Microfilled resin-based composites:

They were developed between 1970 and the early 1980s, with an average filler size less than 1 μm diameter to improve the inferior properties of traditional types.[47] The microfilled RBCs offered adequate polishability and color stability, however, reduction in filler loading (45-50 weight %) reduced the wear resistance in load bearing restorations and in addition elastic modulus and fracture strength were also lower in contrast to macrofilled RBCs.

Lu *et al.*, 2006 identified lower diametral tensile strength, flexural strength and flexural modulus of microfilled RBCs compared with nanofilled and microhybrid RBCs.[48] Due to inferior mechanical characteristics compared with hybrid RBCs, the applications of microfilled RBCs are mainly confined with class III, class V and small class I restorations.[48]

2.4.3. Hybrid resin-based composites:

Hybrid RBCs were developed to retain the advantages of both traditional macrofilled and microfilled RBCs by containing a blend of fillers of different particle sizes and particle size distributions ranging from 0.6 to 1 micrometers, and containing 0,04 micrometer sized colloidal silica and a filler load greater than 80 weight%. The materials showed a better wear resistance compared with traditional macrofilled RBCs but surface properties remained inferior because of the intrinsic wear pattern in a RBC that contains larger filler particles.(49)

The further advancement in RBCs occurred with the development of the 'universal' hybrid material which is indicated for all classes of cavities as they comprised a bimodal filler distribution and exhibited a flexural strength comparable with macrofilled RBCs and adequate surface smoothness for anterior restorations.(50)

All Purpose Hybrid RBC was introduced in late 1980s and was used for both anterior and posterior restorations and showed superior tooth-color matching properties.(50)

2.4.4. Bulk-fill composites:

In response to the difficulties encounter on using resin material having a limited curing depth, preventing total polymerization of greater increments, and seeking of clinicians to control the material's shrinking effects due to polymerization reactions, a new generation of RBCs has been introduced, known as "Bulk-Fill RBCs" materials.(51)

2.4.4.1. Classification of bulk-fill RBCs:

A classification of these materials was established according to their viscosity, indication of use, and application technique into three category.

- Flowable bulk-fill RBC to be used as cavity base.
- Flowable bulk-fill RBC with sonic activation to be used as direct restorative material.
- Bulk-fill RBC of regular viscosity to be used as direct restorative material.

While manufacturers indicate the use of this material in the entire cavity, it is important to mention that in some cases it has been recommended to add a final surface layer of conventional RBC to provide better esthetic properties.[52]

A) Flowable bulk-fill RBC

These are low-viscosity composite resins, with lower percentage of inorganic filler making them more fluid than conventional composite resins. They are characterized by high wettability of the tooth surface to ensure penetration into every irregularity; ability to form layers of minimum thickness, so improving or eliminating air inclusion or entrapment,[53] high flexibility, so less likely to be displaced in stress concentration areas; radio-opaqueness and availability in different colors. The drawbacks include high curing shrinkage which is due to lower filler load, and weaker mechanical properties.[53]

They are indicated in class V cavities and minimal occlusal restorations or as liner materials in class I or II cavities.[53]

B) Flowable bulk-fill RBC with sonic activation

This type of resin needs a special sonic handpiece for its application and whose manufacturer has even touted that it can be used in 5 mm increments. It is activated by means of sound vibration, producing a momentary drop in viscosity during application, And it is indicated in classes I and II with no occlusal layer.(54)

C) Bulk-fill RBC

It is characterized by containing low filler content with large filler size and having a regular viscosity of conventional consistency to be used as direct restorative material in 4- or 5-mm thick increments using a monoblock or single-layer technique.(55)

It was reported that, the greater curing depth and the superior physical and mechanical properties in conjunction with low polymerization shrinkage observed in bulk-fill RBCs are due to the incorporation of more efficient initiation systems,(56) greater translucency which would allow deeper light penetration by reducing light absorption by pigments, and decreased matrix/fill surface interface, which reduces light

Refraction.(56)

2.4.5. Nano filled composite resins

Nanotechnology has led to the development of a new composite resin characterized by containing nanoparticles measuring approximately 25 nm and Nano aggregates of approximately 75 nm, which are made up of zirconium/silica or Nano silica particles. The distribution of the filler (aggregates and nanoparticles) gives a high load, up to 79.5%.(57)

Nano filled composite resins achieved good mechanical properties ,less curing shrinkage , and possible less post-operative sensitivity for use in the anterior and posterior teeth due to incorporation of nanoparticle sizes.[58]

The drawback is that since the particles are so small they do not reflect light, so they are combined with larger-sized particles, with an average diameter within visible light wavelengths which is around or below (1μm), to improve their optical performance and act as a substrate.[58]

2.4.6. Low shrinkage composite

This class of materials depends on modification of the resin matrix by incorporation oligomers additive into methacrylate networks to promote homogeneous methacrylate network formation, increase the degree of conversion, improve mechanical properties, and lower the volumetric shrinkage because of the high molecular weight of Additives.[59] Other products depend on addition of certain functional groups to the monomer shown to undergo bond breaking and reforming as the same structure throughout the resin polymerization, resulting in the rearrangement of network strands. Another, containing ring-opening reaction also plays an important role in reducing volumetric shrinkage.[60]

2.4.7. Self-adhesive composites (SACs)

Recently, Self-adhesive flowable composites were introduced to dental practitioners and manufacturers claimed that (SACs) can be used without a separate adhesive as they possess the advantages of all-in-one bonding systems and flowable composites altogether.[61] The clinical advantages of this type of composite include easy use since they are not needed a separate etching, priming or adhesive application, prevention of procedural errors related to clinical application of conventional bonding agents such as over-drying and over-wetting and finally, reduction of chair time.[61] However, durability and physical and mechanical properties of these composites remain a concern for many dental clinicians due to limited studies.[62]

2.5. Overview of the polymerization process of photocure composite

2.5.1. Polymerization process:

The term polymerization is referred to the procedure of transformation of resin-based composite (RBC) from a plastic phase to a semisolid phase wherein the monomer is converted into polymer through this process which takes place in stages named activation, initiation, propagation, and termination.[63]

In a light cure composite resin, the initiation occurs when camphorquinone the photoinitiater system, is activated by blue light, transforms chemically into an excited triplet state which in turn, reacts with the tertiary amine in the presence of accelerator to produce greater amount of free radicals, These free radicals react with monomer molecules, forming active centers for polymerization. In the propagation stage, monomers are sequentially added to the active centers and form the initial end of long cross-linking polymer chains, which bring them closer to form covalent bonds.[63]

2.5.2. Polymerization shrinkage:

Before a polymerization reaction, the monomer molecules are held together by Van der Waals forces and they are separated from one another by a distance of approximately 0.3–0.4 nm. During polymerization, the molecules move closer together by forming covalent bonds into the distance of about 0.15 nm.[64]

It was reported that the reduction in intermolecular distance results in volumetric shrinkage and its magnitude showed a linearly relationship to the degree of conversion of monomer into polymer.[64]

Dental composites used in restorative procedures exhibit volumetric shrinkage ranging from less than 1% up to 6%, depending on the formulation and curing conditions.[65]

Although a high degree of conversion is vital to enhance and ensure optimal composite properties, it is usually accompanied with high volumetric shrinkage and contraction stress.[64]

So, if the shrinkage stress exceeds the bond strength of the dentin bonding agent, debonding along the restoration/tooth interface will occur leading to gap formation of a few micrometers in width which may extent throughout the wall interface and eventually cause microleakage.[66]

2.5.3. Factors Affecting Polymerization Shrinkage

Previous studies had reported that the polymerization shrinkage of RBCs is influenced by several factors including the filler volume fraction, composition and degree of convergence of the resin matrix, shade, light curing duration, increment thickness, light unit system used, cavity diameter, cavity location, light curing tip distance from the curing RBC surface, substrate through which the light is cured, filler type, and temperature.[67]

2.5.3.1. Filler volume fraction

Wang and Chiang., 2016 reported in their study that there is an inverse relation between filler volume fraction and volumetric shrinkage, as the volume of filler content increases, the volume of resin matrix decreases and hence volumetric shrinkage reduces proportionately.[65] Other study showed that flowable composites produced higher polymerization shrinkage because of the low filler content, whereas in packable composites, there is lesser shrinkage.[68] Further study demonstrated that the polymerization shrinkage is high in traditional micro-filled composites because of the smaller, spherical filler particles produced by pyrogenic and precipitation methods, which have a very high surface area resulting in agglomeration of filler particles and hence reduced filler loading.[69]

2.5.3.2. Degree of conversion of resin matrix

Braga *et al.*, 2005 affirmed in a systematic review study that the degree of conversion is the major parameter, which influences polymerization shrinkage and stress development.[50] It was reported that the final degree of conversion in commercial composites in which C=C double bonds converted to C–C single bonds to form long-chain polymers is between 55% and 75%.[69] Other studies showed that there is a direct proportional between the volumetric shrinkage and the degree of resin matrix conversion due to increase of the modulus of elasticity of resin.[70]

2.5.3.3. Composition of resin matrix

According to Ilie and Hickel, 2011 the polymerization shrinkage is influenced by monomer functionalities, molecular structure, molecular mass, and size. Silorane-based composites which depended on the use of ring-opening systems like oxirane-based resins cured under visible light conditions showed lower polymerization shrinkage than methacrylate-based composites.(71)

2.5.3.4. Configuration factor.

Feilzer *et al.*, 1987 introduced the term "C factor" or "Configuration factor," which is defined as the ratio of bonded to unbounded surfaces of the composite restorations.(72) Also, they stated that if the number of unbounded surface increases, the magnitude of shrinkage stress will be less due to the fact that the increased surface area will help to relieve the generated Stresses.(72)

Versluis *et al*., 1998 reported in their study that the shrinkage of the composite resin was determined by the bonding of the composite resin to the tooth structure and by the free surfaces rather than by the orientation of direction of the curing light as supposed earlier. Cavities with C factor less than one generate least stress and it increases as the C factor increases.(73)

The factors that might influence the C factor and the stress generation include the extent of caries removed, the amount of remaining tooth structure, type and location of the tooth in the arch, type of the curing light, and photoinitiator and composite resin used.(74) Shallower and wider cavity preparation generates lower stress compared to deeper and narrower cavity.(74)

2.5.3.5. Effect of cavity location

Curing of the restoration on the buccal or lingual surfaces of the posterior teeth is difficult and could limit the degree of conversion of the cured RBC increment due to poor accessibility, improper direction of the curing light with increasing distance between the LCU tip and the RBC surface.

Additionally, Price *et al*., 2010 stated that placement of the LCU at 45° to the surface of the RBC results in a 56% reduction of light radiant exposure.(75)

On other hand, several studies reported that placement of direct resin restorations in class II preparations with deep cervical margin in dentin represented a great challenge for the dental surgeon for controlling the polymerization shrinkage of composite resin due to their high susceptibility to the occurrence of microleakage.(76,77)

Class II composite restorations can be placed at an acceptable standard if the cervical margin is in sound enamel when the adhesive restorations are located below the CEJ (cemento-enamel junction) and cervical lesions have no enamel the quality of the marginal integrity is questionable.(78) Below the CEJ the bond with dentin is weaker: the polymerization shrinkage can result in gap formation between composite resin and the cavity walls. Marginal gap formation contributes to microleakage permitting the passage of oral fluids and bacteria from the oral cavity and become a source of postoperative sensitivity, pulpal inflammation and recurrent caries.(79)

Idriss, *et al* ;2007 in vitro study investigated the correlation between factors related to cavosurface marginal adaptation and microleakage in Class II cavities restored with a light- or chemical-activated resin composite. Standardized cavities were prepared in 40 molars that were randomly divided between both materials. Each of the groups was, in turn, divided, so that the restorations were placed by incremental and bulk techniques. The marginal gaps measured by scanning electron microscope. After sectioning the teeth, interfacial dye penetration was assessed by light stereomicroscopy according to an ordinal scale at the same locations as for the marginal gaps. no correlation between marginal gap size and microleakage was found. It was concluded that, irrespective of the possible role of marginal gap in the occurrence of microleakage, the choice of material and placement technique are important determining factors in microleakage.[80]

2.5.3.6. Intensity of curing light

A linear relationship found to be existed between polymerization shrinkage and light intensity, which means that higher light intensity produced greater polymerization shrinkage when exposure time is constant due to greater degree of conversion.[74] On other hands, the slower polymerization delays the gel point, which provides a time for stress relaxation in the resin and the interface.[26] Polymerization shrinkage is highest with ramp curing modes and high intensity modes, whereas it is lesser with step-curing and low intensity modes.[69]

On other hand, Price *et al.*, 2003 reported in order to avoid reduction of light irradiance levels by increasing the curing distance by more than 4mm. between the LCU tip and the RBC surface, it is recommended to either extending the curing time or using a higher irradiance level LCU to compensate for the expected reduction in irradiance exposure.[81]

2.5.3.7. Thickness of composite resin, shade, and opacity of composite

It has been proved that incremental curing induces lesser polymerization shrinkage stress than bulk curing.[81]

According to Donly and Jensen 1986, bulk placement of composite induces more strain because the buccal and lingual walls are pulled together, Gingivo-occlusal incremental layering technique induces intermediate strain.[82] In this technique, though the buccal and lingual walls are pulled together, the volume of composite increment is small, resulting in lesser strain than bulk placement. Buccolingual incremental layering induces least strain as only one wall is pulled at a time.[82]

On other hand, several studies proved that the difference in the shades of light-cured restorative materials causes some variations in their polymerization rates and in the amount of polymerization shrinkage due to their chemical compositions.[83,84]

2.5.4. Consequences of polymerization shrinkage (PS)

The stresses induced by polymerization shrinkage (PS) of resin composites are most destructive on the resin composite/ tooth interface leading to adhesive failure of restoration/tooth interfaces when the contraction stresses exceed the adhesive bond strength. This may create micrograps between the restoration and internal cavity walls leading to a microleakage and its sequel including marginal staining, postoperative sensitivity, and recurrent caries.[85]

Clinical effects of strain relief have been noted as white lines at the tooth-resin interface, cracks in enamel adjacent to the margins, and post-operative sensitivity.[74]

Furthermore, polymerization contraction stresses may induce or propagate microcracks within the restorative material. Another scenario can possibly take place when the dental adhesive's bond strength exceeds the polymerization contraction stresses within the restoration is the development of enamel microcracks or cuspal deflection which may lead tooth fracture during masticatory function.(86)

2.6 . Methods Introduced to overcome microleakage of resin based composite in Class II restorations

Microleakage, is defined as a micro-channel between the cavity wall and composite material formed during composite application or while it is working as a consequence of polymerization shrinkage and through this space a series of substances, including bacteria, liquids, molecules, and ions, can penetrate but it cannot be directly detected clinically.(87)

Microleakage is one of the most frequently encountered problems in posterior composite restorations, especially at the gingival margins of the proximal box of class II cavities the restoration. Another potential clinical problem associated with class II cavity preparations is the creation of voids along the gingival margin which results from the incapability to adequately adapt the materials to margins before

Curing.(88)

This microleakage phenomena is considered the main cause that affecting the longevity and durability of the adhesive restorations.(88) and causes their failure due to the see passage of bacteria, liquids, molecules, and ions between margin of the restoration and tooth structure causing marginal staining, tooth hypersensitivity, secondary caries and development of pulpal pathology.(89)

Several factors attributed to marginal microleakage are the adhesive bond strengths to different dental substrates which in turn depend on the histological and morphological characteristics of the enamel, dentin/cementum,[90,91] residual stress created by resin composite shrinkage, differences among enamel/dentin and restorative materials coefficient of thermal expansion, polymerization source variables, cavity location and C-factor, resin composite insertion techniques all of which aggravate several clinical variables.[92]

Hence, adequate marginal integrity between the tooth and composite resin restoration is needed to increase the durability of the restoration. Consequently, different composite resins, adhesive systems, and clinical techniques have been developed to minimize microleakage in adhesive-restorative procedures and to improve their clinical performances become an important issues for researchers and clinicians.

Many approaches have been used in an attempt to decrease the amount of polymerization shrinkage and hence the microleakage in restoring Class II with RBC's.

These approaches have included an incremental technique when applying RBC's which decreases the bulk of RBC cured at one time and helps in decreasing the polymerization shrinkage and gap formation.[93]

Various studies suggested that to avoid the clinical consequences of polymerization shrinkage which is marginal leakage and to obtain effective marginal seal, the incremental filling techniques are usually preferred over the bulk filling method.[94,95] It has been postulated that the incremental techniques have the ability to compensate the polymerization shrinkage of composites, by utilization of a large number of small, thin increments that prevents or diminishes excessive stress generations within the tooth-restoration system.[96]

Another approach is the use of bulk fill composite which manufacturers claim have very good marginal adaptation and low polymerization shrinkage.[97]

2.6.1. Incremental Placement Technique:

The incremental technique is widely used and it is accepted as the gold standard for the placement of resin-based composite restorations in Class II cavities.[98] It was reported that when the composite resin is layered, minimal contact with the cavity walls during polymerization occurred which reduces the bonded to unbonded surfaces thus reducing the C-factor and stresses on the RBC restoration and on other hand, a reduction in shrinkage rate with smaller composite volume is achieved which consequently resulted in reducing the adverse effects of polymerization shrinkage and marginal gap formation.[72]Shrinkage stresses are also significantly reduced by compensating for the shrinkage of each layer with the next consecutive layer.[26]

Among of these incremental techniques used are vertical layering (facio-lingual), horizontal layering (gingiva-occlusal), oblique layering (wedge-shaped),which are named according to the direction of the placement increment to the cavity wall.[26][27]

2.6.1.1. The type of incremental techniques used in the present study were:

- **Horizontal incremental technique:**

As a general approach, a horizontal incremental technique has been used in which the composite is layered and light-cured in increments of less than 2 mm.(26)

Several studies reported that using this technique for composite application leads to increase the C-factor, and thereupon increases the shrinkage stresses between the opposing cavity walls (99,100), (Figure 2).

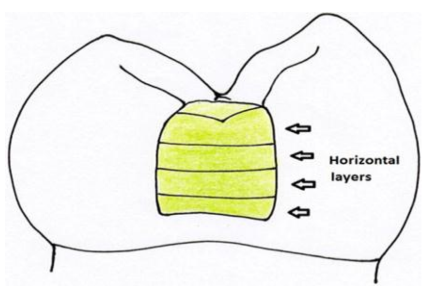


Figure 2 : Horizontal layering technique.

