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DENTAL COMPOSITE

A project submitted to the department of Dentistry , Babylon University in partial fulfillment of the requirements for Degree of Bachelor in Dental Surgery (B.D.S)

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بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ.

(هُوَ الَّذِيَ أَنزَلَ عَلَيْكَ الْكِتَابَ مِنْهُ آيَاتٌ مُّحْكَمَاتٌ هُنَّ أُمُّ

الْكِتَابِ وَأُخَرُ مُتَشَابِهَاتٌ فَأَمَّا الَّذِينَ في قُلُوبِهِمْ زَيْغٌ فَيَتَّبِعُونَ

مَا تَشَابَهَ مِنْهُ ابْتِغَاء الْفِتْنَةِ وَابْتِغَاء تَأْوِيلِهِ وَمَا يَعْلَمُ تَأْوِيلَهُ إِلاَّ

اللّهُ وَالرَّاسِخُونَ فِي الْعِلْمِ يَقُولُونَ آمَنَّا بِهِ كُلٌّ منْ عِندِ رَبِّنَا

وَمَا يَذَّكَّرُ إِلا أُوْلُوا الألْبَابِ)

صدق الله ﷻ العظيم

الشكر والاهداء

اول من يُشكر ويْحمد اناء الليل واطراف النهار وهو الوهاب الذي اغرقنا بنعمه التي لا تُحصى واغدق علينا برزقة الذي لا يفنى وانار دروبنا وعلمنا مالم نكن نعلم وحثنا على طلب العلم أينما وجد ووفقنا والهمنا الصبر على المشاق لانجاز هذا العمل المتواضع فله جزيل الحمد والثناء العظيم

والشكر موصول الى كل معلم افادنا بعلمه منذ اولى المراحل الدراسية حتى هذه اللحظة

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واخيراً نشكر من ساندنا بالصلاة والدعاء وسهر الليالي لاجلنا وشاركنا لحظات الحزن والفرح وعلمنا ان الدنيا ساحة كفاح سلاحها العلم والمعرفة وكل من مد لنا يد العون من قريب او بعيد

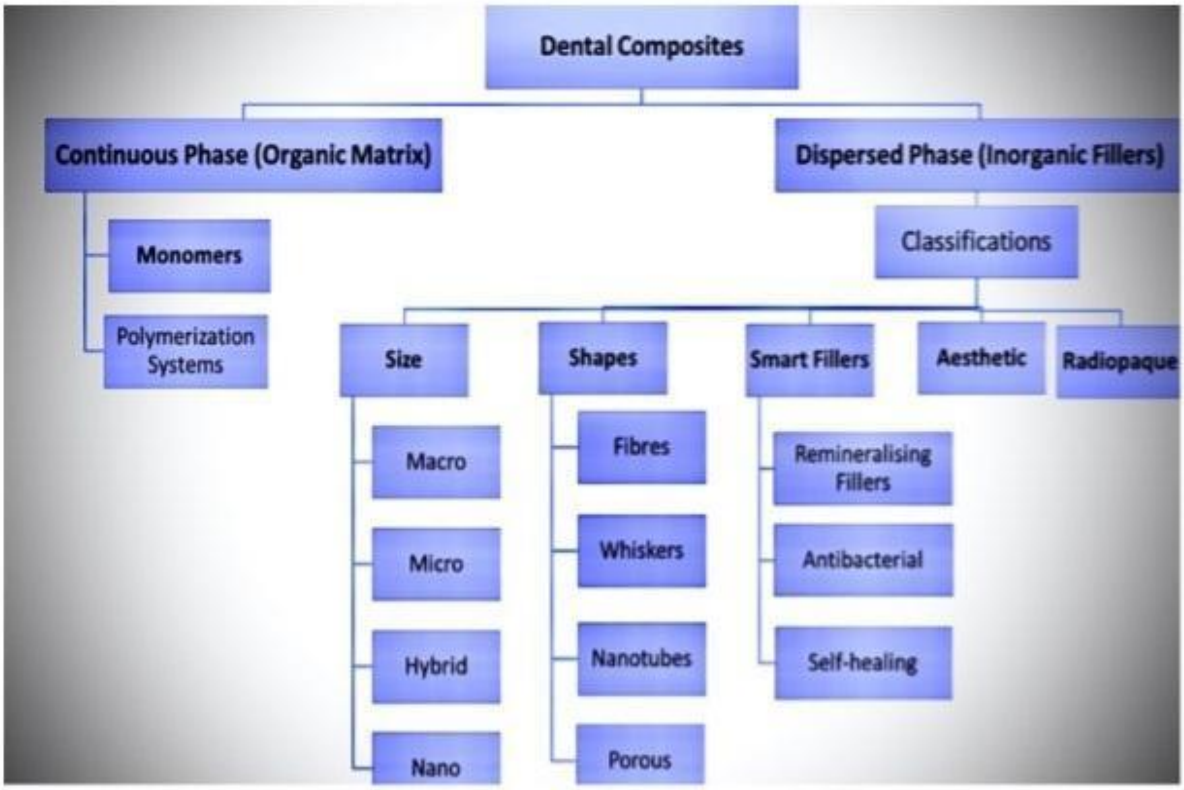
لا يسعنا الا أن ندعو الله عزّ و جل أن يُحسن الى كل من احسن الينا