- **Oblique layering technique:**

an oblique layering method or a Z technique has been developed which allows the transfer of shrinkage stresses to unbound free surfaces by determining that the most important effect of the cavity geometry during polymerization is the configuration factor. In this 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.(27) This results in a relative increase in the free surface of the filling material, reducing the C-factor and a decrease in the extent of polymerization(27), (Figure 3).

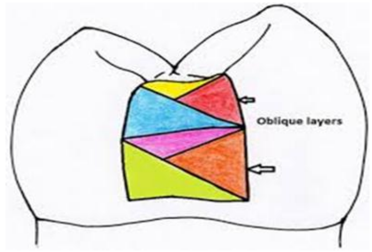


Figure 3 : Oblique layering technique

- **Vertical layering technique:**

This technique involved placement of small increments in vertical pattern starting from one wall such as buccal or lingual and carried to another wall. The curing process is started from behind the wall, i.e., if buccal increment is placed on the lingual wall, it is cured from outside of the lingual wall so, the gap at gingival wall will be reduced and hence postoperative sensitivity and secondary caries will not induce(33)**,**(Figure 4).

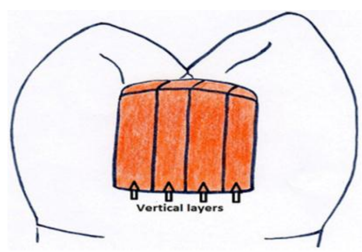


Figure 4 : Vertical layering technique.

2.6.2 . Bulk Placement Technique:

Innovations in the types and formulas of RBC's have recently claimed low polymerization shrinkage values of new bulk fill RBC systems. These materials are marketed as RBC's having greater depth of cure that can be placed in a single increment (4mm or 6mm cavity) instead of the standard increments of 2mm. Companies claim that these RBC systems reduce the amount of polymerization shrinkage and the working time[101,102] , (Figure 5)

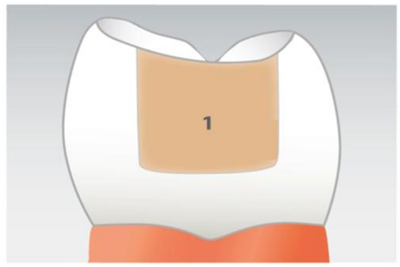


Figure 5 : Bulk fill technique.

Tetric N-Ceram Bulk Fill Ivoclar Vivadent which was used in the present study developed as a consequence of universal composite Tetric N-Ceram. Tetric N-Ceram Bulk Fill is a scultpable light-cured bulk fill hybrid composite used “bulk”increments of up to 4 mm for direct restorations of Class I and II in posterior teeth.[103]

According to the manufacture claims which were provided by Wanner, 2014, the monomer technology of the Tetric N-Ceram Bulk Fill contains the same dimethacrylates as Tetric N-Ceram including Bis-GMA, Bis-EMA and UDMA which are converted into a cross-linked polymer matrix on polymerization. The organic matrix of Tetric N-Ceram Bulk Fill accounts for approximately 21% of the mass. On other hand, Filler technology of Tetric N-Ceram Bulk Fill is based on the incorporation several different types of fillers such as barium aluminium silicate glass with two different mean particle sizes, ytterbium fluoride and spherical mixed oxide in order to achieve the desired composite properties. Tetric N-Ceram Bulk Fill has an overall standard filler content of approximately 61% by volume and 17% polymer fillers. The initiator systems used in this Bulk-fill composite according to manufacturer assert are camphorquinone plus an acyl phosphine oxide, together with a recently patented initiator Ivocerin dibenzoyl germanium derivative 9,10 which allows the application and curing of posterior restorations in larger increments of up to 4 mm, without compromising the optical properties of the composite.(104)

Bucuta, *et al.,* 2014 stated that high-viscosity bulk fill resin-based composites represent more promising materials, as they offer greater mechanical properties than the less filled flowables .Also, they pointed out the clinical advantage provided by a bulk fill resin composite that can be placed as a single-step material, without the need for an additional capping layer.(23)

Juloski *et al.,* 2013 assessed the microleakage of Class II cavities restored with experimental bulk fill resin composites which were G-aenial Flo bulk fill, GF; G-aenial Universal Flo bulk fill, GUF; GC Kalore bulk fill, GK at enamel and dentin margins by scoring the depth of silver-nitrate penetration. The researchers reported that the GC-experimental materials obtained optimal seal to enamel in vitro.(105)

Poggio *et al.,* 2013 evaluated microleakage in class II slot cavities on mesial and on distal surfaces on each side of the tooth conventional and bulk-fill composite resin restorations, the authers concluded that all composite resin restorations showed some degree of microleakage.(106)

Rengo *et al.,* 2015 found no significant difference in microleakage when three conventional composite resins were used to restore class II cavities with the incremental filling technique and when class II cavities were restored with bulk-fill composite resins in permanent teeth.(107)

Abdul Kader *et al.,* 2015 performed an in‑vitro study to quantitatively evaluate the microleakage of class II composite restoration done with incremental and bulk fill techniques. A total of 40 sound extracted molars were used for class II preparations restored with incremental (Group I, 20 teeth) and bulk fill technique (Group II, 20 teeth). Samples were accessed for dye penetration and pairwise comparison was done using Wilcoxon rank test. The results of the study showed that none of the composite insertion techniques were able to completely eliminate the microleakage and there was no statistically significant difference in microleakage irrespective of the insertion technique used in the study.(108)

Madani L, *et al.,* 2019 compared the microleakage of cavities filled with bulk-fill composite at enamel and dentinal margins. a total of 102 sound human premolars were randomly divided into six groups. In groups 1, 3, and 5, Class II cavities were prepared with their gingival margins above the cement-enamel junction (CEJ). In groups 2, 4, and 6, the gingival margins were below the CEJ. In groups 1 and 2, cavities the composite were incrementally packed with Filtek Z250. In groups 3 and 4, the gingival 2 mm of the cavity was filled with Filtek bulk-fill, and the rest of the cavity was restored with Filtek Z250. In groups 5 and 6, the gingival 4 mm of the cavity was restored with Filtek bulk-fill, and the remaining part was restored with Filtek Z250, and evaluated under a stereomicroscope at. Results: showed no significant difference was noted in the microleakage scores of the gingival margins of the six groups (P=0.168).(109)

Misilli and Yılmaz, 2018 evaluated the effect of different layering techniques bulk, oblique, centripetal, split horizontal on the marginal microleakage of forty-eight standardized Class II cavities prepared on both mesial and distal sides of extracted molars. After restoration, the teeth were exposed to thermocycling then to dye penetration for microleakage evaluation under a stereomicroscope. They reported that there were no statistically significant differences among four placement techniques but incremental placement techniques showed lower microleakage compared with bulk and lower microleakage was seen at occlusal margin compared with gingival margin.(110)

2.7.1. Comparing the marginal adaptation using one type of resin based Composite placed with different techniques (Layering versus Bulk):

Mullejans, et al., 2003 compared the marginal adaptation of RBC's placed in bulk or incremental technique. Thirty extracted premolars and molars were used and Class V cavities were prepared with gingival margins extended past the DEJ. Teeth were divided into three groups of ten teeth each. All cavities were restored with Dyract AP (Dentsply detrey) and the adhesive system Dyract-PSA and cured with spectrum 800 curing light (Dentsply). 1) 1 mm thick layer of polyacid modified RBC was applied to the coronal portion and cured for 40 seconds. The rest of the cavity was filled and cured for 40 seconds, 2) restored in the same manner of group 1 but the first layer was placed in the apical portion instead of the coronal, 3) A single increment technique (bulk technique) was used without mentioning the curing time. Results of this study showed the percentage of gap formation at the enamel and dentin interface were generally higher at the dentin margins. Authors concluded that in dentin margins of Class V cavities, the percentage of gap formation was less using the incremental technique compared to a single 2mm increment.(111)

Albargash *et al.,* 2017 performed an in vitro study to investigate the marginal integrity of composite restoration in class II cavities placed using three different placement techniques at the gingival and occlusal restorative margins by means of microleakage. Class II cavities were prepared at mesial proximal surface of Sixty human maxillary premolars. Teeth were randomly and equally divided into 3 groups (n=20). In-group I, a Nano-hybrid composite in a single layer was used. In-group II, oblique placement technique was applied. In Group III a centripetal placement technique was employed. Microleakage scores among all groups at occlusal and gingival margin were compared with ANOVA andp-value of<0.05 was considered as significant. At occlusal margin, highest mean microleakage was found to be in-group III (centripetal) and lowest in group I (bulk). Maximum microleakage at the gingival margin was found in group III (centripetal) and lowest in group I (Bulk). All three-restoration placement techniques showed microleakage at gingival and occlusal margins.(112)

Zubaidah *et al.,* 2019 determined microleakage differences between bulk and incremental technique on bulk fill resin composite restoration. The experiment done with cavity of 4 mm depth with and with 2 mm width. Two samples were divided in to groups, each group consisted of 12 premolars. Group 1 with bulk technique (4 mm) and group 2 with incremental technique of 2 layers (2 mm) horizontally. Samples were submersed in 0.3% methylene blue for 24 hours before testing . these included that There were significant differences between sample groups (p<0.05), and the microleakage produced by incremental technique was smaller than bulk technique. Incremental technique on bulk fill resin composite restoration created less microleakage than bulk technique.(113)

Donly, and Jensen., 1986 evaluated the strain produced during placement and polymerization of Class II posterior composite resin restorations in primary teeth. They used one type of posterior composite with

3 different application techniques, for technique I-placement and polymerization in single complete unit; for technique II-placement and polymerization in gingivo-occlusal (horizontal) increments; and technique III-placement and polymerization in bucco-lingual (vertical) increments. The results showed that the buccolingual incremental polymerization produced a statistically significant lower amount of strain on the tooth than polymerizing the restoration as single complete unit. This findings were attributed to 2 factors: 1- with the gingivo-occlusal incremental placement, there was less volume, therefore less shrinkage; 2- the bond that creates the most stress occurs when the enamel and dentin of both the buccal and lingual walls have composite adapted against them before polymerization. As shrinkage occurs, the walls are pulled together. Using the buccolingual technique avoids this phenomenon, since the first increment is in contact with only the buccal wall. With no composite touching the lingual wall, there is no possibility of shrinkage of the composite to pull the lingual wall centrally, therefore eliminating that possibility of stress. The final incremental placement allows shrinkage of only a thin buccolingual layer to pull the buccal and lingual walls together, therefore causing less stress than the previous 2 techniques.(82)

Mohammed Fahmi *et al.,* 2019 evaluated the effect of multilayering incremental technique on the microleakage of high-viscosity bulk-fill composite restorations in endodontically treated teeth. A total of 60 human mandibular premolar teeth were divided into four groups after standardized access preparation with a protaper technique followed by single-cone obturation to receive the following restorations for the access preparations. Group I : bulk-fill composite (Filtek™ Bulk fill) using a bulk technique, group

II : bulk-fill composite (Filtek™ Bulk fill) using an incremental layering technique, group III (negative control): gutta-percha was kept intact at the access orifice and covered with a nail polish, and group IV positive control : gutta-percha was kept intact at the orifice. The samples were thermocycled and followed by dye penetration with 2% methylene blue and then the scoring was done under a stereomicroscope. These found that there was a significant difference among all the groups except groups II and III. Bulk-fill composites used with an incremental layering technique sealed significantly better than the other groups followed by bulk-fill composite in the bulk technique.(114)

Sarfi *et al.,* 2017 compared effect of different layering techniques on microleakage of nanofilled composites in class I restorations. Fourty extracted maxillary premolar teeth were assigned to 2 different groups of 20 teeth per group. Group 1 the cavities were filled with composite using oblique incremental technique while Group 2 the cavities were filled with composite using vertical incremental technique. Specimens were thermocycled for 1000 cycles (5/55°C,30 seconds) and immersed in 2% methylene blue dye for 24 hours before microleakage testing using a stereomicroscope. It was concluded that the difference between the oblique group and the vertical group was found to be statistically non-significant (P value >0.05) but mean microleakage was more in vertical group compared to oblique group.(28)

Other studies performed by Santhosh *et al.,* 2008 and Usha *et al.,* 2011 to estimate the influence of different composite placement techniques on microleakage in high C-factor cavities and they found that there was no statistically significant difference between the microleakage of different groups.(30,31)

On other hand, Eakle and Ito, 1990 found that the diagonal insertion technique had the most leak‑free margins when the proximal box ended on enamel, and Bagis et al., 2009 found that the nanohybrid composites showed better results with vertical layering technique compared to oblique layering for enamel margin in class II cavities.[32][33]

2.7.2. Comparing the Marginal leakage using Different Types of Resin Based Composites Placed with Different Techniques (Layering versus Bulk):

Hoseinifar *et al*., 2019 evaluated the effect of occlusal loading on the gingival microleakage of two type of bulk fill composites compared with a conventional composite in box only class II cavities prepared on the mesial and distal surfaces of 36 maxillary premolars. The samples were divided into three groups and restored as follows: Group 1 incremental filling, Group 2 and 3 bulk filling. All restorations were thermocycled and immersed in 0.5% basic fuchsin for 48 hours before microleakage evaluation using a stereomicroscope. They found that there were no significant differences among the gingival microleakage of three composites in both unloaded and loaded groups, and the microleakage of class II cavities restored with the bulk filling technique was similar to that of restored with the incremental technique.[115]

Kapoor *et al.,* 2016 compared newer bulk-fill composites with an incrementally filled composite for adaptability and subsequent gap formation at the pulpal floor of Class I cavities prepared in 60 intact molars. The samples were divided equally into four groups according to the material used; smart dentine replacement (SDR), Sonic Fill, Ever X Flow and Z350 XT, restored to a depth of 4 mm. Following thermocycling, samples were sectioned bucco-lingually and examined under a stereomicroscope. Seven samples from each group were coated with nail varnish except for approximately 1 mm around the tooth restoration junction. These samples were examined under stereomicroscope after staining with 2% buffered methylene blue dye. The remaining samples were examined under a scanning electron microscope for gap formation. The data were statistically analyzed and the results indicated that Bulk-fill composites performed better than incremental composites, demonstrating better adaptability and less gap formation at the pulpal floor.(116)

Radhika, *et al.,* 2010 evaluated and compared marginal microleakage in deep class II cavities restored with various techniques using different composites, Standardized class II cavities were made and were restored using composites of different consistencies with different placement techniques. Group 1 with Microhybrid composite, Group 2 with Packable composite, Group 3 Microhybrid composite with a flowable composite liner, Group 4 Packable composite with a flowable composite liner, Group 5 Microhybrid composite with precured composite insert in second increment and Group 6 Packable composite with precured insert in second increment. The results demonstrated that in the occlusal wall, packable composite, showed significantly more marginal microleakage than the other groups. In the cervical wall, teeth restored with a flowable composite liner showed less marginal microleakage when compared to all other groups.(25)

Lanteri, *et al.,* 2019 evaluated the microleakage at the interproximal horizontal margin in Class II restorations using four different types of composite resins. two of these were used following a bulk fill technique, while the other two were used the traditional incremental technique. The samples were then thermocycled and immersed in a solution of Fuchsin dye for 24 hours. Followed by sectioning mesiodistally to examined using an optical microscope Results of this study showing that the best performance was observed in Group 2 (Xtra-base® VOCO in which the composite applied by bulk-fill technique, since no signs of microleakage were noticed. In Group 1 (SDR® Dentsply; Bulk Fill technique) the worst performance was observed: five samples showed no infiltration, while the other five showed a score of 2. In group 3 (Ceram-X™ Dentsply; Incremental technique.) six samples showed a score of 0, two samples a score of 1 and two samples a score of 2. In group 4 (GrandioSO® VOCO; Incremental technique) seven samples showed a score of 0, while one sample showed a score of 1 and two samples showed a score of 2. The Kruskal-Wallis test, did not reveal any statistically significant difference which was supported by Whitney tests in approving no statistically significant differences between the different composites and techniques.(117)

Swapna, *et al.,* 2015 evaluated and compared microleakage at the occlusal wall and cervical wall in Class II cavities restored with one Sonic Fill Bulk Fill composite and two conventional Bulk Fill composites. Teeth were divided into three groups. Standardized Class II cavities were made on the mesial and distal surfaces of each tooth and restored using SonicFill Bulk Fill composite and two conventional Bulk Fill composites. After storage, thermocycling and immersion in 0.6% rhodamine dye solution specimens were sectioned and evaluated for microleakage at the occlusal and cervical walls using confocal microscope. They found that , SonicFill Bulk Fill composite showed less microleakage than the other conventional Bulk Fill composites.(118)

Gallo, *et al.,* 2000 compared the ability of three packable resin-based composite (RBC) systems, placed and light-cured in either incremental layers or in bulk, to seal the gingival margin of Class II preparations. Packable RBCs were used to restore 60 extracted human premolars with Class II preparations using an incremental-cure technique or a bulk-cure technique. After the restorations were completed, the specimens were thermocycled, stained, sectioned, and viewed under a light microscope for microleakage detection at the gingival margin. They found that no statistically significant difference was found between the bulk-cure and incremental-cure techniques for each of the RBC systems evaluated.(119)

2.8. Methods for Measurement of microleakage :

The evaluation of microleakage is a significant index in assessing restorative materials and has been performed in vitro, as an in vivo model is difficult to apply. Various techniques was used to evaluate the level of interfacial microleakage in vitro include compressed air, chemical, bacteria, radioactive markers, dye penetration, electrochemical investigations, scanning electron microscopy (SEM), and recently X-ray microcomputed tomography (micro-CT) and optical coherence tomography (OCT).(120)

A) X-ray micro computed tomography (Micro-CT)

Without destroying the original specimen, micro- CT recreates a virtual model with a spatial resolution at a micrometer level by using X-rays to scan cross-sections of a 3D object which quantifies the volume of leakage using micro-CT, silver nitrate permeation, and image segmentation.(121)

Nondestructive micro-CT has been used to analyze the internal adaptation of composite resin to dentin; micro-CT has also been used to evaluate the relationship between internal adaptation and polymerization shrinkage.[122]

Zhao *et al,*. 2014 concluded that micro-CT has accuracy comparable with that of the conventional dye-penetration method in terms of measuring leakage in the dentin region but offers inferior accuracy in the enamel region as a result of the lower radiopacity contrast of silver tracer to enamel.[123]

The same conclusion was reached by Guhr *et al,*. 2016 who suggested that to better utilize micro-CT, a new microleakage tracer which would distinguish well between dental tissue and materials would be necessary. Micro-CT is not yet an absolutely reliable method of assessing the marginal integrity of dental restorations.[124]

B) Optical coherence tomography (OCT)

Optical coherence tomography (OCT) is a relatively new, completely nondestructive, and powerful tool. It has great prospects in dentistry and may provide a good method for the diagnosis of microleakage.