Introduction:

Skinners (1991) defined composite as a compound of two or more distinctly different materials with properties that are superior or intermediate to those of the individual constituents [1,2]. The first composite filling, invented in the 1960s, gave way to a more alternative option for those looking for a filling. Compared to the traditional resin and silicate t be matched, ’options of the time,composite fillings had improved durability that couldn teeth[3].Composite filling materials have allowing people to overcome their issues with their superior aesthetic properties over silver amalgam restorations and Composites have recently emerged as the best viable replacement for amalgam as a direct restorative material[4,5] s teeth, the use of composites is more conservative to ’Because match the colour of a patient the tooth structure due to its adhesive system [5], With improved adhesion, appearance, and polishing[3], Resin reinforced with silica / porcelain particle constitute these composite operative sensitivity further leading to low protection due to -resin[6]. Micro leakage and post discoloration, tensile pressure and scrapped area van be considered to be imposing flaws of these materials.These composite resin contribute to multifarious success of modern [7]. biomaterial research[8]. Certain properties of inorganic filler of composite resin that comprises of rigidity, strength and hardness and that of organic resin matrix include subsequent polymerization for rapid setting, sufficient fluidity for easy application. A silane coupling agent bonds the filler and matrix together[9]. In order to directly bond the composite resin filler to dentine / enamel a separate binding agent is used[10]. Although amalgams have to twenty years after placement compared to shown outstanding clinical performance for up other types of direct tooth filling materials [11]. However, owing to the toxicity of mercury which makes up about 50% of the total composition[12].The first composite was created by s mouth. While ’mixing two pastes together, resulting in a quicker hardening time in the patient improvements to the mixture were made overtime, composite fillings were made to become more comfortable to work with and efficient in their hardening time through the use of special Since last 50 years, these composite resins have been used in clinical dentistry. as [3] .lights it restores biological tissue not only in appearance but also in function[13]. Although the current restorative composites have superior mechanical and physical properties compared to classic composites[14,15], they have an average duration of just under ten years[16]. The common causes of clinical failure are recurrent caries and restorative bulk fracture. According least 5% of these restorations were analyses of resin composite restorations, at-to meta anticipated to experience bulk fracture during 10 years,while 12% will exhibit significant wear[17(a,b,c,d)].stresses resulting from the polymerisation shrinkage, high surface affinity water sorption and solubility. However, the most -to bacterial biofilm formation, high significant enhancements and changes have been in the fillers such as size reduction, shape ..enhancement (platelike, rods, nanoparticles), and bioactive ability.

Composition of dental composites:

Graphical summary of the general composition of dental resin composite with different :types of fillers added



(Fig 1 : phase of composite and classification)

Composition of composite (filler):

The main composition of composite is the inorganic filler,Fillers play a pivotal role in the performance of composite resins.which gives rigidity, hardness and strength to the filling, and for easy application of the an organic resin matrix, which provides sufficient fluidity composite , and allows polymerisation for rapid setting of the composite resin . Slica is commonly used as a filler in dental composite restorations. Four types of silica fillers nonporous silica particles, mesoporous silica particles, silica gels with micropores, and fumed) :silica particles) have been used . Here are some advantages and disadvantages

Advantages:

1: Improved Mechanical Properties: Silica fillers can significantly enhance the mechanical strength of composites, providing better wear resistance and durability.

2: Aesthetics: Silica particles are capable of mimicking the refractive index of natura teeth, leading to improved aesthetic results.

3: Thermal Expansion: The thermal expansion coefficient of silica fillers is relatively similar to that of tooth structure, reducing the risk of leakage and secondary caries due to thermal cycling.

4: Reduced Polymerization Shrinkage: By adding silica fillers, the polymerization shrinkage of the resin matrix is reduced, which can minimize gap formation between the restoration and tooth structure.

5: Radiopacity: Silica can be modified to enhance radiopacity, allowing the dental restoration to be distinguishable from tooth structure in X-rays.

Disadvantages:

1: Handling Properties: High filler content can lead to a stiffer composite material which might be more difficult to manipulate and shape during placement.

2: Wear of Dental Tools: Silica particles can be abrasive and may cause increase wear on dental burs and instruments.

3: Water Absorption: Some silica-filled composites might absorb more water, which could potentially lead to hydrolytic degradation over time.

4: Polymerization Stress: Although reduced, polymerization shrinkage still occur and can lead to stress at the bond interface, potentially causing microleakageandpostoperativesensitivity.

The balance between these pros and cons often determines the specific applicationofsilica-filledcompositesindentalrestorations

category Filler	**Type**	**Influence on properties of dental composites**
Filler size	–	The size of the filler influences its refractive index and degree of light scattering in the which ‘matrix phase can alter dental .composite and depth of Cure.
	Large filler size	Poor wear resistance due to crack propagation at the filler/ resin interface, and loss of filler particles, resulting in poor polishability, as well as early discolouration and staining due to .roughness
	Reduced filler size	Filler size reduction reduces particle projection at the surface which improves wear resistance. Furthermore, increases matrix viscosity and limits the total polymerisation which adversely affects the mechanical .properties
	Fibres	sized electrospun -Nano fibres found to improve composite properties such as flexural .strength, and modulus
Filler Shapes	Whiskers	Silicon nitride whiskers

		better compared to the silicon carbide whiskers (in strength and toughness, hardness and modulus of dental .(resin composite
	Nanotubes	Silanated carbon nanotubes enhanced the flexural strength of the composite resin by 23% affected and adversely the optical properties .due to their dark colour
	Porous fillers	Composite resins enforced by porous fillers showed better wear resistance filled -Mesoporous silica composites demonstrated superior transparency, higher glass transition temperature, and adhesive increased strength than conventional silica .fillers
	Bioactive glass	BRP composites showed improved mechanical properties as well as water sorption and solubility compared to typical .based composites-BAG
Smart multifunctional) fillers	Calcium phosphate	recharged to maintain a .continual ion release Ca3(PO4)2 results in a reduction in the strength

		.of the composite The flexural strength was twice higher in the filler mixture compared to the composite contained Ca3(PO4)2 filler only Cap enhances the material's water sorption Composites with crystalline calcium phosphate have lower translucency and aesthetics due to the difficulty in manipulating their refractive indices A new Ca3(PO4)2 inhibition in bacterial biofilm and did not show any effect
	Hydroxyapatite	assist in the remineralisation HA whisker (HW) and showed nanofibres superior reinforcing properties compared to .particulate HA
	Zinc oxide particles	bacterial growth while maintaining strength reduced depth of cure due to the opacity of .ZnO

healing fillers-Self		Adding Heavy atoms such as BaSO4, TIO2, or ZrO2 as opacifying .components
Radiopaque fillers		A1203, ZrO2, TiO2 and modify the translucency .of dental composites

Macro filled composite:

the othername conventional or tradi-tional composites.Traditional resin composites included Concise and Adaptic .Fillers made of inorganic particles larger than 1µm These particles were introduced to theBisGMA/TEGDMA .The addition of these fillers resulted in asignificant enhancement inproperties when comparedto unfilledacrylicmaterials[18].However,due to the large filler size any drawbacks were reported such as poor wear resistancedue to crack propagation. the fillers most commonly used in this type of composite Ground quartz,strontium,or heavy metal glasses containin gbarium[19,20].

Micro filled resin composites:

The name was not precise as it was to express the fact of the microscopical size of the particles, as the size of the amorphous spherical silica was around 40 nm.introduced to overcome the macro filled disadvantages and to comply with the aesthetic needs for polishable filled resin composites, they have also been shown to have -composites .Compared tomacro lower fracture resistance, stiffness, and fatigue strength compared with heavily filled duced larger in size to improve the -polymerised fillers (PPRF) intro-pre ،.[23-composites [21 isation shrinkage and improves polish ability-filler volume fraction also decreases the polymer when compared to conventionally filled resin composites [24,25]. However, PPRF lack the active binding sites for surface coupling which results in reduced bonding to the resin matrix .[26,27] and consequently compromised mechanical properties.