OCT offers high resolution and a penetration depth of up to a few millimeters and does not need specimen preparation or vacuum conditions. Additionally, it provides real-time restoration observation without X-ray radiation exposure.[125]

Huang *et al.*, 1991 were the first reported on OCT, which has since been widely used in clinical applications. OCT is an advanced tool that uses a microscale cross-section imaging technique to adopt near low-coherence interferometry; the principle is to convert the backscattered light into a signal intensity that is displayed as an image after a laser beam is projected across a restoration.(126)

Swept-source optical coherence tomography (SS-OCT) is a type of OCT that has a high axial resolution of about 10 μm, which provides

sufficient information for dental clinical applications such as the detection of cracks and microleakage.(127)

C) Dye-penetration method

One of the most common techniques used for microleakage evaluation is the dye penetration measurement because it is simple and fast. This method allows the production of sections showing leakage in contrasting colors to both tooth and restoration without the need for further chemical reaction or exposure to potentially hazardous radiation.(128)

Dyes that can bind to tooth substance or to the restorative materials are a potential source of error in leakage studies because penetration studies in dentine also exhibit some dentine staining that should be distinguished from the actual gap between the cavity wall and the restorative material.(128)

Kidd *et al.*,1989 they used dyes such as basic fuchsin solutions particularly those in propyl glycol co-solvent preferentially bind with carious dentine, This propensity has been made use of in the manufacturing of the caries-disclosing agents. This makes the effectiveness of such dyes questionable particularly when demonstrating an inert space between tooth substance and restorative material as an area of stained dentine in cross-section that can be mistaken for a larger gap than actually exists.(129)

Dyes used in dental research are provided as either solutions or particle suspensions of differing particle size dependent upon manufacturer and individual behavior of the dye. The literature reveals that the choice of dyes used continues to be based on an apparent basis with little attention given to the different size of dye molecules particles and their behavior.(130)

The conventional dye-penetration method has been the one most used in vitro, because microleakage itself is always related to liquid commonly penetration. Various dye solutions have been used, typically involving fluorescein, methylene blue, silver nitrate solution, fuchsin solution, or aniline-blue,(194) After different dwelling times, the sample is sectioned to visually examine dye penetration around the restoration under a microscope. One of the major drawbacks of this method is qualitative assessment by observing the presence or absence of the dye in a particular section.(131)

A semi-quantitative result may be achieved by using a length scale, Another drawback of this method is that the results obtained are two-dimensional (2D) in nature in addition, it is necessary to distinguish between a certain degree of dentin staining and actual microleakage.(132)

2.9. Marginal adaptation analysis using Scanning electron microscope (SEM)

Marginal adaptation has been defined as the degree of proximity and interlocking of a restoration to a tooth surface.(133) This property has a great influence on the longevity, esthetics and mechanical properties of composite restorations. The marginal gap can start forming from a space created between the restoration and tooth, 0.5 to 1 um wide, where bacteria, oral fluids and debris may enter and destroy the bond declining the longevity of the restoration and speeding up its functional and mechanical failure.[133]

Venhoven *et al.,* 1993 and Roeters *et al.,* 2005 reported in their study that the marginal gap was due mainly to the filler particles size and content and type of degradation.[134,135] Other opinions have suggested that marginal gap is induced as a consequence of the polymerization shrinkage and contraction stresses of composite once the material becomes rigid enough to resist sufficient plastic flow to compensate for the original volume.[136]

Clinically, these contraction stresses may be transferred to the margins of the restoration producing powerful forces leading to separation at the composite resin/ tooth interface and hence, affecting marginal quality,[137] and induce problems like leakage, recurrent caries and pulpal irritation.[53]

Campos *et al.,* 2014 reported that stresses generated during polymerization shrinkage of composites have potential to cause an adhesive failure or microcracking of restorative material and/or enamel or gap formation if the adhesion is not strong enough to resist these stresses. Also, they showed in their study that marginal adaptation in dentine was lower than in enamel reaching a mean value of only 19.89% after thermo-mechanical loading. This problem is distinct for class II composite resin restorations when the margin of the proximal box exhibits only minimal enamel.[138]

Manhart and Trumm, 2010 studied the marginal integrity of resin composite restorations in class II cavities after thermoload cycling using the replica SEM. They obtained higher percentages of a perfect margin that ranged from 95.9 % to 99.6 % in enamel and 85.9 % to 96.0 % in dentin.[139]

Achievement of successful adhesion to enamel and dentin is the priority when restoring using adhesive resins. Although high quality adhesive systems have been recently introduced,[140] several studies approved that bonding to enamel using conventional etch-and-rinse adhesive approach which is called the gold standard is more reliable to achieve superior retentive micromechanical bond and fatigue resistant enamel bond.[141,142]

This result was based on analysis postulated that using of conventional 37 % phosphoric acid-etching causes selective demineralization of hydroxyapatite crystals of enamel surface through which the resin is absorbed by capillary attraction within the created etch prisms and upon polymerization the micro and macro - resin tags are formed and micromechanical adhesion is achieved.[142]

Roggendorf *et al;* 2011 found a significantly higher percentage of continuous margins with total-etch adhesives than with self-etch adhesives at dentin margins with an insignificant difference in effect at enamel margins. Variation in results was attributed to materials and testing protocol variations.[143]

On other hands, despite the great developments in the field of adhesives 100 % perfect margin is not realistically achievable,[141] and gap formation may occur at the margins in enamel and dentine as well as along the resin-dentine interface due to loss of internal adaptation.[144]

These gaps result from either insufficient compensation for initial polymerization shrinkage stresses occurring prior to the first occlusal loading, or from lower, repeated stresses which are below the maximum stress the adhesive restoration can resist.[144]

On other hands, the main disadvantages of incremental techniques are the possibility of trapping voids between layers and the time required to place the restoration hence, the bulk application technique is simpler and it makes the work quicker by reducing the number of clinical steps.[145]

Other studies found no significant differences in marginal quality using different packing methods of composite restorations.[146,147]

Harbi, *et al.*, 2015 performed a study which aimed at analyzing the cervical marginal integrity of bulk-fill vs incremental and open-sandwich class II resin composite restorations after thermomechanical cycling using replica scanning electron microscopic (SEM) and ranking according to the World Dental Federation (FDI) criteria. The researchers found that the marginal integrity was not significantly influenced by the use of bulk-fill materials, bonding techniques, or variation in the location of cervical margins.[148]

Different methods are used for evaluation of the marginal quality among them is replica SEM which is regarded as the gold standard laboratory technique for qualitative and quantitative evaluation of margin analysis of the restorative margins in vitro as well as in vivo with an advantage that the samples can be retested at different study levels.[149]

Points of weakness in the procedure of the replica technique as it was recorded by several researchers included the accuracy of the impression relative to the type of bonding agent used, a lack of detailed description of impression taking, and a weak to moderate correlation to clinical findings.[150]

Two different procedures for Ranking of marginal integrity of restorations were employed in the assessment :

A - According to Aschenbrenner *et al.,* 2012:[151] the quality of the marginal seal at the gingival margins of restorations was categorized into three scores following the methodology of Aschenbrenner and otherssto :

1. Perfect margin: The margin appears with smooth and uninterrupted tooth-restoration continuity.

2. Marginal gap: A distinct gap exists at the tooth restoration margin.

3. Non assessable margin: Does not fit the previous two categories.

Accounting for imperfections in the impression material or the epoxy resin.

B - According to World Dental Federation (FDI) ranking criteria suggested by Hickel *et al.*,2010:[152]

Category 1: Harmonious outline, no gaps, no white marginal lines.

Category 2: Small marginal gaps ,150 lm indicated by the presence of

white lines or small ditching removable by polishing (slight).

Category 3: Marginal gap , 250 lm indicated by definite gaps or

defects not removable by polishing(major).

Category 4: Gaps .250 lm indicated by base/dentin exposed (severe)

Category 5: Ditching or marginal fracture (larger irregularities).

Ibrahim *et al.,* 2018 evaluated the marginal integrity of three types of bulk-fill composite resins in class II cavities. Simple class II cavities with parallel walls were prepared in 40 extracted human sound molars. The teeth were randomly divided into four groups (n = 10 each):group 1: Tetric N-Bond

Universal and Tetric EvoCeram Bulk Fill composite; group 2: Single Bond Universal and Filtek Bulk Fill posterior composite; group 3: Futurabond U and Admira Fusion X-Tra; group 4: Tetric N-Bond Universal and Tetric EvoCeram composite. All samples were thermocycled and examined under scanning electron microscopy. the results showed that group 3 recorded the lowest mean marginal gap length value, while group 4 recorded the highest mean marginal gap length value. One-way analysis of variance was used to compare the tested groups at a level of significance ($P \leq 0.001$) For the width of proximal gap the lowest mean marginal gap length value found in group 3, while the highest mean value of gap width proximally found in group 1. for the width of the cervical gap the lowest mean marginal gap length value was found in group 3, while the highest mean value of gap width cervically found in group 4. One-way analysis of variance test was used to compare the tested groups at a level of significance ($P \leq 0.05$) showed that Admira Fusion X-Tra has good results compared to other used bulk fill and conventional composites.(153)

Chapter 3

3. Aim of the study

3. Aim of the study :

To evaluate the microleakage at the gingival seat of the proximal class II cavity prepared at 1 mm distance above the cement enamel junction (CEJ) restored with bulk fill composite resin material using different placement techniques.

The objectives :

- To evaluate microleakage induced by bulk placement technique.
- To evaluate microleakage induced by using different incremental placement techniques :
  - Horizontal placement technique.
  - Oblique placement technique.
  - Vertical placement technique.
- To evaluate and compare the microleakage produced by using different composite placement techniques.

Chapter 4

4. Materials and methods

4.1. Materials:

Different composite packing techniques that are used in reducing polymerization stresses were tested in the current study to evaluate their effects on the microleakage level at the cavity margins of class II composite restorations by using the dye penetration test and assessed by microleakage score.

The materials used in this study were one commercial bulk fill composite resin and universal bonding system with total etching technique as shown in (Figure 9) and (Table 1).

4.2. Methods :

4.2.1. Samples selection:

Forty intact, recently extracted sound non-carious, unrestored permanent human premolars extracted for orthodontic reasons were collected to use in this study (Figure 6).

The teeth were examined by illuminated multi- power head magnifier (Figure 7) to ensure that they were free of any major or minor defects.

The teeth were first hand scaled then, they were polished by rubber cup with polishing paste using low speed hand piece.

After that the teeth were kept in normal saline (0.9 % isotonic saline) till the time of using which was no longer than one month, the normal saline was changed every 3 days.[154]

The teeth were mounted vertically to the level of 2 mm. below the cement enamel junction in readymade plastic containers used for ice quips of

2.5 cm in height and 3cm in diameter filled with fast setting dental stone (Figure 8) [a, b, c].

Figure 6: The collected teeth used in the study after cleaning.

Figure 7 : Illuminated multi- power head magnifier.

(a)

(b)

(c)

Figure 8 : (a,b,c) Mounting of extracted teeth in dental stone

(a) showed the readymade plastic tray used in the study.

(b) showed the specimens after mounting in the tray filled with fast setting stone.

(c) showed preparation and adjustment of the stone block using trimmer.

Figure 9 : The material used in the study.

Table (1): Showed materials used in this study:

Product/manufacturer	Composition	Manufacturer instructions
Tetric N-Flow Bulk Fill / Tetric N-Ceram Bulk Fill Ivoclar vivadent	- The Monomer matrix: dimethacrylate (19-21% weight). - The inorganic filler (75-77% weight). - the filler consist of barium glass, prepolymer, ytterium trifluride and mixed oxide. - additives catalysts, stabilizers and pigments(<1.0% weight). - the particle size of inorganic fillers is between 0.04 and 3 mm. - shade: universal A	1- tetric N Ceram Bulk fill should be applied in increment of max. 4mm. 2-adapted to the cavity walls with suitable instrument. 3- sufficient exposure to the curing light to prevent incomplete polymerization. 4- the exposure time with light intensity 500 mW/cm^2 was 20 s. 5- additional polymerization from the buccal and palatal aspects after removal of the metal matrix.
Tetric N- Bond Ivoclar vivadent	- phosphonic acid acrylate, HEMA, Bis-GMA, urethane dimethacrylate, ethanol, film-forming agent, catalysts and stabilizers. - Light-curing, nano-filled single-component bonding agent for enamel and dentin bonding used in combination with the total-etch technique.	1- apply a thick layer of tetric N-Bond on the enamel and dentin surfaces, using application brush. 2- brush the material gently into the dentin for at least 10 seconds. 3- remove the excess material by gentle stream of air. 3- light cure Tetric N-Bond with light intensity 500mW/cm^2 was 10 s.

4.2.2. tooth Preparation:

Eighty class II cavities with parallel walls, rounded internal angles and a cervical margins established at one mm. above the cemetoenamel junction (CEJ) with no bevels placed at the cavosurface margins were prepared on mesial aspect mesio-occlusal (MO)and distal aspect disto-occlusal (DO) of each tooth as shown in(Figure 10 a , 10 b)

(a)

(b)

Figure 10 : (a) and (b) Cavity preparation on mesial and distal aspect of the maxillary upper premolar.

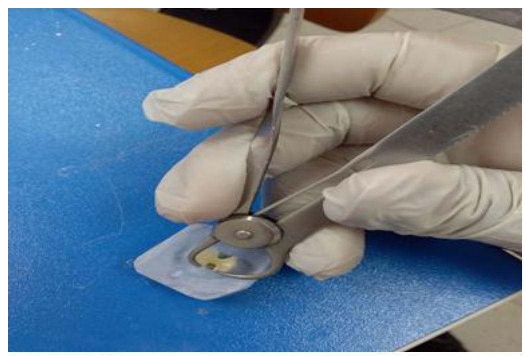
The class II cavities were done using a drill #245 in a high-speed handpiece under air/water spray. A new bur was used after every five cavities since etching effectiveness is influenced by the surface texture of the cut enamel.[154]

The specimens were prepared following a standardized pattern in which the class II cavity had a width of 4.0 mm, depth of 2.0 mm in axial direction and a cervical located at 1 mm occlusal to the cemento-enamel junction

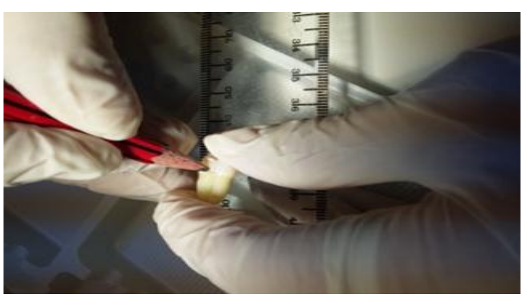
(CEJ). A rubber stopper was fitted on the shank of the bur to adjust the required depth needed for the cavity preparation.

The width of the cavity was adjusted using the vernier caliper (Figure 11a , 11 b) by performing indentations on the proximal surface represented the buccal and lingual border lines of the class II cavity followed by drawing a vertical lines along the indentations on the buccal and lingual sides independently (Figure 11 c) , So the width of the cavity was identified on the proximal surface of the tooth before the cutting was started. After tooth preparation, the cavities were thoroughly rinsed with oil free compressed water spray and gently dried with oil free compressed air to be ready for bonding and restorative procedures(Figure 11d).

(a)



(b)



(C)

(d)

Figure 11 : (a) and (b) Adjustment of cavity preparation by varnier caliper, (c) indentations on the proximal surface,(d) the teeth ready to for bonding and restorative procedure.

4.2.3. Specimens Grouping:

The forty prepared premolars were randomly divided into four equal groups according to the methods of composite backing. Each group was consisted of 10 teeth with a total of 20 cavities(n = 20) for each techniques.

The experimental groups were as following (Table 2):

Group1: Consisted of 10 teeth (n = 20) with a total number of 20 cavities in which the method of composite backing was Bulk Technique.

Group2: Consisted of 10 teeth (n = 20) with a total of 20 cavities in which the method of composite backing was Horizontal layering Technique.

Group3: Consisted of 10 teeth (n = 20) with a total of 20 cavities in which the method of composite backing was wedge - shaped layering technique.

Group 4: Consisted of 10 teeth (n = 20) with a total of 20 cavities in which the method of composite backing was Vertical layering Technique.

Table (2) Showing the methods of composite resin packing groups:

Group 1	the method of composite backing was Bulk Technique.
Group 2	the method of composite backing was Horizontal layering Technique.
Group 3	the method of composite backing was Oblique layering technique.
Group 4	the method of composite backing was Vertical layering Technique.

4.2.4. Bonding procedure:

The bonding procedure was performed with Tetric-N Bond adhesive system (Table 1) following the manufacturer's instructions in combination total-etch technique in all the groups to reduce variability in results.

The mesial and distal cavities of all the samples were etched with 37% phosphoric acid (I-GEL phosphoric acid etching gel) for 15 seconds (Figure12), rinsed with water for 15 seconds and dried with cotton pellets leaving the surface visibly moist.

Figure 12: Application of etching gel in each group.

Then the bonding agent was applied to the cavity walls with a microbrush for 20 s. A light air drying using an air syringe was performed at 10 cm distance for 5 s before the application of a new adhesive layer.[155]

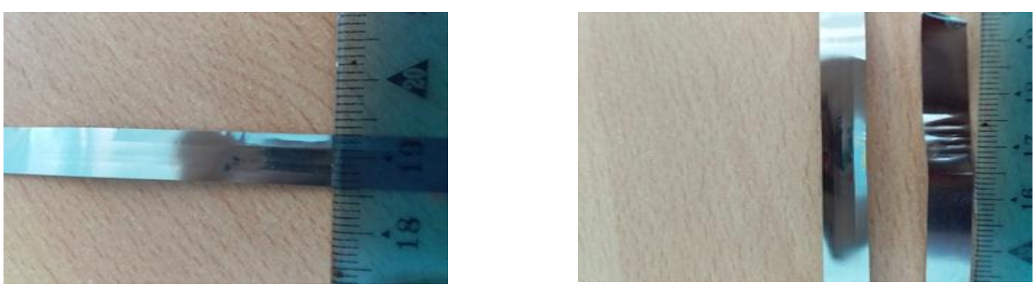
Every sample was light-cured at continuous intensity of 1500 mW/cm^2. For 40 sec using a light-emitting diode (LED) as shown in (Table 4) and (Figure 13).

Figure 13 : light curing unit (LED).

The intensity of light from the curing light unit was verified with the light meter before exposing the bonding agent and the restorative material to the light. This calibration is important since variations in the energy output may affect the development of polymerization shrinkage stress in resin composite restorations making it difficult to determine the role played by the placement technique.[156]

4.2.5. Matrix band applications

A metal matrix band of 0.05 mm, was adopted and held in its place around the contour of the tooth using tofflemire retainer (Table 3). A dental probe was used to place marks on the outer surface of the matrix to control the height of the subsequently applied increments before its fixation around the tooth (Figure 14).



(a) (b)

Figure 14 : a and b showed marks on the outer surface of the metal matrix.

4.2.6. Composite resin application

A single type of Bulk fill resin composite (Table 1) was employed in this study and it was applied according to the composite packing technique used with each experimental group.

A- For group 1: Bulk placement Technique :

All the prepared cavities (n = 20) in this group were filled with the composite using the bulk insertion technique. The composite was applied in a single increment of about 4mm in all the boxes of each cavity and was cured for 40 seconds from the occlusal surface according to manufacturer instruction. Additional curing for 20 seconds applied on proximal surface after removal of the metal band.

B - For group 2: Horizontal layering placement Technique:

In this technique, the composite was inserted in horizontal layers of 2mm height , each placed from the gingival toward the occlusal wall. The first layer was horizontally placed at the preparations in the gingival third. The second layer was subsequently applied at the preparations in the middle third and the last increment at the preparations in the occlusal one third. Each increment was cured for 40 seconds from the occlusal surface.

The height of each layer was determined by the level of the marks on the metal band. Additional curing for 20 seconds was performed on the proximal surface after removal of the matrix band and the retainer.

C - For group 3: Oblique insertion technique:

In this insertion technique the prepared cavities in this group were restored using an oblique layering technique in three increments.

The first oblique increment was applied to contact the gingival axial and distal walls. After the first increment was cured for 40 sec, the second oblique increment was inserted to contact the occlusal, axial and mesial walls and then light cured for 40 sec. A third increment was applied to cover the other increments, sealing the cavosurface margins and was subsequently light cured for 40 sec. Additional curing for 20 seconds was performed on the proximal surface after removal of the matrix band and the retainer.

D - For group 4: Vertical layering Technique:

In this technique the composite was placed in vertical pattern of 2mm thickness starting from one wall, i.e., buccal or lingual and carried to another wall. Each increment was cured for 40 sec. from occlusal direction.

The thickness of each increment was determined by the marks on the metal band (Figure 14).

Additional curing for 20 sec. was performed on the proximal surface after removal of the matrix band and the retainer.

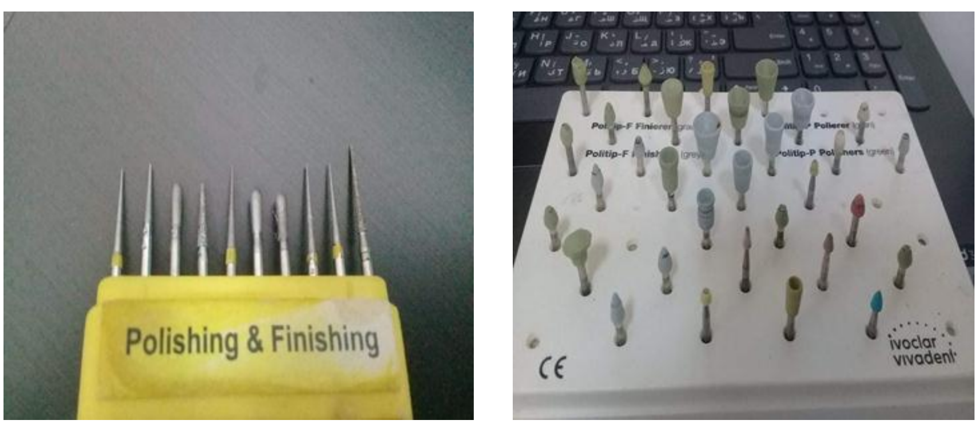
The output of the light-curing unit was checked using a curing radiometer (Blue phase Meter II) to ensure a light intensity of at least 1000 mW/cm^2.

The intensity was checked before each sample run using a UV Light Meter SENTRY ST-513 UVAB measure ultraviolet radiation tester Lux meter(Figure 15).

Figure 15: UV Light Meter

4.2.7.Finishing and Polishing:

All the restorations were finished with Dental FG High Speed Diamond finishing stones and polished with polishing points (Figure16 a) used in a high-speed for 15 seconds with water coolant followed by rubber polishing points which were used in a low-speed hand-piece (Figure 16 b) while being air-dried to eliminate any excess material especially in the cervical region and to promote a smooth surface.(157)



(a) (b)

Figure 16 (a,b) : a- dental FG high speed diamond burs. b- rubber polishing points.

Finally, all the specimens were stored in distilled water for 24 h. before testing to ensure complete polymerization process[157] (Figure17).

(a) (b)

Figure 17(a,b) : the specimens stored in distilled water for 24 h.

4.2.8. Thermocycling:

Laboratory simulations of clinical service are often performed because clinical trials are costly and time consuming. Thermal cycling is an in vivo process often represented in these simulations, but the regimens used vary considerably and with few exceptions are always proposed without reference to in vivo observations. Standardization of conditions is necessary to allow comparison of reports. Temperature regimens previously used for in vitro tests. Thermal cycling is common in tracer penetration (leakage), shear bond strength and tensile bond strength tests of dental materials. The mean low-temperature point was 6.6°C (range 0 – 36 °C, median 5.°C). The mean high temperature point was 55. 5°C (range 40 – 100°C, median 55°C). The majority of reports quoted used just hot and cold temperature points. The number of cycles used varied from 1 to 1000 cycles, with a mean of about 10 000 and median of 500 cycles. Dwell times were sometimes not stated, but the mean stated dwell time was 53s, the median 30s, with a range of 4s - 20 min.

Sometimes a longer dwell time 23s was used with an intermediate temperature of 37°C ,and a shorter dwell time 4 s for the temperature extremes, presumably in an attempt to mimic expected intraoral timings.(158)

In this study the number of cycles used was 5000 cycle's equivalent to 6 months. Dwell times were 25 s. in each water bath (Robota automated thermal cycle; BILGE, Turkey) as seen in (figure18) with a lag time 10s. The low-temperature point was 5°C. The high temperature point was 55°C.(159)

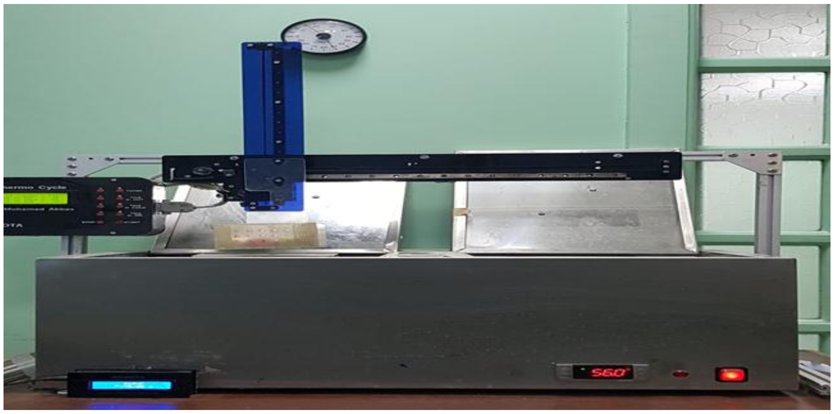
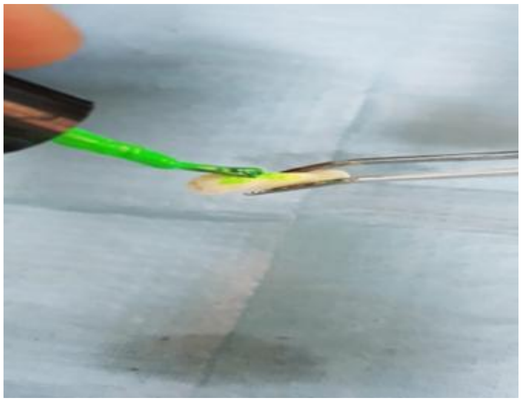


Figure 18: show thermocycling machine (Robota automated thermal cycle; BILGE, Turkey)

4.2.9. Microleakage test :

A- Varnishing :

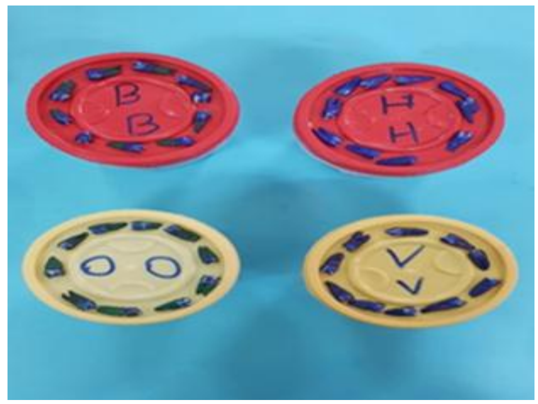
The apex of each tooth was sealed by wax and the surface of each tooth except for 1 mm around the restoration margin was covered with two layers of nail polish then immersed in a solution of 2% methylene blue dye for 24 hours at 37 °C temperature. Then the teeth were taken out of the dye solution, washed with water, and the samples were mounted onto special holding device for section (Figure19).



(a)

(b)

(c)

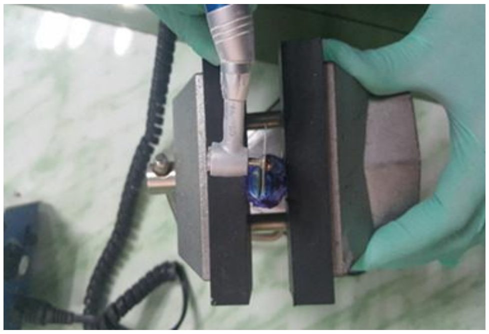


(d)

figure 19 (a,b,c,d): (a),(b) tooth was sealed by wax and the surface of each tooth except for 1 mm around the restoration margin was covered with two layers of nail polish.(c) incubation of teeth for 24 hours at 37 C^o, (d) the teeth ready for sectioning.

B - sectioning :

The teeth were sectioned mesio-distal with a low speed diamond saw as shown (table 3) under water spray,[160] as seen in (Figure 20)(a). The specimens were rinsed in running water and then dried with tissue paper. The dye penetration along the cavity wall (including both axiall and gingival margins) was assessed with a measuring Stereomicroscope as shown (Figure 20)(b) at 35× magnification in which the image of the restoration was captured and transferred to a computer equipped with the image analysis software program where the leakage was assessed.

(a) (b)

Figure 20 (a,b) : a.sectioning of teeth mesodistally, b. photographic image of Stereomicroscope.

Criteria for microleakage evaluation of dye penetration: (Figure21)

Score 0 - No dye penetration.

Score 1 - Dye penetration extending to 1/3rd of the cervical wall.

Score 2 - Dye penetration extending to 2/3rd of the cervical wall.

Score 3 - Dye penetration into whole of the cervical wall.

Score 4 - Dye penetration into the cervical wall and axial walls toward the pulp.

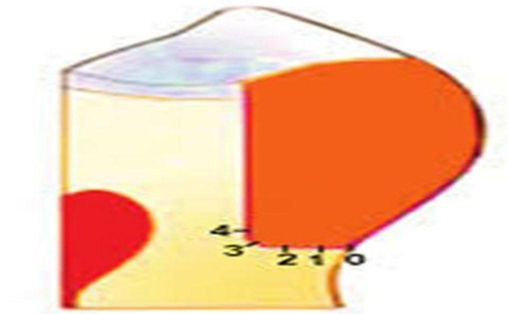


Figure 21 : scores for microleakage in class II cavity filled with resin composit.

4.2.10. Scanning electron microscope:

Scanning electron microscopic examination at dentin / resin interface:

For morphologic evaluation of the dentin / resin interfaces by SEM (Figure 22). Eight maxillary premolars were selected randomly in which two specimens from each group. The samples were prepared by sectioning the crown perpendicular to the long axis of the tooth using a low speed diamond disc under water coolant to remove occlusal enamel and expose a flat dentinal surface. The teeth were then embedded in self-cured acrylic resin using cylindrical teflon mold such that the long axis of the tooth was perpendicular to the surface of the mold.

The dentinal surfaces were abraded with 360/grit silicon carbide paper under running water to create a flat, uniform, smooth dentinal surface. The teeth were selected as representative samples for each group with its prementioned protocol of adhesive application to the dentin surface but without the crowns. A split Teflon mold was used (with a central hole of 3 mm diameter and 2 mm depth) for resin cement application. Representative samples (two teeth) for each of the 4 groups were sectioned longitudinally through the dentin-resin interface perpendicular to the bonded surface of each tooth, using a low speed rotary cutting machine under copious water coolant. After the surfaces were polished with soflex polishing discs, they were immersed in 6 ml/liter hydrochloric acid (HCl) for 30 seconds to demineralize any minerals within the hybrid layer that was not protected by resin infiltration. This was followed by rinsing the specimens with water for one minute.

The specimens were then immersed in 1% sodium hypochlorite (NaOCl) for 10 minutes to dissolve all exposed collagen beneath the hybrid layer, and then thorough rinsing with water was performed for 5 minutes. The specimens were dehydrated in ascending concentration of alcohol, subjected to critical point drying and then all specimens were gold sputtered. The hybrid layer and the resin tags at dentin/ resin interfaces of these specimens were observed with SEM at magnification 1000 X.[161]

Figure 22 : SEM (Jeol, XL, Pillips, Holland)

Table(3) Showed instruments and tools for tooth preparation and restoration.

The instrument /tool	Manufacture	Uses
High speed handpiece	NSK pana-max made in japan	Used for cavity preparation, removal of tooth structure.
Low speed handpiece	SN 05876 Made in Austria	Used with low speed finishing burs and polishing /cups
cutting burs	Carbid fissure bur 245 (Dentsply/Caulk, Milford, DE, USA)	Rotary Burrs used for cavity preparation

finishing burs	NMD high speed composite finishing kit (yellow band, diamond stone).	Used for finishing the restorations.
Polishing burs	Composite Polishing Kit for Low-Speed Handpiece Ivoclar vivadent	For polishing of the restoration
Dental Universal Tofflemire Straight Retainer.	AISI 420 German stainless steel.	To hold the metal band around the tooth
Metal matrix band	Tofflemire matrices, 0.05 mm thin, No 1001/30,Kerr Hawe SA, Bioggio,Switzerland)	Acts as an artificial wall in the missing part of the cavity and against which the composite was packed.
low speed diamond saw	Top Dent, Edenta Golden, Swiss	for tooth sectioning

Table (4): Showed the devices and equipments that used in the study

The equipment	**manufacture**	**Uses**
Thermocycling machine	Robota automated thermal cycle; BILGE, Turkey	To simulate many factors in the oral environment.
Light cure device	Cordless light emitting diode (LED) COXO DB- 686 Latte fashan COXO medical instrument united kingdom) wavelength:: 420-480nmwith Light power:≥1200mW/cm²,	For curing of the adhesive and composite restoration
UV Light Meter	SENTRY ST-513	measure ultraviolet

	UVAB	radiation
Stereomicroscope	Nikon Eclips E600, Tokyo, Japan	Used to evaluate the score of mickroleakage.
Scanning electron microscope	JEOL JSM-7610FPlus Field Emission SEM	Used to produce images of a sample by scanning the surface with a focused beam of and to give information about the surface topography and composition of the sample.

4.2.11. Data analysis :

- Distribution test was used to evaluate proportions of microleakage scores within each testing groups and within overall study samples.
- Kruskal Wallis test was used to compare microleakage across different techniques of composite resin used in the study.
- Mann Whitney U test was used to compare microleakage score by tooth surface.

Chapter 5

5. Results

5. Results :

The study sample comprised of 40 teeth and each tooth comprised of two class II cavities giving an overall 80 composite restorations placed equally using four different techniques. The restorations were distributed equally (20 for each technique). Bulk technique group was used as control whilst the three remaining groups were to test microleakage of composite when applying different layering techniques.

5.1. Proportions of Microleakage scores:

(Figure 23) shows the distribution of microleakage in overall study sample (80 restorations). Micoleakage is quite common in different types of composite placement techniques. No microleakage was observed in less than quarter of study samples 23.8 %. On the other hand, nearly half of samples demonstrated score 4 (Infiltration of the dye up to the whole length of the gingival wall and along the axial wall). Scores 1 and 2 which indicate lower levels of microleakage were uncommon representing together 12.5% of total study samples.

(Figure 24) shows the distribution of microleakage when composite restorations were places using oblique technique. No microleakage was observed in 25% of the sample. Score 4 was the most prominent and observed in 45% of the sample and this was followed by scores 3 and 2, respectively. Score 1 was not observed.

(Figure 25) shows the distribution of microleakage in horizontal layering technique. No microleakage was observed in 35% of the restorations. Like oblique technique, score 4 was the most common form of microleakage followed by scores 3 and 2, respectively and score 1 was not observed.

(Figure 26) depicts the proportions of microleakage scores for vertical technique. Twenty percent of the sample exhibited no microleakage. However, score 4 was the predominant type of microleakage affecting 40% of the restorations. Unlike previous layering techniques, score 1 was observed in 10% of restorations.

(Figure 27) shows the distribution of microleakage in bulk technique. The lowest level of no microleakage and highest level of microleakage were observed in this technique (15% and 55%, respectively). However, like other technique, score 4 was the most common form of microleakage followed by scores 3 and 2, and score 1.

(Figure 28) shows comparison of proportions of no microleakage which was observed in different techniques. It can be seen that Horizontal technique showed the least microleakage whereas bulk techniques showed the highest level of microleakage. However, these differences were not statistically significant (p = 0.565).