Hybrid resin composites:

µm, as well as 50–The first introduced contained large filler particles, of a size of 10 colloidal silica of particle size of 40 nm.introduced to solve the mechanical and the shrinkage and -lems, also finishing problems, of macro filled composites [59].consist of both micro-prob fillers and share the characteristics of them both.ideal for use as universal composites -nano filled However, they do not have the final finish and -due to combine the advantages of macro filled resin composites [28,29]. Fillers come in a wide range of -translucency of micro chemical compositions[30] Conventional dental fillers are usually spherical, irregular reinforced polymers -granules or particles and can detach from the resin matrix [31] Fibre composites have widespread applications . The superior properties of fibre reinforced polymers composite prompted their use in dental composites. Fibres have a relatively high aspect ratio and flexible. Nanotubes are slightly different from fibres as they too have a high aspect ratio but possess hollow centres giving them a tubular shape. Whiskers have the lowest aspect ratios within fibrous fillers and are generally rigid [32,33,34] Although fibrous fillers enhance mechanical properties of the matrix, they produced inferior aesthetics due to the .mismatch in the refractive index

Fibers:

Fibres are elongated homogeneous materials having a transverse cross sectional. with an aspect ratio that is often more than or equal to 100. when the aspect ratio of the fibres might be less than 100 there are several situations such as short fibres, chopped fibres, whiskers, or s type, length, ’staple fibres. The mechanical characteristics influenced by the fiber orientation, and volume percentage [35]. Glass fibres are the most common fibres used in dental composites and share the same refractive index and chemical composition with sillica.Glass fibers show high mechanical properties and excellent bonding compared to other types of fibres [35,36]. the mechanical characteristics of short glass fibre resin composite structures made as temporary dental crowns and bridges. discovered that these structures had higher flexural strength and compressive load bearing capacity than those made of temporary crowns and bridges. When fibres were incorporated in low weight spun fibres were found to -sized electro-nano ‹with spheroidal silica fillers (%5–1)fractions sized-improve composite properties such as flexural strength, and modulus, unlike micron The most used glass fibres in dentistry are E-glass and S-glass such in Vectris Pontic and FiberKor [36].. S-glass is more expensive and has a shorter lifespan than E-glass, and it also has higher tensile strength and elastic modulus compared to E-glass.

Nanotubes:

Nanotubes are hollow fibrous fillers with a high aspect ratio. There are several chemical compositions of nanotubes such as Kaolinite nanotubes [37], and carbon nanotubes were the nanotube surface most widely explored [33]. Salinized methacrylate groups on the carbon enhanced the flexural strength of the composite resin. TiO2 nanotubes displayed several impressive qualities such as a increase in the surface area. Alkaline hydrothermal synthesis is often used to produce TiO2 nanotubes (TNTs) [39] and adding TNTs as fillers to flowable .strength and the elastic modulus ’dental composite improved the composites

Porous filler :

Porous fillers are a more stable form of micromechanical interlocking with the resin matrix. porous fillers may be infiltrated by liquid resin to strengthen the bonding between the matrix and the fillers and increase the mechanical characteristics of dental resin composites. composite resins enforced by porous fillers showed better wear resistance due to the strong mechanical bond between the resin and the fillers which prevent the filler detachment. -micro porous and mesoporous -the filler loading of composites may be enhanced by combining nano silica, the mechanical characteristics remained unsatisfactory. Inadequate infiltration of the resin matrix into the filler porosity results in poor mechanical properties especially flexural strength compared to the conventional silica filled composites. The issue of resin penetration assisted mixing of porous fillers -was addressed using two ways. The first featured vacuum .and resin [40], while the second required adding solvents to lower resin viscosity facilitate

Whiskers:

-A whisker is a single crystal in the form of a fiber. Whiskers can be considered as a sub group of fibers possessing shorter lengths compared to conventional fibers.whiskers used in dental composites to enhance flexural strength and fracture toughness of composites. Various µm 200–whiskers with a diameter ranging from 5 nm to 1 µm and length in the range of 10 have been used. The inclusion of silicon nitride whiskers showed better strength and toughness of dental resin composite compared to the silicon carbide whiskers, Silicon carbide whiskers. With the improvement in the mechanical properties they still lack the ability to prevent secondary caries. The nano DCPA whisker composites had double the strength compared to .the conventional calcium and phosphate releasing composites

Smart (multifunctional) fillers:

Smart fillers are those having the capacity to produce a change in their characteristics in a regulated behaviour when they are exposed to external stimuli such as Mechanical Stress pH,moisture fluctuations,temperature electric or magnetic fields In dental composites, this ، property was utilized to react against the following sections different types of smart fillers healing activity filler -well be discussed such as remineralising filler antibacterial filler self the fillers in dental composites is to raise their mechanical and physical properties, however, these fillers did not give to the bioactivity of the composites and prohibition recurrent caries [41].recurrent caries correlated to dental caries that affects the area adjacent to dental -tion failure [42]. Acidic by -restoration and is one of the major causes of composite restora products from bacteria is the major cause of dental decay [43,44]. S. mutans are cariogenic bacteria that are cause dental decay they attach to tooth surfaces and restorations and develop a biofilm. Oral biofilm is responsible for causing dental caries [45], gingivitis and periodontitis, and candidosis [46]. Oral biofilm functionally and structurally organized polymicrobial communities that are embedded in an extracellular matrix of exopolymers on dental surfaces [45]. The extracellular polymeric substances such as polysaccharides, proteins, nucleic acids, and lipids, these kept biofilms integrity .Dental composites tend to retain a lot of biofilm thickness than glass ionomers and amalgams [47]. This could be due to the ionomer and amalgams. some studies reported that -cariostatic ions released from glass which could be adversely ،bacterial growth was increased with composite restorations affecting the ecosystem of the dental plaque biofilm [48,49]. to control oral biofilm formation caries composites were developed with antibacterial and -and prevent secondary caries , Anti remineralising activities Antibacterial composites were developed by mixing resin matrix and bacterial particles such as BAG, metal/metal -bacterial particles . Many types of anti-anti mineralising activities Bioactive glass -oxide, and polymer nanoparticles *Fillers with re has several meanings, a substance that develops a connection ”bioactive“(BAG). the word with a tissue [50] and advertise the creation of hydroxyapatite (HA) when it meets physiological fluids [51,50]. In restorative dentistry, a material may be bioactive if it dissolve microbial activity (including the increase in pH) [50]. -or leach components that have anti BAG is an biomaterial use for restoration of both soft and hard tissues and has been added to gap penetration by dental composites for different purposes such as minimising the marginal bacteria, dentin remineralisation, and bacterial acid neutralisation. It has also been tested for applications in restorative dentistry such as adhesives, pulp capping, and implants [51,50] .L. Hench produced the first BAG in 1969, Bioglass 45S5, It consists of a blend 46.1 mol% SiO_2, mol% CaO, 24.4 mol% Na_2O, and 2.6 mol % P_2O_5 [51]. The antibacterial properties of 26.9 BAG are mostly owing to its alkaline pH and osmotic qualities, which are induced by the presence of silica, salt, and calcium ions in glass [53]. When dental composites containing BAGs are Subject to a moist environment, their mechanical properties can be compromised phobic resin matrix due to their hydrophilicity resulting -as BAGs tend to cluster in the hydro like -in swelling and cracking [41] . To solve this problem, amphiphilic bioactive raspberry porated into dental composites as -composite particles (BRP) were synthesised, and incor fillers [32,52]. The BRP was based on two active components: a hydrophobic polymer -trix) and a hydrophilic bioactive component to enhance mineral pre -component (resin ma based -cipitation within the composite. The BRP composites outperformed typical BAG composites in terms of mechanical properties as well as water sorption and solubility Additionally, a dense layer of minerals was observed when BRP composite was applied on a. eralised dentin, compared to a few micro particles were found with composites -demin containing BAG. The rich mineral layer was caused by the ion released from the BRP [54]. Because sodium in BAG is hydrophilic which reduce strength of the composite and reduce its mechanical properties , focus on change its composition have been made. As a result, most Mg^{2+}, ، −BAG fillers are now low in sodium [55]. In addition to that , ion change such as F Zn^{2+}, and Sr^{2+} are frequently replaced with sodium. A recent study compared the acid neutralizing ability of a novel low sodium, fluoride containing BAG experimental composite with the conventional 45S5 composition, after being immersed in hydrochloric acid and lactic h immersion and showed comparable results to the -acid of pH 2.6 and 4.5 respectively over 1 conventional BAG without lowering the degree of conversion caused by the decreased resin The novel bioactive composites containing 40 wt% of BG .mobility related to the filler size fillers after 28 days of PBS immersion showed the ability to form fluorapatite in the calcium phosphate precipitated on the composite surface, unlike conventional BAG composite [56]. modified BG may -In comparison to the precipitate generated by standard BAG, fluoride .provide a more stable marginal gap repair

.Calcium phosphate (CaP):