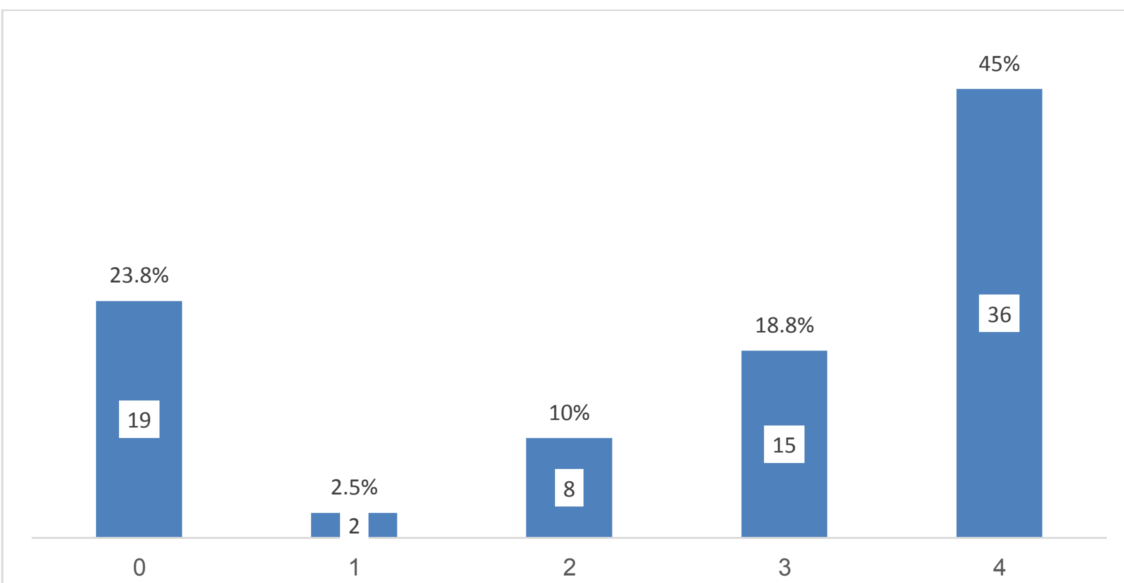


Figure23 : Distribution of Microleakage scores in the study sample (n = 80).

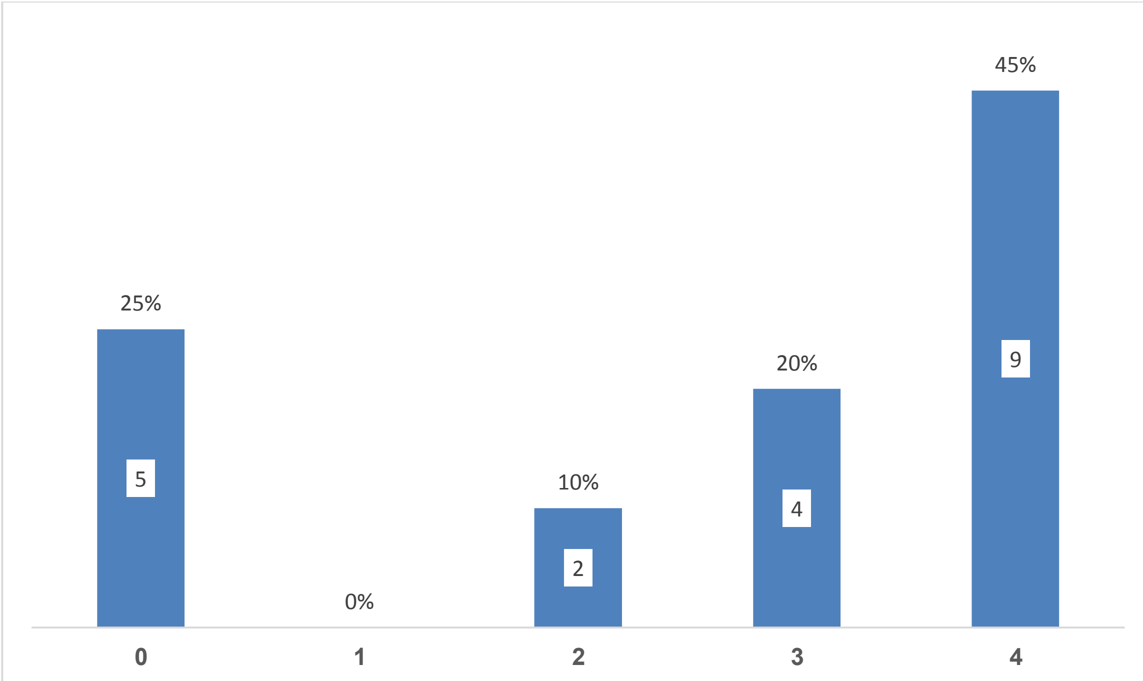


Figure 24 : Distribution of microleakage score in oblique technique (n = 20).

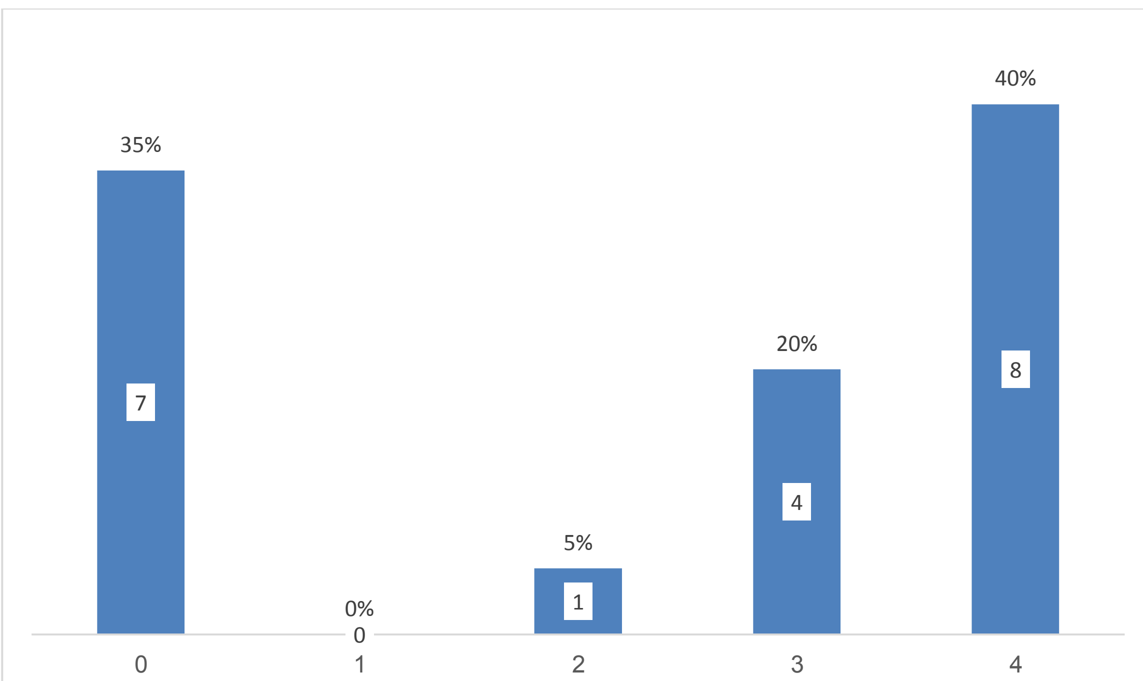


Figure 25 : Distribution of microleakage scores in horizontal technique (n = 20).

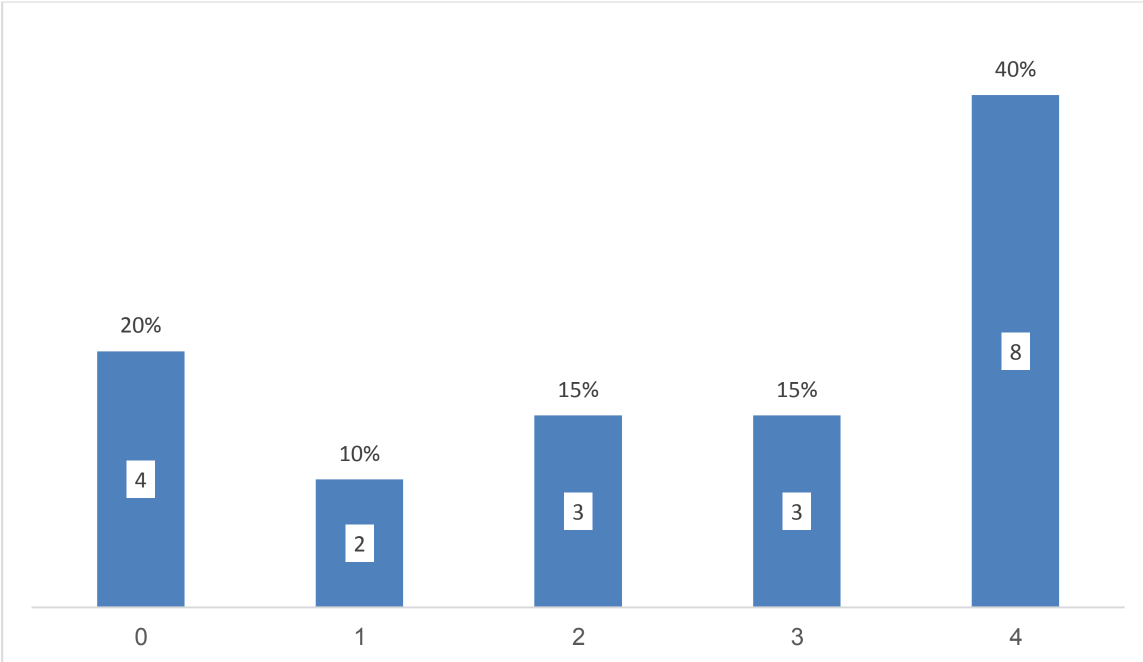


Figure 26 : Distribution of microleakage score in vertical technique (n = 20)

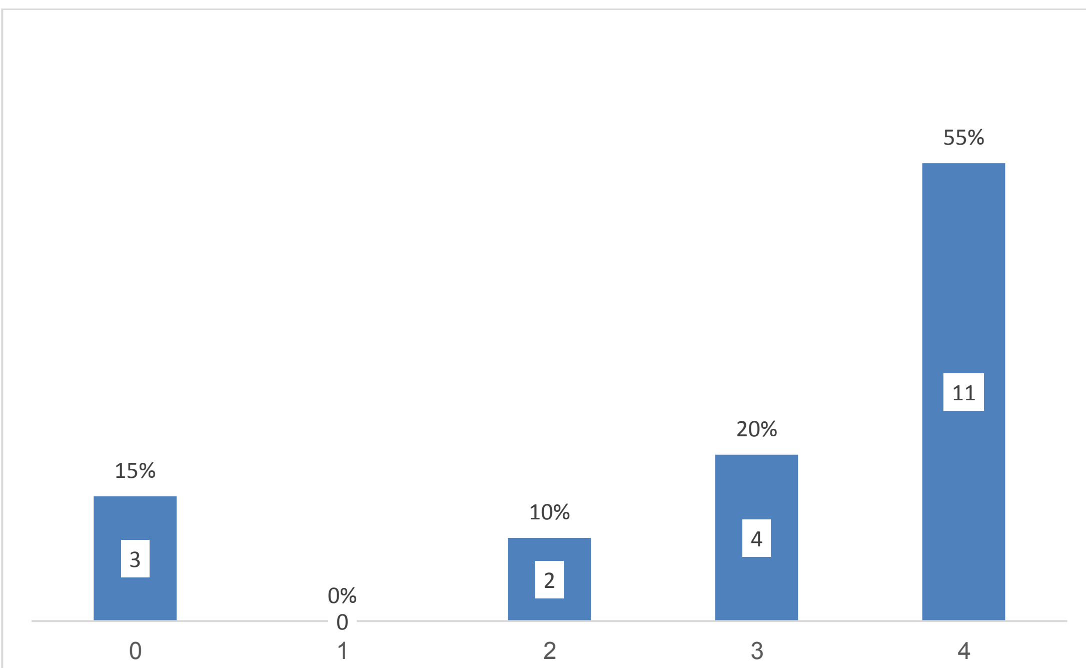


Figure 27: Distribution of microleakage scores in bulk technique (n = 20).

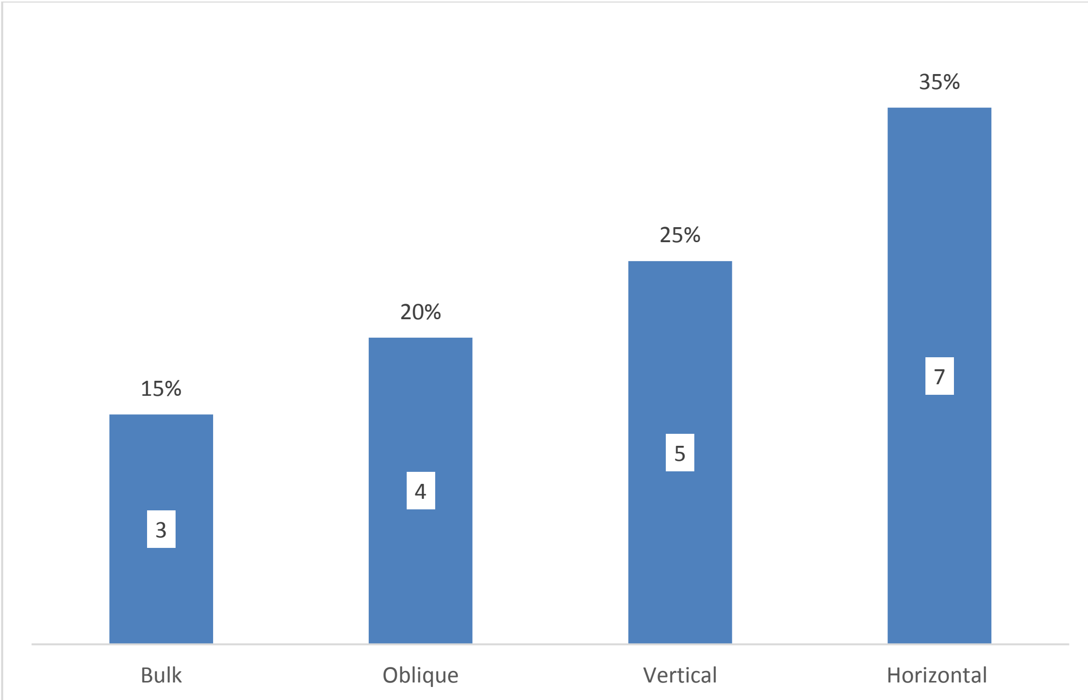


Figure 28 : Distribution of no microleakage scores in bulk fill composite in all techniques (n=80) Fisher exact test was used to compare proportions (p = 0.565).

5.2. Comparison of microleakage by tooth surface and composite placement techniques:

(Table 5) shows the results of normality tests of the distribution of microleakage scores by tooth surface and composite placement techniques. The data was not normally distributed and hence non-parametric tests were chosen to compare microleakage scores.

(Table 6) shows the comparisons of mean, median, standard deviation and mode of microleakage scores by tooth surfaces. Although various difference margins were reported. All these differences were not statistically significance. Also, there were no general pattern of these differences and the mean scores , mean and median for overall mesial and distal restorations were of negligible difference.

(Table 7) shows the comparison of microleakage scores by different techniques. Although the differences were not statistically significant (p=610), it can be noted that bulk technique had the highest mean and median for microleakage score(3.0 ±1.451 & 4). On the other hand although horizontal, vertical and oblique techniques has similar median score, the horizontal technique has the lowest mean score. .

Table (5) : Tests of Normality

	Kolmogorov-Smirnov[a]		Shapiro-Wilk	
	Statistic	Sig.	Statistic	Sig.
Mesial	.241	.000	.771	.000
Distal	.292	.000	.736	.000
Oblique	.249	.002	.750	.000
Vertical	.233	.006	.819	.002
Bulk	.305	.000	.704	.000
Horizontal	.251	.002	.742	.000

Table (6) : comparison of microleakage scores by mesial and distal tooth surfaces (n=80):

Technique	Tooth Surface	Number of samples	Mean score	SD	Median	Mode	P value
Overall	Mesial	40	2.58	1.610	3	4	0.723
	Distal	40	2.63	1.617	3.5	4	
Oblique	Mesial	10	2.50	1.841	3.5	4	1.000
	Distal	10	2.70	1.567	3	4	
Vertical	Mesial	10	2.50	1.509	3	3	0.912
	Distal	10	2.40	1.776	3	4	
Bulk	Mesial	10	3.40	.843	4	4	0.592
	Distal	10	2.60	1.838	3.5	4	
Horizontal	Mesial	10	1.70	1.829	1.5	0	0.123
	Distal	10	2.90	1.663	4	4	

Mann Whitney U test was used to compare microleakage score by tooth surface.

Table (7) : comparison of microleakage scores by different technique (n=80)

Technique	Number of samples	Mean score	SD	Median	Mode	P value
oblique	20	2.60	1.667	3	4	0.610
vertical	20	2.45	1.605	3	4	
bulk	20	3.00	1.451	4	4	
horizontal	20	2.30	1.809	3	4	

Kruskal Wallis test was used to compare microleakage across different techniques.

(Figure 29) in bulk technique The result showed that more than half of the sample 55% gave score 4 followed by score 3 which was 20% then score 2 which was represented by 10%, score 1 was not observed in this group.

(Figure 30) in horizontal technique, the distribution of microleakage scores was 40% for score 4, 20% for score 3 , 5% for score 2 and zero for score 1. It was reported that the percentage of no microleakage or score zero 35%.

(Figure 31) in oblique technique, The distribution of microleakage score showed 25% was for score zero while the highest percentage of microleakage was registered for score 4 , then score 3 20% followed by score 2 which was 10 % and finally score represented by zero.

(Figure 32) in vertical technique, the distribution of microleakage score within this group from the highest level to the lowest was 40% for score 4, 15%for score 3 and score 2 and finally 10% for score 1 and the group showed 20% score zero.

(A)

(B)

(C)

(D)

Figure 29 : (A,B,C,D)different scores of microleakage in teeth filled with bulk technique.

(A). represented score 4, (B). represented score 0, (C). represented score 2,

(D) represented score 3

(A)

(B)

(C)

(D)

Figure 30: (A,B,C,D) different scores of microleakage in teeth filled with horizontal technique.(A). represented score 2, (B). represented score 3, (C). represented score 4, (D). represented score 0.