−Calcium phosphate particles (Ca3(PO4)2) have been reported to release Ca2+ and PO34 dental caries involving remineralization in an acidic environment ions as a method to inhibit [57,58].filled amorphous Ca3(PO4)2 -In addition to the ability to remineralize, nanoparticle to maintain continuous ion release, −nanoparticles can also be charged with Ca2+ and PO34 which is considered a beneficial property that contributes to Maintains its properties and thus improves its properties in the long term. Terminological ability to prevent tooth decay [57,58]. Amorphous Ca3(PO4)2 is known for its water solubility, making it easier to release ions into the oral cavity compared to other forms of Ca3(PO4)2. Since it is metastable and can was added as a stabilizer during −spontaneously transform into hydroxyapatite (HA), P2O47 Ca3(PO4)2 filler is low, resulting the synthesis [59,60]. However, the mechanical strength of in reduced strength of the composite. This can be solved by adding auxiliary fillers with Ca3(PO4)2 fillers, such as nanosilica fused silicon carbide whiskers and dimethyl tetrachloroterephthalate (DCPA) nanoparticles [61,62}.The flexural strength of the filler mixture was two times higher compared to the composite containing only Ca3(PO4)2 filler. Furthermore, the ion release is equal to or slightly exceeds that of Ca3(PO4)2 filled composites. Another disadvantage of CaP is that it increases the water absorption of the material, thereby accelerating the degradation of the resin matrix, resulting in a significant deterioration of the mechanical properties of the composite [62]. In order to maintain ion release without affecting the mechanical properties of the material, an optimal amount of Ca3(PO4)2 filler addition was used. Furthermore, crystalline calcium phosphate composites exhibit lower translucency and aesthetics due to difficulty in controlling the refractive index [57].A novel Ca3(PO4)2 nanocomposite with antibacterial activity and rechargeability was synthesized by adding dimethylaminohexanediyl methacrylate (DMAHDM) to sodium cyclopentadienide (NACP). This novel composite exhibits an inhibitory effect on bacterial Although .−biofilms and has no effect on the release and replenishment of Ca2+ and PO34 the mechanical properties tested did not change significantly in comparison control group [57].caries filling -This innovative rechargeable CaP composite shows promise as an anti .term remineralization and antimicrobial properties-material with long

Hydroxyapatite:

As a common bioactive material, hydroxyapatite (HA) with the chemical formula Ca10(PO4)3OH has the potential for application in biomaterials, especially in dental implants and bone replacement materials [63, 64, 65]. In principle, HA could be a promising bioactive filler for dental resin composites since it is the main biological component of dentin and enamel and provides optimal radiopacity and mechanical strength to hard tissues [66]. Additionally, in dental restorations, adjacent collagen can be remineralized, potentially sealing small gaps between dental composites and natural tooth tissue, thereby reducing the risk of The mechanical properties, biological properties and stability .[67] recurrent caries over time of dental composites are affected by the shape and size of the HA particles [66,65]. Particulate HA was initially used as a filler in dental resin composites; however, it did not exhibit HA filled resin composites are -sufficient strength properties. On the other hand, pure nano inefficient in practical applications, which is related to their significant water solubility and insufficient mechanical properties. However, to overcome this drawback, a mixture of microparticles and nanoparticles HA was used to improve the overall filler loading and mechanical properties .Recently, innovative dental fillers, such as HA whiskers (HAW) and added to hybrid mixtures with nanofibers, have shown improved reinforcing properties when conventional silica particles, Among them, the flexural strength, flexural modulus and compressive strength were improved by 36.1%, 61% and 50.1% respectively compared with the material filled only with HAW [65]. However, since these high aspect ratio fillers (whether matrix interface properties, they tend to -silane treated or not) have unfavorable filler agglomerate in the resin matrix, resulting in poor filler distribution and composites with lower fillers with loose Internal structure, without bones, which impairs strength than agglomerated stress transfer and leads to the formation of weak points, leading to failure and ultimately like hyaluronic acid (UHA) was -reduced mechanical properties [63]. A unique sea urchin recently synthesized using microwave irradiation and used as a dental filler with silica nanoparticles. It exhibits high flexural strength, elastic modulus and compressive strength But its main disadvantage is that the refractive index does not match the matrix, resulting .[63] .in a lower degree of conversion and a smaller depth of hardening

Fillers with antimicrobial activities:

Zinc oxide (ZnO):

The electronic band structure of ZnO comprises a valence band and a conduction band. Upon exposure to ultraviolet or a visible light, the electrons in the valence band absorb energy and of holes (positively transfer to the conduction band. This jump results in the development charged) in the valence band and free electrons in the conduction band (negatively charged) resulting in the semiconducting ability of ZnO. The positive holes in the valence band oxidise H2O2 resulting in the formation of HO. The electrons in the conduction band on the other hand, can reduce O2 to form a series of intermediates such as O2 HO2 H2O2, and HO. These are known as reactive oxygen species (ROS) which play a significant role in ZnO antibacterial findings revealed that the addition of zinc oxide nanoparticles activity . In a recent study the to matrices, successfully inhibited bacterial growth while the compressive strength of (%5–0) the group that included 1% ZnO nanoparticles was significantly greater than that of the unmodified control group. However, the opacity of zinc oxide resulted in a drastically reduced curing depth as the fraction of ZnO nanoparticles increases, both flexural and compressive SiO2 nanoparticles by coating ZnO particles with -strength decrease Chen developed ZnO@m mesoporous SiO2 .An improved interfacial bonding between the matrix and fillers in relation to the mesoporous structure of these particles was reported which resulted in improved compressive strength (32.5%), flexural strength (121.2%), and modulus (67.1%) of dental SiO2 compared to the control filler with SiO2. -resins composites comprising 7 wt% ZnO@m An effective antibacterial rate of more than 99.9% was reported with no major changes in –shaped SiO2-other properties of the composite. Similar results were obtained when regular drying technology were used. The overall -ZnO complex clusters (CCs) synthesised by spray ZnO CCs were further improved, and the –performances of composites containing SiO2 composites filled with 70 wt% Si66Zn4 exhibited greater antibacterial ability (antibacterial ratio >99.9%) and satisfactory depth of cure, degree of conversion, and biocompatibility Because of the antibacterial effect and satisfactory properties of ZnO, it proved to be an . could be used in dental composites as secondary fillers in effective antibacterial filler that .minimal amount

Polymer nanoparticles:

The introduction of polymerisable antibacterial monomer particles into a dental composite -was used to overcome the porosity and poor mechanical properties by introducing un leachable antimicrobial age. When the antibacterial monomer is copolymerized with the resin, it prevents the bacterial growth on the composite surface during contact .Methacryloyloxydo decyl pyrimidinium bromide (MDBP) has received the most attention among antibacterial quaternary ammonium (QA) compounds and because of the colour instability of MDBP, it is often used for repairs when appearance is not a factor. For the first time in 2012, ionic dimethacrylates (IDMAs) were registered and suggested to be used in dental applications s antibacterial activity was ’GMA/TEGDMA matrices, IDMA-When integrated into Bis. similar to that of MDBP .One of the disadvantages of immobilisation of polymerisable agents, .bacteria is in contact with the surface is their action is limited only when the

Anti-microbial treated fillers:

Traditionally, nanoparticles are coated with phenols or antibiotics to improve their performance .which prompted the coating of antibiotics to readily penetrate the bacterial cell membrane, exerting a strong and sustained inhibitory impact on bacterial growth. This procedure significantly minimises the likelihood of antibiotic resistance and systemic toxicity. coated copper nanoparticles used as -A study investigated the anticariogenic efficacy of drug an antibacterial filler in a light cures resin composite .Which demonstrated that the experimental material had a greater antibacterial impact in the contact test when compared to the control groups. Additionally, the material demonstrated a persistent release of antimicrobial particles for up to 28 days. Furthermore, the material demonstrated enhanced .hardness when the coated fillers fraction was increased

ceramic-Piezoelectric bio:

charge when subjected to mechanical stress .This A piezoelectric material generates an electric material category has been effectively used in a variety of biomedical applications, including bone regeneration, tissue engineering, and drug delivery, however, in the field of dentistry, the use of piezoelectric materials is still in its infancy. Some piezoelectric materials can maintain electrical charges for over 12 million mechanical loading/unloading cycles, equating (BaTiO3) to a little more than two decades of clinical operation .Piezoelectric barium titanate nanoparticles demonstrated a considerable decrease in bacterial growth of up to 90% in the groups containing 10% piezoelectric fillers exposed to cyclic ’experimental dental composites point bending at 2 Hz (~40 MPa) and a stress ratio of R = 0.1.41 The stress -loading of 3 amplitude (σa) was set to 2 MPa, which is 25% of the endurance limit (6.5 MPa). The test was working in concert for 6 days conducted for ~1 M cycles, resembling the magnitude of stress range available in clinical settings .Furthermore, a significant production of rich and heavy layers of calcium phosphate minerals in mechanically stimulated for up to 7 days in and 30% vol) ،20 ،10)-piezoelectric groups. Moreover, the antibacterial activity of BAG Sodium Potassium Niobate (NKN) composites against S. aureus and E. coli bacterial cells .C◦was enhanced on poled composite samples at 20 kV for 30 min at 500