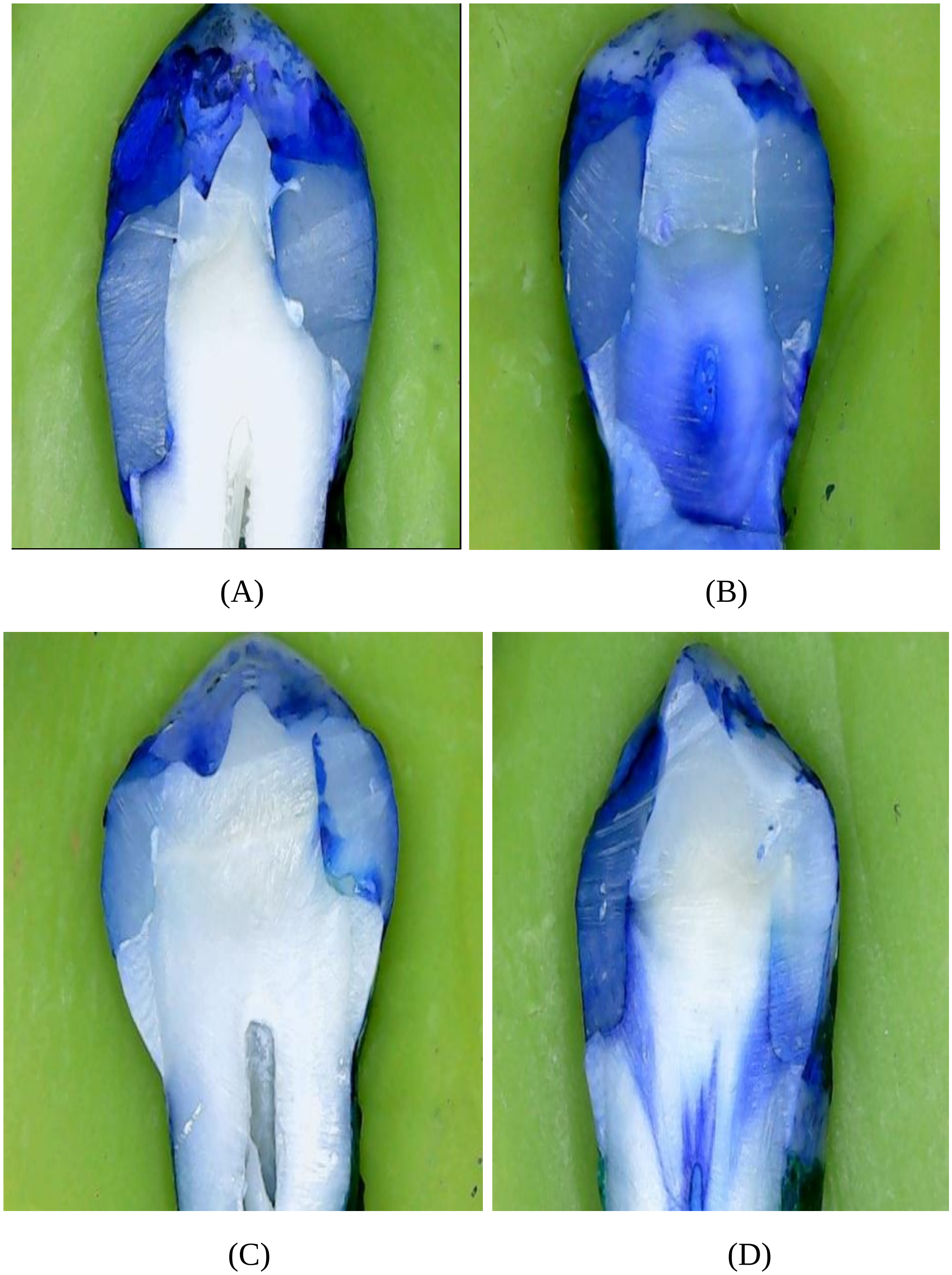
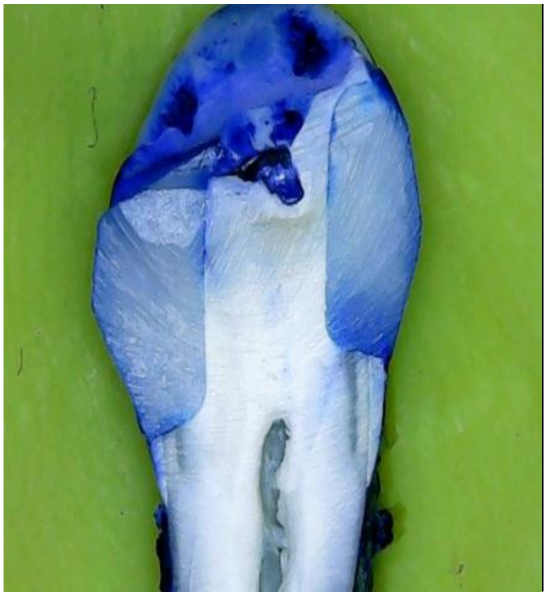


Figure 31:(A,B,C,D) different scores of microleakage in teeth filled with oblique technique.(A). represented score 3,(B). represented score 1,(C). represented score 1&0,(D).represented score 4.

(A) (B)

(C) (D)

Fiqure 32 : (A,B,C,D) different scores of microleakage in teeth filled with vertical technique.(A). represented score 3&2, (B).represented score 4&0, (C). represented score 2&4, (D). represented score 3&1.

(Figure 33) the SEM images of the horizontal placement composite samples, it was observed that only the horizontal technique with bulk-fill composite showed hybrid layer with numerous short resin tags penetrating inside the dentinal tubules provided a marginal continuity and adaptation with no gap formation at the tooth restoration interphase.

(Figure 34)The SEM images of vertical placement composite samples, dentin interface, showed a non-uniform hybrid layer that appears with short, thin, spaced and few dentin resin tags extend to small distance of dentin thickness with gap formation along the interface.

(Figure 35)the SEM images For oblique placement composite samples, the SEM image illustrated that the resin/dentin interface showed a thin hybrid layer that appears with many long and ruptured dentin resin tags arranged perpendicular to the interface with continues gap along interface.

(Figure 36) the SEM images for bulk placement composite samples, the scanning photomicrograph of the resin/dentin interface, showed a thin hybrid layer that appears with scarce long and ruptured dentin resin tags arranged perpendicular to the interface with continues gap along interface.

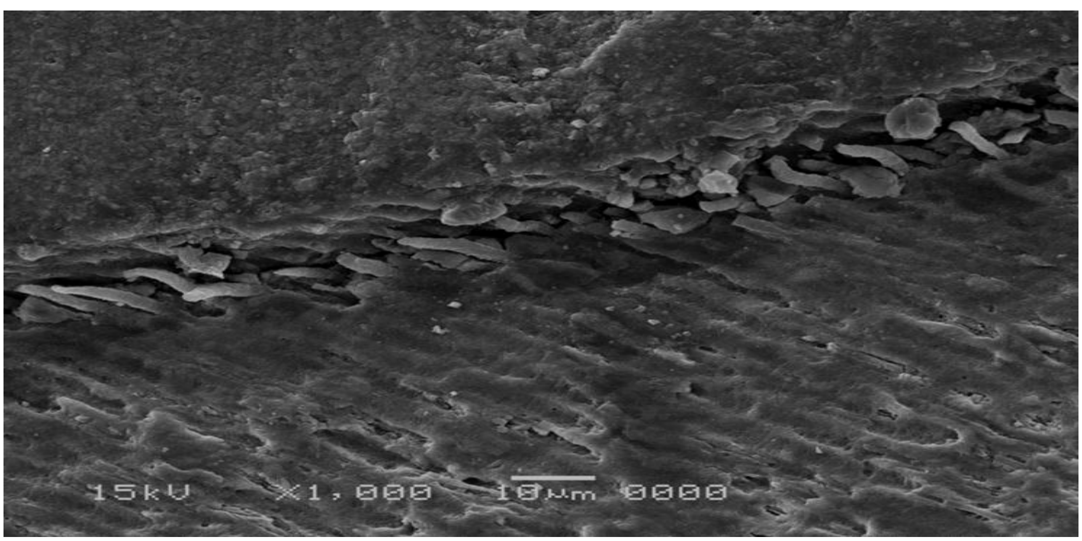


Figure 33 : Scanning photomicrograph of HH group resin/dentin interface, showing: hybrid layer with numerous short resin tags penetrating inside the dentinal tubules

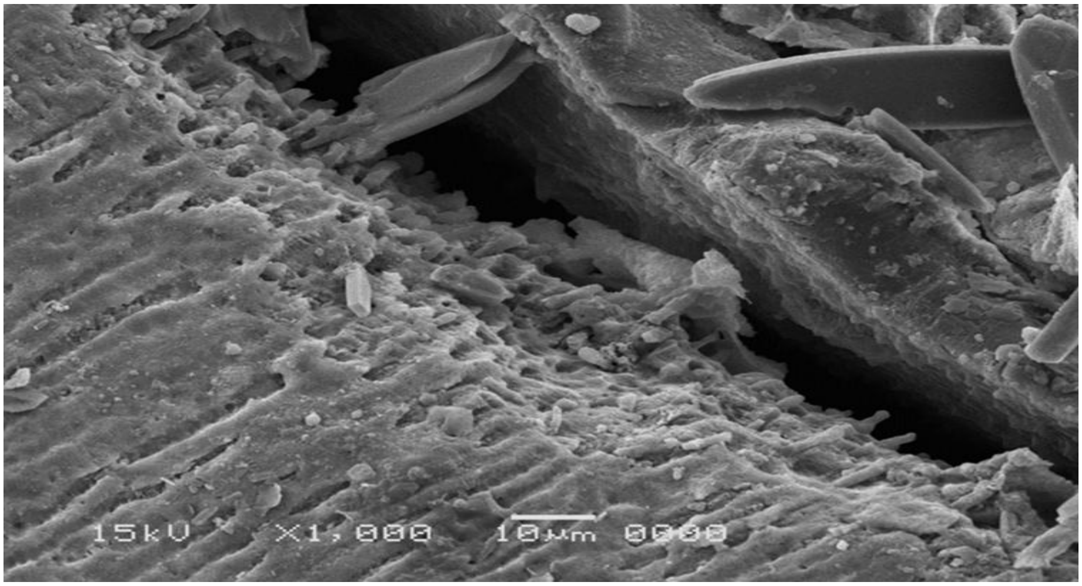


Figure 34 : Scanning photomicrograph of VV group resin/dentin interface, showing: a non-uniform hybrid layer that appears with short, thin, spaced and few dentin resin tags extend to small distance of dentin thickness with gap formation along the interface.

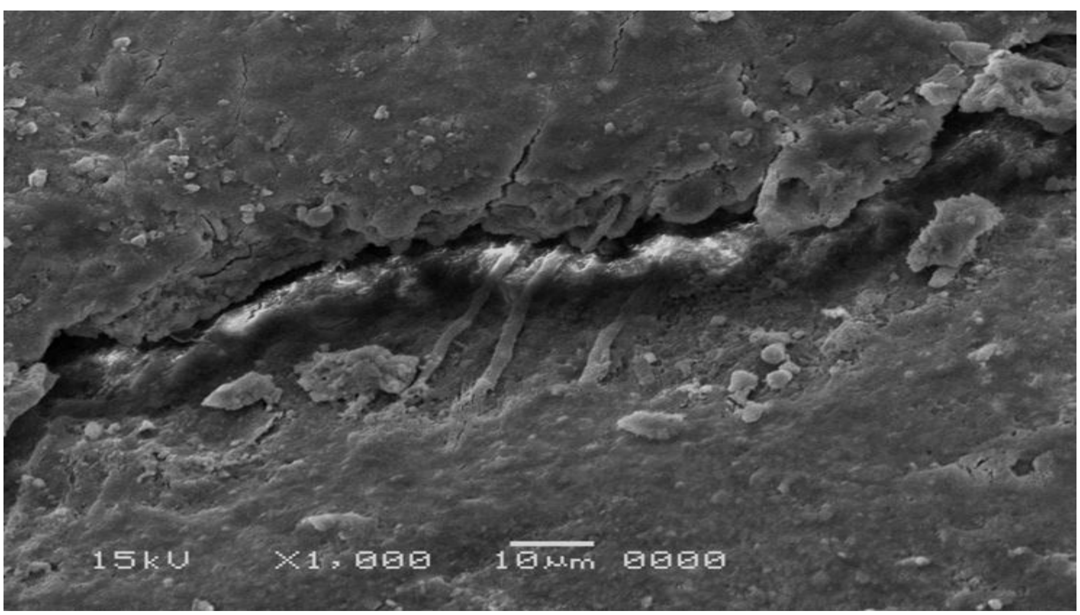


Figure 35: Scanning photomicrograph of OO group resin/dentin interface, showing: a thin hybrid layer that appears with many long and ruptured dentin resin tags arranged perpendicular to the interface with continues gap along interface

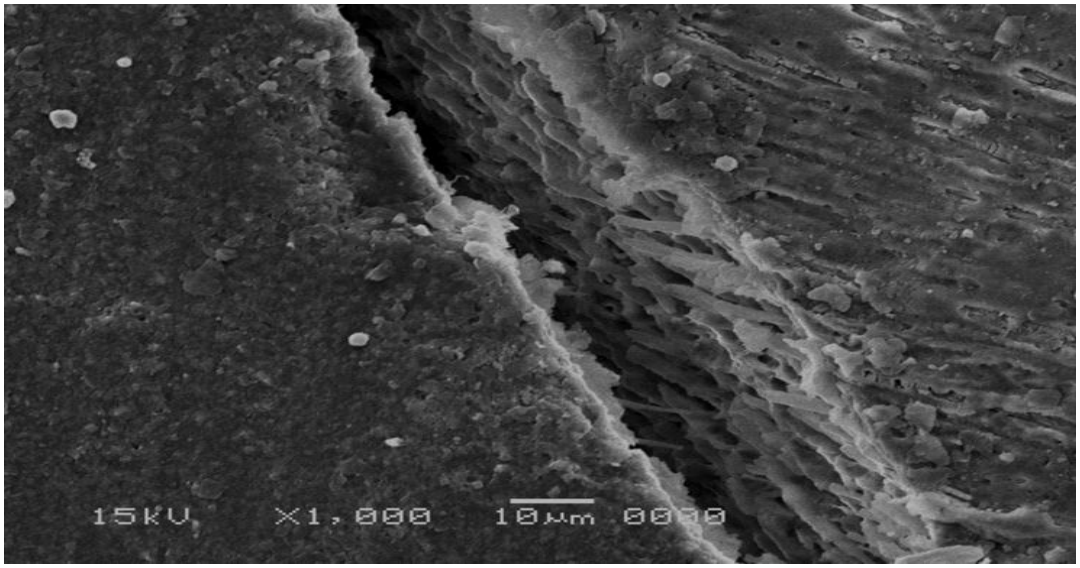


Figure 36 : Scanning photomicrograph of BB group resin/dentin interface, showing: a thin hybrid layer that appears with scarce long and ruptured dentin resin tags arranged perpendicular to the interface with continues gap along interface

Chapter 6

6. Discussion

6. Discussion:

The utilization of composite resin is becoming more popular for the restoration of posterior teeth especially in class II cavities due to the increase of patients' aesthetic demands and to the great progressive and advancements in composite resins and adhesive systems.[162]

However, despite these vast improvements in the aesthetic appearance, wear resistance and most importantly, the preservation of tooth structure in cavity preparation of resin composites, the suitability of this type of restoration has been limited by the integrity of the tooth-restoration interface which cannot be achieved completely because of shrinkage stresses which are developed during polymerization process of the composite.[163]

Consequently, microleakage remains a major drawback of resin composite restorations which is due to the shrinkage stresses that generated during polymerization process of the resin based composite when the contraction is obstructed and the material is rigid enough to resist sufficient plastic flow to compensate for the original volume.[145]

Microleakage, an important property used to assess the clinical success of restorative material, is described in literatures as a diffusion phenomenon through which the oral fluids and bacteria from the oral cavity find their way to tooth-restoration interface reaching the dentinal tubules and hence, they will pave the way for secondary caries, enamel cracks, staining of restoration, postoperative sensitivity and pulpal inflammation.[164]

Amaral et al., 2001 reported that micro leakage could be the consequences of several contributing factors such as the oral environment including occlusal forces and temperature variation and to other several differences between the physical properties of teeth and restorative materials including polymerization shrinkage, coefficient of thermal expansion, and modulus of elasticity.[165] other factors which are related to cavity configuration, and restorative procedures.[166]

According to previous literatures, if poor bond strength exists between the tooth and restorative material, adhesion failure may occur due to shrinkage stresses, and microscopic gaps at the tooth/restoration interface will be subsequently formed causing a restoration failure.[167]

It was reported by Leevairoj et al., 2001 that microleakage at the gingival level of class II cavities restored with resin composite was higher than at the occlusal level due to the difficulties in the restoration technique, curing process and continuous exposure to subclavicular fluid at this site.[168]

So, all the efforts have been directed towards lessen the microleakage phenomena of the composite resin restorations through introducing a new resin composite materials based on different material formulation strategies while others used different restorative techniques.

Recently, Bulk Fill resins (BFCs) with improved mechanical and chemical characteristics have been developed which depend on modifications in the organic matrix of composites.[169] These materials have been indicated for use in a single layer in deep cavities of 4 to 5 mm. even with a high cavity configuration.[138]

Some studies showed that BFCs presented adequate marginal adaptation,[170] low polymerization shrinkage, good bond strength, and possessed high reactivity to light curing.[171]

Other methods which have a great effect in decrease microleakage and improvement the clinical performance of the composite resin restorations are the restorative procedures and placement techniques, which are also recognized as a major factor in the modification of shrinkage stresses.[94]

To lessen the clinical consequences of polymerization shrinkage, incremental filling techniques are usually preferred over the bulk filling method to obtain effective marginal seal.[94]

Incremental techniques have been suggested to compensate the polymerization shrinkage of composites,[95] by reducing the stresses developed within the tooth-restoration system.[98] In some studies, better marginal quality with incremental methods of composite placement was observed.[96][98] However, other studies found no significant differences in marginal quality using different placement methods [172]

Although incremental technique may be important for adequate light penetration, its disadvantages are the possibility of trapping voids between layers and the time required to place the restoration.[173]

Others preferred bulk application technique due to its simplicity and less time consuming by reducing the number of clinical steps.[174]

So, the goal of this study was to evaluate and compare the effects of different placement techniques on the microleakage of class II cavities prepared in posterior teeth using Bulk-fill composite.