This combination of both antibacterial and remineralising activity of piezoelectric materials restoration by resisting pathogenic bacterial species and is ideal to enhance composite developing a new mineral layer at restoration margins for long periods .However, despite the advantages that could be gained from the piezoelectric fillers as they offer longstanding drug resistance, and lack of ion release -therapeutic results without affecting the bacterial which could enhance the biocompatibility, however, their effect should only impact the pathogenic species and -pathogenic bacteria where some investigations indicated that non .mammalian cells might be negatively affected leading to inflammatory reactions

Radiopaque fillers:

The radiopacity of composite fillings is an important property to help dentists detect and diagnose recurrent caries or the presence of any defect in the restoration.In dental composites, the radiopacity is directly proportional to composition, thickness, and materials density.[68,69].The radiopacity is influenced by the type and amount of filler used, with materials like Clearfil Majesty Posterior and Arabesk Top being among the most radiopaque composites1.Additionally, the composition of fillers significantly affects the ability of composite resins to absorb X-ray radiation. Several types of elements with heavy atoms are added as opacifying components such as $BaSO4$, $La2O3$, or $ZrO2$, where these atoms can enhance the radiopacity by absorbing and then scattering the X-ray[68,70].It’s important to note that while radiopacity is a key factor, other properties of the materials should also be considered for clinical use.Objects with high atomic numbers show as white in the x-ray while low atomic number objects show as a black shadow. However, excessively adding radiopacifying fillers in the dental composite can adversely affect the translucency of the material and affect the mechanical properties [69,71,72]..Amirouche investigated the radiopacity of materials by comparing the effect of different types of radiopacifying ceramic fillers namely BaO,$BaSO4$, $La2O3$, $ZrO2$, and SrO, their loading, and the composition of monomer. [69]The radiopacity of pure resin matrix was low compared to enamel and like dentin since it is composed entirely of organic components with low atomic numbers. While radiopacity levels somewhat higher than enamel was attained with $ZrO2$ starting at 30 wt%.A recent study in which a unique radiopaque filler structure was created and called Core-shell structured $SiO2$–$ZrO2$–$SiO2$ (SZS) microspheres[73]. These fillers were added to the composite in different ratios as secondary fillers and resulted in a great improvement of the radiopacity at 20% SZS with 52% silica which exceeded the radiopacity of the enamel as well as showed lower shrinkage and enhanced mechanical properties compared to the composites filled with monodispersed silica microspheres [73].

Aesthetic fillers:

Dental resin composites with the ideal translucency should resemble human enamel. Certain oxides, such as $ZrO2$, $TiO2$, and $Al2O3$, can be used to modify the translucency of dental composites. The opacity and size of materials is affected by the difference in refractive indices between the opacifying agent (such as ceramic fillers) and the resin matrix. $ZrO2$ absorbs minimal incident light and backscatters most of the incident light which makes $ZrO2$ translucent, like tooth dentine. Additionally, $ZrO2$ also has outstanding biocompatibility physical and mechanical properties making it a widespread an excellent choice in the field of dental materials [74–76]. Another important aesthetic property is fluorescence [77]which occurs when an object is exposed to light and after 10-8 s, it spontaneously produces a longer-wavelength light. Both dentin and enamel exhibit this phenomenon, with dentin exhibiting a stronger fluorescence owing to its structure’s higher collagen content. The fluorescence of dental materials can be defined by the colour difference during and after the exposure to UV light [78],and it can be measured using spectrophotometer. Certain dental composites lack this feature, resulting in a colour match with the teeth during the day, however, a mismatch under UV light. Some rare earth oxides can be used to overcome this mismatch such as ($Eu2O3$, $Tb4O7$, $Dy2O3$), in addition to quantum dots and fluorescence whitening agents [78].

Opalescence is another phenomenon that can affect the aesthetics of composite resin. This is caused by the light scattering, which occurs due to the variation in the refractive indices of both the resin matrix and fillers. It results in a blue object in the reflected light but orange/brown in transmitted light . By adjusting the refractive index and adding ceramic fillers such as $ZrO2$, $Al2O3$, and $TiO2$, the opalescence of the dental resin composite can be obtained [179,180]. This can be achieved by several methods such as, adding organic groups to the silica filler resulting in an inorganic-organic hybrid filler, increasing monomer to filler ratio, or reducing the particles size (100 nm in diameter) to achieve the appropriate level of opalescence [77]

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