A total of 40 extracted sound premolars were used in this study.

A standard class II cavity was prepared one on the mesial and one on the distal sides of each tooth with a gingival margin 1mm. coronal to the CEJ.

Inner angles of the cavities were rounded and the enamel margins were unbeveled. To standardize the restorative technique a total etching adhesive system was applied to all cavities, and single type of a high viscosity/full body Bulk- fill composite was used for testing.

The teeth were randomly divided into four equal groups according to the methods of composite packing. Each group was consisted of 10 teeth with a total of 20 cavities (n=20) for each techniques. The experimental groups were G1, control group the composite packed using bulk Technique, G2, for horizontal layering technique, G3, for wedge - shaped layering technique and G4, for vertical layering technique.

All the specimens underwent thermocycling which is frequently working to initiate stresses in the oral cavity during lab investigations, followed by immersion in a dye solution of 2% methylene blue for 24 hours which is the recommended immersion time from the ISO/TS11405 (2015). Dye penetration has been considered as an easy method since the dye penetrates successfully into the flaws and crevices of the test object, but it is influenced by the observer's ability to evaluate the infiltration.[175]

The penetration capacity of methylene blue is considered as a good tracer for microleakage test because the particles of dye are smaller (0.12 μm) than the size of bacteria (0.5- 1 μm) and diameter of dentinal tubules (1-4 μm). and its penetration into the specimen can be easily detected by stereomicroscope.[176]

After that the teeth were sectioned to and examined under Stereomicroscope for microleakage assessment according to dye penetration score using the method, as per Radhika et al., :[25]

0- No infiltration.

1- Infiltration of the dye up to one - third of the gingival wall.

2- Infiltration of the dye up to two - third of the gingival wall.

3- Infiltration of the dye up to full length of the gingival wall.

4- Infiltration of the dye up to the whole length of the gingival wall and along the axial wall. (Figure 21)

The Quality of the internal adaptation was evaluated by scanning electron microscope in which tow specimens were selected randomly from each testing group. The quality of the marginal seal at the gingival margins of restorations was categorized into two categories:

1. No gap : The margin appears with smooth and uninterrupted tooth-restoration continuity.
2. presence of gap : A distinct gap exists at the tooth restoration margin.

The data of the study was statistically analyzed by Kruskal Wallis test was used to compare microleakage across different techniques of composite resin application bulk technique, horizontal technique, oblique technique and vertical technique.

6.1. Proportion of microleakage scores in overall study:

In general, the results of this study showed that micro leakage is quite common in different type of composite placement techniques since none of the techniques had completely eliminated the microleakage in overall study sample which were 80 restoration using Bulk-fill composite resin.

The proportions of microleakage scores according to their distribution in overall study sample 80 restoration were 23.8 % for score zero which means no microleakage was observed in less than quarter of the study sample.

Dye infiltration up to the whole length of the gingival wall and along the axial wall score 4 which represented the infiltration of the dye up to the whole length of the gingival wall and along the axial wall was observed in more than half of the total sample score 3 which represented by infiltration of the dye to the full length of the gingival wall was observed in 18.8 % of the samples and score 2 which represented by dye infiltration up two- thirds of the gingival wall was observed in 10 % of the total study samples. While score 1 which represent dye infiltration up to one – third of the gingival wall was observed in 2.5 % of the total sample.

The main factor which is responsible for microleakage is attributed to the polymerization shrinkage which is considered an inherent property responsible for main drawback of composite resin material.[(177)]

This polymerization shrinkage may lead to debonding of the restoration from the cavity wall. The polymerization reaction in RBC is mandatory step to proceed in its setting reactions to change the viscous phase into a rigid phase.[(177)] In this process, the cross linking of all monomers occurs thus decreasing spaces between them and causing a reduction in the general volume of a restoration and creates contraction stresses in the resin composite restoration leading to microleakage and internal stress in the surrounding tooth structure.[(178)] The type of RBC directly affects the rate of polymerization shrinkage, gap formation.[(174)] It was reported that both polymerization shrinkage and elastic modulus highly depend on the filler content, and the lower filler contents give rise to greater shrinkage stresses.[(179)] Several studies reported that the polymerization of dimethacrylate-based composites is always accompanied by substantial volumetric shrinkage in a range of 2 to 6 %.[180,181]

It was claimed by the manufacturer that Tetric N- Ceram Bulk Fill composite resin which used in the present study, has moderate viscosity, with a nanofilled filler content of 79-81 wt%, producing a volumetric shrinkage of 1.74% and a shrinkage stress of 1.1 MPa.

So, the polymerization shrinkage which is an inherent property of composite resin material is considered the main disadvantage of composite resins even with the continuous evolution of these resins.[39]

Furthermore, variations in the coefficients of the thermal expansion between composite restorations and tooth structures can lead to different volumetric changes in the resin and the tooth structure during temperature changes. The different volumetric changes directly affect microleakage and gap formation.[182] Dental restorations are subjected to constant and extreme thermal changes in the oral environment, during food intake and drinking fluids at various temperatures. To simulate the oral environment, in vitro thermocycling is performed for testing the sealing ability of restorative material.[183]

Previous studies have demonstrated that thermocycling is the most influential factor in enhancing the process of microleakage due to the thermally induced stresses, which may result from the mismatch between the coefficients of thermal expansion for the restorative material and the natural tooth structure.[184] Another paper revealed effects of the wide range of cycle numbers, temperatures and exposure times for in vitro thermocycling regimens.[185]

The conditions used in the present study was 5000 cycle's equivalent to 6 months of 5 ± 2°C to 55 ± 2°C with 60-s dwell time were based on the conditions used in recent studies on Class V restorations.(153)

On other hand, it's well known that polymerization shrinkage increases in cavity designs with high C-factors due to the inability of RBC's to reduce the extra stress by the flow through unbonded surfaces of high C-factor preparations because the unbounded is the only surface that can act as a reservoir for the plastic deformation that happens during polymerization shrinkage as in case of class II cavities which yield high C-factor.(186)

Other causes due to the restorative procedures, and curing protocol used to decrease polymerization process.(187)

6.2. The distribution of microleakage scores within each individual group:

I - Bulk technique :

The results showed that the control group in which the composite packed by bulk technique gave the highest percentage of microleakage even among other groups as (Figure 29). The result showed that more than half of the sample 55% gave score 4 followed by score 3 which was 20% then score 2 which was represented by 10%, score 1 was not observed in this group which could be attributed to fracture of the undermined enamel at the unbeveled gingival margin during specimens preparation and sectioning and it may due to cracked enamel during thermo cycling as we know that enamel is brittle structure , so it might suffer from minute cracks due to repeated hot and cold cycles. So this cracks may allow dye penetration and find its way direct to dentin. Also it was recorded that only 25% of the sample showed score zero.[188]

II – Oblique technique

For oblique technique, The distribution of microleakage score showed 25% was for score zero while the highest percentage of microleakage was registered for score 4 , then score 3 20% followed by score 2 which was 10 % and finally score represented by zero.

III – Horizontal technique :

For horizontal technique, the distribution of microleakage scores was 40% for score 4, 20% for score 3 , 5% for score 2 and zero for score 1. It was reported that the percentage of no microleakage or score zero 35%.

IV- Vertical technique :

For vertical technique group, the distribution of microleakage score within this group from the highest level to the lowest was 40% for score 4, 15%for score 3 and score 2 and finally 10% for score 1 and the group showed 20% score zero.

Ongoing through the results of the distribution of microleakage scores in each placement technique, we found that the bulk technique showed the greatest microleakage scores when compared to all other tested groups. In this technique the bulk fill composite was placed into the cavity in one bulk where it got in contact with 4 walls and only two unbounded free surfaces remained. In such a case, the C-factor which is defined as the ratio of bonded to unbonded surfaces of the composite restorations is high,[112] and for that reason the competition between shrinkage stress and the adhesion of the composite to the tooth surface is the highest which might result in adhesive failure once the polymerization stress surpasses the bond strength.[189]

Our results are in parallel with several previous studies which indicated that placement of large increment of bulk-fill resin composite into a cavity increased the potential of creating high shrinkage stress. In addition, Donly and Jensen, 1986, declared that bulk placement of composite induces more strain because the buccal and lingual walls are pulled together which might cause adhesive failure and microleakage.[82]

According to Naghili etal., 2019, the possible explanation of gingival microleakage of composite resin in large cavities (4 mm) using bulk fill composite is that increased in cavity dimensions resulting in increased C-factor and in the mass volume of composite resin leading to a greater polymerization shrinkage resulted in a significant increase in microleakage.[190]

Yap, 2000 postulated that in bulk technique high internal stresses may be generated in the material and loss of marginal integrity can occur, as the larger the volume of composite to be polymerized, the more will be the polymerization shrinkage, and other reason due to decrease effectiveness of polymerization at deeper portions of the composite.[191]

A study performed by Braga etal.,2006 observed a direct and significant relationship between microleakage and composite resin volume and cavity dimensions.[192] Other study indicated this technique to be the least advantageous in terms of polymerization shrinkage.[193]

On other hands, it has been shown that composite with high viscosity is more difficult to condense into the prepared cavity due to its thickness, stickiness or dryness and thus becomes more resistant to accurate adaption to the prepared cavity.[194]

Also it was reported that the single paste light activated composites had voids present to a percentage of 0.05-1.5% per volume.[195]

Further study had shown that, the presence of voids at the tooth/restoration interface and within the material itself leads to the development differences in internal stress due to the volumetric shrinkage of the material on the voids which ended up by increasing of the microleakage and/or adhesive failure. [196]

A microleakage study with SDR bulk fill composite indicated that most of the prepared specimens for voids assessment were shown under stereomicroscope evaluation to had voids in the material.[197]

Other study showed contrary results, Jedrychowski et al.,2001 evaluated the shrinkage stresses generated by resin composites placed by different incremental placement techniques. They found few differences in polymerization shrinkage stresses between incremental placement techniques and the bulk technique and the later produced the lowest shrinkage and microleakage.[198]

According to Tantbirojn et al., 2011 the ideal bulk fill composite would be one that could be placed into a preparation having a high C-factor design and still exhibit very little polymerization shrinkage stress, while maintaining a high degree of cure throughout.[199]

As it was claimed by the manufacturer that Tetric N- Ceram Bulk Fill composite resin which used in the present study, has high viscosity, with a nanofilled filler content of 79-81 wt%, producing a volumetric shrinkage of 1.74% and a shrinkage stress of 1.1 MPa. It was reported by Ceclia and Aranha , 2004 that Tetric Ceram in bulk placement did not differ from the incremental technique and Tetric in bulk placement had significantly less microleakage than Surefil composite either in bulk or in increment techniques.[(200)]

Furness et al.,2014 reported in their study that Tetric N Ceram Bulk Fill represents the high viscosity type bulk fill and its curing depth of 4 mm is achieved mainly due to the patented photo-initiator, Ivocerin, which is more reactive than conventional initiators.[(13)]

On other hand, Leinfelder, 1991 postulated that Tetric N Ceram Bulk Fill is a stiffer composite which might help in restoring good contacts in posterior teeth but it may not adequately adapt to internal areas and cavosurface margins at the cervical joint.[(201)] Also others reported that viscosity of the bulk fill restorative material influenced the proportion of gap-free marginal interface and the internal adaptation in dentin.[(202)]

Also, another study advocated that the bulk technique is a safe restorative technique because it fills the total volume of the preparation and creates less residual shrinkage stress than the incremental technique. But since this concept is based on the elastic deformation of the restorative material flowing toward the free surfaces, more residual stresses should be expected and more microleakage.[(203)]

Another concern regarding a bulk technique is whether the composite cures enough in the deeper portions, and at this moment, there are few studies evaluating the degree of conversion and polymerization kinetics of bulk-fill composites.[204]

II - Incremental techniques :

Regarding the outcome of the distribution of microleakage scores within the different placement techniques in our study , it was observed that all the incremental techniques showed decrease in microleakage compared to the bulk placement technique which was used as a control group. A ranking for the microleakage distribution in placement techniques from the highest microleakage proportion to the lowest was that the bulk technique was the highest, followed by the vertical layering technique, then the oblique layering technique, and finally the horizontal layering technique.

Our result was coincided with Ozel and Syman, 2009, Giachetti et al., 2006 and Van Meerbeek, 1992 Who postulated that using of layering or increment techniques in Class II cavities reduce the adverse effects of polymerization shrinkage and marginal gap formation comparing to the bulk technique. In addition, they reported that their results were attributed to the use of a small volume of material with incremental technique which reduces the bonded to unbonded surfaces thus reducing the cavity configuration factor (C-factor) and stresses on the RBC restoration as it provides minimal contact with the opposing cavity walls during polymerization.[205][26][206]

On the contrary other study found no significant different between bulk and incremental techniques on microleakage evaluation.[207]

From other hand, the results showed that all the incremental techniques showed less microleakage comparing to the control group which was the bulk technique.

A - horizontal technique:

It was observed in the present study that horizontal placement technique showed the least microleakage among all the groups (Figure 30). 40% of the specimens presented with microleakage involving infiltration of the dye up to the whole length of the gingival wall and along the axial wall (score 4).

According to Welime, 2014 the horizontal placement technique was ranked as the easiest to use clinically amongst the incremental placement techniques.[208]

Winkler et al., 1996 reported that this technique is acceptable method for resin composite insertion at enamel margins since standardized layers of equivalent volume allow superior control of the polymerization shrinkage levels.[190]

As a general approach, horizontal placdement technique has been used in which the composite is layered horizontally in gingivo-occluasl direction and light-cured in increments of less than 2 mm.

Our study was in agreement with a study done by Frankenberger et al., 2007 using different adhesive systems and layering techniques who found that the horizontal layering technique had the best marginal and bond qualities compared to the vertical and oblique layering techniques if it is performed in a standardized approach.[150]

Furthermore, Crim, 1991 reported in his study that horizontal placement technique has been shown to provide superior bonding results as compared to the bulk technique.[209]

Whereas in another investigation horizontal (gingivo-occlusal) increments was suggested to be more appropriate and produced less microleakage compared to vertical increments for class V restorations.[210]

Perhaps the most important contribution of horizontal incremental technique would be an adequate polymerization for bulk fill composites and adequate degree of conversion of the material in this thickness, as it was postulated by Campas et al., 2014 in their study.[211] In this regard, the result could be related to the benefits claimed by the manufacturer that higher translucency and light transmission properties of bulk-fill resin were enhanced, and modified by adding prepolymer shrinkage stress relievers, polymerization modulators chemically embedded in the center of polymerizable resin backbone, high-molecular weight base monomer to optimize flexibility and network structure and highly light-reactive photoinitiator system, benzoyl germanium (Ivocerin) to enable rapid polymerization and greater curing depth.[138]

Yumei et al, 2009 reported that in their study that the shrinkage of a single horizontal thin layer of composite generates remarkably less tensile force than the contraction of a composite bulk that fills the whole cavity.[212] So, the optimal polymerization of the incremental restorations could result in a better degree of conversion compared to the bulk technique.[176]

Other reason could be attributed to the location of the gingival wall at enamel margins in this study, since enamel is a better substrate for bonding especially with selective total etch adhesive system used in the bonding procedure which creates microporosities, allowing penetration of the adhesive system, thus forming a micromechanical bonding with the resin composite restoration.[213] Khosravi et al., 2009, revealed in their study that acid etching prior to adhesive application is effective in reducing microleakage.[214]

On the contrary to our result, several authors reported that using this technique for composite application leads to increase the C-factor, and thereupon increases the shrinkage stresses between the opposing cavity walls which lead to microleakage since there is a direct correlation between microleakage and polymerization shrinkage stress in resin composite restorations.[215,216]

Also, a study done by Versluis & Douglas et al. 1996 showed that the layering technique increased the deformation of the restored tooth and caused higher polymerization shrinkage and marginal gap formation.[217]

B- oblique technique :

According to our study, the next best results of microleakage distribution was in oblique technique, It was observed in the present study that oblique placement technique(Figure 31). with the highest microleakage percentage (45%) for score 4 and lowest value for score 2.

In this technique which also described as Z-technique, the composite resin was 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. The idea of oblique technique as proposed by Lutz et al.,1986 in order to increase adhesive free surface to allow better resin flow and hence reduction of polymerization shrinkage could be achieved.[150]

Therefore, this technique was developed as a method to reduce the C-factor, and limits the development of contraction forces between opposing walls, which could be detrimental to the restoration quality such as stress build-up, gap formation, and cuspal fracture.[218]

Other study have shown that the incremental technique especially the oblique technique tends to improve marginal adaptation by resisting resin composite shrinkage stress.[219]

Our study was in agreement with a study performed by Lopes et al., 2004 using finite element analysis to evaluate the effect of resin placement technique on the resin-dentin interface. The authors observed that oblique and vertical placement techniques utilized for placement of resin composite restorations caused progressive inward deformation of the cavity walls which might result in a more stressed tooth-restoration complex leading to a more microleakage at the resin-dentin interface. [220]

Furthermore, it was reported by Loguercio et al, 2004 that the combined simultaneous shrinkage of the different layers using oblique placement technique may result in much more shrinkage stress and microleakage.[221]

In addition, a study performed by Sillas and Jose,2008 for evaluation of marginal adaptation of class II adhesive restorations showed that oblique technique exhibited significant microleakage despite reduction in C-factor which was attributed to the cuspal movements caused by this technique during the restorative procedure and the increase in polymerization stress might generate a marginal gap.[222]

C- vertical technique :

Our results showed that vertical placement technique provided the highest microleakage proportion among the increment placement techniques

(Figure 32), but it was less than that of the bulk technique. In this technique the composite increments were packed in vertical pattern starting from one wall and carried to another wall in a bucco-lingual direction. Buccolingual incremental layering induces least strain compared to horizontal and bulk techniques as only one wall is pulled at a time.

Donly and Jensen, 1986 reported that the buccolingual incremental layering induces least strain and microleakage compared to horizontal and bulk techniques because only one wall is pulled at a time, a result which was not in agreement with our findings. Also, It was reported, that to eliminate a microleakage and a gap formation at gingival wall which are induced by polymerization shrinkage in a restoration packed with vertical technique, the curing process should be started from outside or behind the corresponding wall in which the increment is packed. So, according to the previously mentioned explanation our finding could be attributed to the difference in the position and direction of the curing light which was performed from occlusal aspect of the restoration causing shrinking vector to be away from the tooth surface.[82]

Our result, was parallel to the finding of Donly et al., 1989 who reported that composite resin placement and polymerization in faciolingual increments produced substantially less cuspal deflection and microleakage than bulk placement technique. [223]

Furthermore, our results were in agreement with the findings of Aguiar et al.,2002 who reported in their investigation for class V restoration, the use of horizontal increments are more appropriate and produced less microleakage compared to vertical increaments.[210]

6.3. Comparison of microleakage by tooth surface and composite placement techniques:

According to Mann Whitney U test which was used to compare microleakage score by tooth surface, there were no statistically significance differences for overall mesial and distal restorations.

It is believed that the location of the preparation either on the mesial and distal specimens should not significantly affect the results because all specimens on the mesial and distal were similarly prepared on the same tooth with the same type of RBC and placement technique, however the tooth substrate to which the restoration bonds to may have an effect on the shrinkage stresses due to the different substrate compliances to the applied stresses, which may have affected the amount of gap formation.

On other hand, this result reflected the standardization which was followed in each step during specimens' preparation and testing.

6.4. Comparison of microleakage scores by different techniques(n=80):

Comparison of microleakage scores by different techniques showed that there were no statistically significant differences since p- value=610 according to Krusal Wallis test. It was observed that bulk technique gave the highest microleakage score, while horizontal, vertical, and oblique techniques had similar microleakage scores with the lowest score achieved by horizontal technique (Figure 27).

This result indicated that none of the composite placement techniques were capable of eliminating marginal microleakage completely.[108] The incremental techniques did not significantly reduce microleakage compared with the bulk method, but there was a clear tendency for reducing microleakage in Class II cavities with layering techniques.[108]

6.5. Marginal adaptation analysis using Scanning electron microscope:

The shrinkage of composite resins during photopolymerization remains an unavoidable problem, which may compromise the integrity and longevity of posterior restorations. This shrinkage induces stresses at the tooth/restorative interface which have the potential to cause an adhesive failure or a gap formation and possibly affecting the marginal quality of the restoration if the bonding to tooth structure is not strong enough to resist these stresses.[224] Consquently, when marginal quality is not adequate, problems like leakage, recurrent caries and pulpal irritation may occur.[225] Even by considering that an absolutely perfect marginal seal is not achievable clinically, a good marginal quality should be the main objective for clinicians.[53]

The marginal seal of a restoration to the tooth structure can be measured by either marginal adaptation measurements or micro-leakage measurements.

Quantitative marginal analysis was introduced by Porte *et al.*, 1984 and was later refined by Blunck and Roulet, 1989 It was stated that using of scanning electron microscope for evaluation of microleakage provides a quantitative analysis of the amount and width of gaps formed at the margins and marginal irregularities rather than the qualitative isolated analysis provided by microleakage.[226,227]

So, scanning electron microscope (SEM) for marginal adaptation testing was chosen for present study to show of the presence or absence of gaps formed at the margins and marginal irregularities of eight samples which were randomly selected as two sample from each group in the study. The images were taken of the gingival margin at a magnification of (1000 X) Once the image of each sample were obtained, the images were examined for gingival marginal gaps.

The criteria for scoring marginal gaps in different marginal analysis studies range from two criteria (Pass or Fail) Frankenberger *et al.*, 2008, also Sabatini, Blunck *et al.*, 2010 categorized the gap criteria into two categories (gap/no gap).[228,229] Roulet *etal.*,1989, Blunck and Zaslansky, 2011 provided four categories,[227,230] and Gjorgievska *et al.*, 2008 illustrated seven criteria.[231]

The quality of the marginal seal at the gingival margins of restorations was evaluated according to Sabatini et al., 2010 who categorized the gap criteria into two categories:[229]

1. No gap: The margin appears with smooth and uninterrupted tooth-restoration continuity.
2. Presence of gap: A distinct gap exists at the tooth restoration margin.

In assessing of the SEM images of the selected samples, it was observed that only the horizontal technique with bulk-fill composite showed hybrid layer with numerous short resin tags penetrating inside the dentinal tubules provided a marginal continuity and adaptation with no gap formation at the tooth restoration interphase. This result could be contributed possibly to the adequate polymerization and to the sufficient degree of conversion of the bulk- fill composite increments due to an adequate light penetration in this thickness using horizontal placement technique (Figure 33).

On the other hand, the SEM images of the other placement techniques showed marginal discontinuities with presence of gaps.

The scanning photomicrograph of vertical placement composite samples, dentin interface, showed a non-uniform hybrid layer that appears with short, thin, spaced and few dentin resin tags extend to small distance of dentin thickness with gap formation along the interface (Figure 34).

For oblique placement composite samples, the SEM image illustrated that the resin/dentin interface showed a thin hybrid layer that appears with many long and ruptured dentin resin tags arranged perpendicular to the interface with continues gap along interface (Figure 35).

Finally, for bulk placement composite samples, the scanning photomicrograph of the resin/dentin interface, showed a thin hybrid layer that appears with scarce long and ruptured dentin resin tags arranged perpendicular to the interface with continues gap along interface (Figure 36).

So , in these cases it seems to be there is inadequate bonding to tooth structures and forces resulting from polymerization shrinkage might give rise to gap formation at cavity wall restorative material interface. Composite resin marginal integrity might be affected by various factors, including the cavity size, the angle at which enamel prisms and dentinal tubules are cut based on their location, the procedure in which dental hard tissues are conditioned, the layering protocol and the polymerization technique

used. [232]

Therefore in the present study, it appears that differences in the placement techniques were responsible for differences in gap formations between the tested samples since, one type of composite resin material and adhesive system were used in addition, a standard class II cavities with similar dimensions and C-factor were prepared in all the samples and the best result was achieved by using horizontal placement technique with bulk-fill composite resin material.

Chapter 7

7. Conclusion

7. Conclusion:

Within the limitation of this in vitro study wich were performed to evaluate the microleakage at the gingival seat of class II composite resin with different placement techniques, it was concluded that :

1 – Microleakage is still the main drawback inherent property of the resin composite materials even with the newely development composite resin materials.

2 – Although there were no significant difference in microleakage between different testing groups, according to the results showed that incremental placement techniques showed less microleakage than bulk increment placement technique.

3 – The horizontal placement technique produced less microleakage scores among the all tested groups, followed by oblique placement technique then the vertical placement technique while the last is the bulk placement technique.

4 – Under SEM, examination, horizontal placement composite restoration showed the best marginal adaptation compared to the other testing samples.

Chapter 8

8. Recommendations

8. Recommendations :

- Further studies should be performed using different types of Bulk- fill composite resin materials for microleakage evaluation.
- Further studies should be carried out to investigate microleakage levels at different location of the gingival margin such as at cementoenamel junction and below the cement enamel junction using the same techniques and material.
- Microleakage evaluation of the Bulk-fill composite restoration using same placement techniques with different microleakage testing procedures.
- Evaluation of microleakage of Bulk fill restorations usig the same placement techniques with different types of adhesive systems.

Chapter 9

9. References

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Chapter 10

10. Appendix 1

INFLUENCE OF COMPOSITE RESIN PLACEMENT TECHNIQUES ON MICRO LEAKAGE AT THE GINGIVAL SEAT OF CLASS II CAVITY PREPARATION

تأثير تقنيات التنسيب المركب الراتنج على التسرب الجزئي في السطح العلوي اللثوي لتحضيرات تجويف الفئة الثانية

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Proposal

Submitted In partial Fulfillment of Requirements

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In

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Supervisor : Prof . Dr. Nagat Hassan Bubteina .

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1. Introduction:

Newer generation composites have been developed with improved properties and reduced numbers of steps for restoration are now the material of choice for posterior restoration due to the increase of patients' aesthetic demands and to the great evolution in the adhesive system.(1)

However, high-polymerization shrinkage continues to represent their major disadvantage.(2) Previous research has shown polymerization shrinkage to lead to bond failure and microleakage of resin composite restorations.(3)

Microleakage is a matter of concern because it leads to passage of bacteria, fluids, molecules, or ions between a cavity wall and restorative material applied which become responsible for staining at the margins of restorations, recurrent caries, hypersensitivity, and pulpal inflammation.(4)

In order to minimize stresses from polymerization shrinkage several techniques have been introduced, and among them is the incremental layer technique in which the composite is layered and light-cured in increments of less than 2 mm.(5,6) The incremental layering of the composite reduces the C-factor, which is defined as the ratio of the bonded surface area to the unbonded surface area of the restoration.(7) This reduces the shrinkage stress at the tooth-composite interface by permitting the stress-relieving flow of composite from the unbounded surface towards the bonded surface. (7)

Since the layering technique and the thin 2mm increments of the composites are widely recommended to minimize shrinkage stress and ensure adequate depth of cure. [8-10] Therefore large posterior composite restorations as in cases of class II cavities would be time consuming and can imply the risk of incorporating air bubbles or contaminants between the increments.[11] Incremental technique has not been without complications, as the material still had a predisposition to shrinkage, resulting in microleakage.[12] Thus, there is a growing trend among practitioners to use bulk-fill resin based composite materials because of their more simplified procedures.[13] Manufacturers mentioned that the main advancement of bulk-fill composite materials was the increased depth of cure, which probably results from higher translucency,[14] and low polymerization shrinkage stress which was related to modifications in the filler content and/or organic matrix with the help of advanced technology.[15]

There are several methods to detect microleakage; one of these methods is the organic dye method which will be chosen for this study because of its extensive use in the literature and its ease of use.[16]

Therefore, different placement techniques that are used in reducing microleakage will be tested in the current study to evaluate their effects on the microleakage level at the gingival cavity margins of class II composite restorations using Bulk-Fill composite resin restorations

2. Aim of the study

The aim of this in‑vitro study is to evaluate the microleakage at the gingival seat of class II cavities prepared at 1mm.distance above the cement enamel junction(CEJ) restored composite restoration using different placement techniques.

3. The objectives:

1- To evaluate the microleakage at the gingival seat of class II cavities composite packed with bulk placement technique.

2- To evaluate the microleakage at the gingival seat of class II cavities composite packed with different incremental placement techniques:

- Horizontal placement technique

- Vertical placement technique.

- Oblique placement technique.

3- To compare the microleakage at the gingival seat of class II cavities composite packed with different placement techniques.

4. Materials and Methods

One type of commercial Bulk -Fill light –cure composite resin material in combination with a single type of total-etch adhesive system will be used in the study.

1. Samples selection:

Forty intact, recently extracted sound non-carious, unrestored permanent human premolars extracted for therapeutic reasons will be collected to use in this study. The teeth will be examined by magnifying lenses to ensure that they will be free of any major or minor defects.

2. Specimen Preparation:

Eighty class II cavities with parallel walls, rounded internal angles and a cervical margins established at one mm. above the cemetoenamel junction

(CEJ) with no bevels placed at the cavosurface margins will be prepared on mesial aspect mesioocclusal (MO)and distal aspect distoocclusal (DO) of each tooth.

3. Specimens Grouping:

The forty prepared premolars will be randomly divided into four equal groups according to the methods of composite placement techniques. Each group will consist of 10 teeth with a total of 20 cavities (n=20) for each techniques.

The experimental groups will be as following:

Group 1: Consisted of 10 teeth with a total number of 20 cavities (n=20) in which the composite will be placed using Bulk placement technique.

Group 2: Consisted of 10 teeth with a total of 20 cavities (n=20) in which the composite will be packed using Horizontal layering Technique.

Group 3: Consisted of 10 teeth with a total of 20 cavities (n=20) in which the composite will be packed with oblique layering technique.

Group 4: Consisted of 10 teeth with a total of 20 cavities (n=20) in which the composite will be packed with Vertical layering Technique.

4. Restorative and curing Procedures:

After tooth preparation, the cavities will be thoroughly rinsed with an air/water spray. The cavities will be blotted or dried with a cotton pellet to avoid tooth not desiccated.

A metal matrix band will be adopted and hold in place using tofflemire matrix retainer. A dental probe will be used to place marks on the outer surface of the matrix, allowing a height control of the subsequently placed increments.

A total- etch bonding system will be used and applied to all the cavities to reduce variability in results that might have occurred. The bonding agent will be applied to the prepared surfaces according to the manufacturer's instructions using a disposable applicator tip and light cured for twenty seconds with a light curing unit.

For group 1 specimens which will be considered as a control group, the composite resin will be packed in a single increment of about 4mm to 5mm in the boxes of all specimens and will be cured for 40 seconds according to manufacturer's instructions.

For group 2 specimens, the composite resin will be packed in horizontal increments of about 2mm. each increment in the boxes of all the specimens and each increment will be cured for 40 seconds according to manufacturer's instructions.

For group 3 specimens, the composite resin will be packed in oblique or wedge- shaped increments in the boxes of all specimens. The thickness of each increment will be about 2 mm. and each increment will be cured for 40 seconds according to manufacturer's instructions.

For group 4 specimens, the composite resin will be packed in vertical increments of about 2mm. each increment in the boxes of all specimens and each increment will be cured for 40 seconds according to manufacturer's instructions.

5. Finishing and Polishing:

All restorations will be exposed to finishing and polishing procedure to eliminate any excess material especially in the cervical region and to promote a smooth surface.

6. Thermal Cycling:

After 24hours storing in tap water at room temperature, the samples will be thermocycled to simulate clinical thermal stress condition.

7. Microleakage testing:

The samples will be prepared for the dye penetration test by coating unrestored tooth parts with a water-proof varnish (nail polish) 1mm close to the restoration margin. Teeth will be immersed in dye solution for 2hours at room temperature. After that the specimens will be washed, dried and sectioned longitudinally through the restorations. The extent of dye penetration along the restoration margin will be detected visually by using stereomicroscope. The degree of marginal leakage will be assessed according to the dye penetration score which is:

0- No dye penetration

1- Dye penetration extending to 1/3rd of the cervical wall

2- Dye penetration extending to 2/3rd of the cervical wall

3- Dye penetration into whole of the cervical wall.

4- Dye penetration into the cervical wall and axial walls toward the pulp.

8. Statistical analysis:

The results of the study will be tabulated and statistical analysis.

All data will be collected and statistically analyzed by Statistical Package for Social Science version 20.0 (SPSS Inc., Chicago IL). Statistical significance will be judged at the 5% level. Qualitative data of microleakage scores will be described using mean, median, number, and percent. Data will be analyzed using Kruskall-Wallis test, followed by Mann Whitney test for pair wise comparison between different testing groups.

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تأثير تقنيات التنسيب المركب الراتنجي على التسريب الجزئي في الاسطح العلوية اللثوية للتحضيرات تجويف الفئة الثانية

(دراسة معملية)

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ملخص

الأهداف: الغرض من إجراء هذه الدراسة هوفحص التسرب المجهري عند الحافة اللثوية للتجويف من الفئة 2 الذي تم إعداده 1مم فوق اتصال السمنتم مع المينا والذي تم حشوه بالكومبوزت المليء كليا باستخدام طرق مختلفة.

المواد والطرق المستعملة: تم جمع 40 سن ضاحك سليمة من أسنان خلعت لغرض التقويم. جميع الأسنان حفرت بتجويف موحد المواصفات من الفئة 2 (متظمنا سطح الإطباق والسطح القاصي والسطح القريب) بحيث كانت الحافة اللثوية 1مم فوق اتصال السمنتم مع المينا. تم توزيع الأسنان على 4 مجموعات كل مجموعة تحتوي على 10 أسنان (20 تجويف في كل مجموعة) وفقا للطريقة المستعملة في تعبئة التجويف. المجموعة 1: الطريقة الكلية، المجموعة 2: الطريقة الطبقية الأفقية، المجموعة 3: الطريقة الطبقية على شكل وتد، المجموعة 4: الطريقة الطبقية العمودية. جميع العينات تم تخزينها في صبغة الفوشين لمدة 24 ساعة وبعد ذلك تم قطعها بشكل طولي من الجهة القاصية إلى الجهة القريبة وفحصها بالمجهر. البيانات التي جمعت تم تحليلها إحصائيا. تم اختيار عينتين من كل مجموعة بشكل عشوائي لفحصها بالمجهر الالكتروني لرؤية ما إذا كان هناك فراغات أو عدم انتظام

عند منطقة التقاء الكومبوزت مع سطح السن. الفحص المجهري الالكتروني تم إجراؤه عند الحافة اللثوية للحشو باستخدام تكبير بمعدل 1000.

النتائج: 80 حشوة أظهرت أن التسرب المجهري شائع في جميع الطرق المستخدمة، فقط أقل من ربع العينات (23.8٪) لم يظهر بها تسرب مجهري. نصف العينات حدث بها أعلى مستوى تسرب (معدل 4) بينما 12.5٪ من العينات حدث بها تسرب بمستوى منخفض (معدل 1، 2). اختبار فشر اكزاكت أوضح عدم وجود فارق ذو أهمية في التسرب المجهري بين الحشوات باستعمال الطرق المختلفة في الحشو (ب=0.565) ولكن مجموعة الطريقة الكلية كان بها أقل معدل لعدم التسرب (15٪)، بينما مجموعة الطريقة الأفقية كان بها أعلى معدل (35٪)، تليها مجموعة الطريقة العمودية (25٪)، ثم مجموعة الطريقة المائلة (20٪). عند استعمال اختبار مان وتني، لم يكن هناك أي فرق ذو أهمية بين الحشوات في الجهة القاصية والجهة القريبة. أيضا اختبار كروسكال واليز لم يبين أي فرق إحصائي ذو أهمية في نعدل التسرب المجهري بين المجموعات (ب=0.610)، ولكن لوحظ أن مجموعة الطريقة الكلية كان بها أعلى متوسط حسابي ووسيط لمعدل التسرب (3.0+ − 1.451، 4) وباقي المجموعات كان بها أقل معدل.

الاستنتاج: لم يكن بالامكان التخلص من التسرب المجهري بشكل كامل باستعمال أي من طرق الحشو في هذه الدراسة حتى باستعمال الكومبوزت الجديد كلي التعبئة. الطريقة الطبقية الأفقية أظهرت أفضل النتائج بالنسبة لاحكام التسرب باستعمال الكومبوزت كلي التعبئة.

الكلمات الدالة: التسرب المجهري، تجويف من الفئة 2، الكومبوزت كلي التعبئة، طرق وضع الكومبوزت

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كلية طب وجراحة الفم والاسنان

جامعة بنغازي

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