ANTERIOR RESTORATIONS

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Resin Composites

- Resin is used for an anterior restoration due to is esthetics. The shade can be matched as best as possible; unlike amalgam restorations
- Resin composites consists of:
  - *Polymer matrix, filler particles, coupling agent, and initiator*

  - Matrix = everything else is added to the matrix to give resin its properties. The matrix can help reduce shrinkage which is important
  - Filler = coated with silane which is a coupling agent, to promote adhesion to the matrix. The filler needs a coupling agent because without it, its not strong at all.
  - Initiator = activates the polymerization reaction of the resin

  The curing light is needed to activate the resin in most cases or a dual system; using a chemical reaction

Mechanical

- Two important mechanical properties of any resin system are its tensile strength and stiffness.
- After a cure period of seven days at room temperature it can be seen that a typical epoxy will have higher properties than a typical polyester and vinyl ester for both strength and stiffness. The beneficial effect of a post cure at 80°C for five hours can also be seen.

- Also of importance to the composite designer and builder is the amount of shrinkage that occurs in a resin during and following its cure period. *Shrinkage is due to the resin molecules rearranging and re-orientating themselves in the liquid and semi-gelled phase.* Polyester and vinyl esters require considerable molecular rearrangement to reach their cured state and can show shrinkage of up to 8%.
- The different nature of the epoxy reaction, however, leads to very little rearrangement and with no volatile by-products being evolved, **typical shrinkage of an epoxy is reduced to around 2%.** The absence of shrinkage is, in part, responsible for the improved mechanical properties of epoxies over polyester, as shrinkage is associated with built-in stresses that can weaken the material. Furthermore, shrinkage through the thickness of a laminate leads to 'print-through' of the pattern of the reinforcing fibres, a cosmetic defect that is difficult and expensive to eliminate.

Remember

- Composite resin must be applied in increments at a time to avoid more shrinkage. Depending on the textbook you read – increments are typically 2-3mm at the most each time.

Wear Resistance

- Generally composites show excellent fatigue resistance when compared with most metals. However, since fatigue failure tends to result from the gradual accumulation of small amounts of damage, the fatigue behaviour of any composite will be influenced by the toughness of the resin, its resistance to micro cracking, and the quantity of voids and other defects, which occur during manufacture.
- As a result, epoxy based laminates tend to show very good fatigue resistance when compared with both polyester and vinyl ester, this being one of the main reasons for their use in aircraft structures.

Physical Characteristics

- An important characteristic is the surface area of the filler particles. The smaller the particle size, the larger the surface area. For example, a cube of filler material with dimensions of 2 x 2 µm would have a surface area of 24 μm^2. By cutting the cube into two halves, the surface area would increase by 8 μm^2, giving a surface area of 32 μm^2.
- The surface area of filler particles is usually given in square metres per gram (m^2/g). The surface area of submicron-sized fumed silica that is incorporated in small amounts into most composites is very high about 130 m^2/g. The surface area measured for filler particles for a number of commercial composites ranged from 4.4 to 65.6 m^2/g.
- Shrinkage can occur up to 7% and this must be reduced as much as possible to retain the composite material. Marginal gaps may also result in microleakage
  - *Increments, enamel bevels, flexible resin liners and slow setting resin-modified glass ionomers have all been recommended to help reduce shrinkage.*
  - Resins have a coefficient thermal expansion 2-6 times higher than the tooth structure. Minimal stress areas (such as anterior teeth) can have less shrinkage

Fillers

- In order to achieve a higher filler loading, a wide distribution of filler particle size must be present.
- In most cases, the filler weight percentage is given, which is unfortunately not as valuable as filler volume percentage, since it is the volume of exposed resin matrix to abrasion and the volume of matrix resin that has to polymerize that are important. It is obvious that a heavier (denser) filler would occupy less volume for a given weight of filler.
- For the same filler loading by weight, for example, if filler "A" had a density of 2 g/cc and filler "B" had a density of 3 g/cc, then the less dense filler "A" would occupy almost 50% more volume than filler "B". Thus, simply quoting the filler loading by weight percentage can be misleading. The filler content by volume does in fact characterize composite materials quite well.

Classifications Review

- Conventional – Macrofilled, do not polish well, wears away quickly, not good for posterior restorations where more stress is given
- Packable – could be a hybrid type
- Flowable – viscosity very low, meaning the risk of porosities inside the restoration increases. Could be a hybrid type.

- (Hybrids have better esthetics)

TYPES

1. Macrofilled

- These were the first type of resin composite marketed in the 1960's for filling front teeth. As the name implies, the particles in a macrofill are fairly large. Crystalline quartz was ground into a fine powder containing particles 1 to 50 microns (µM) in diameter. (A micrometer, also called a micron, is a millionth of a meter, or a thousandth of a millimeter. An average grain of salt is about 60 microns.) The 1µM size is critical, since particles larger than this are visible to the naked eye. Particles 1µM and larger are called macro particles, while those smaller than 1µM are called micro particles
- *The acrylic matrix in a composite tends to shrink on setting.* Excessive shrinkage in a filling material is undesirable because it would either leave a gap between the tooth surface and the filling material, or, if well bonded, would cause cracks in the tooth structure as the filling contracts during setting.
- The inclusion of the glass particles reduces these problems because they reduce the volume of acrylic, and act as a mechanical "skeletal structure" within the composite to help maintain the original volume of the filling when it sets. The advantage of large particle size is that large numbers of particles can be incorporated into the paste without making it too stiff to manipulate. *Macrofills are 70% to 80% glass by weight, 60% to 65% by volume.*
- Due to large particle size, macrofills are not very polishable. As a result, they feel rough and are prone to accumulation of plaque and stain. The relatively soft acrylic polymer tends to wear below the level of the glass particles, which constantly pop out of the surface leaving holes in their place. This leads to a surface which, on a microscopic level, looks like a series of craters interspersed with boulders. This type of surface is prone to staining.
- But wear is the major disadvantage of macrofilled composites. The constant loss of the glass particles exposes more and more of the soft plastic matrix to the abrasive forces encountered in the mouth, and the restoration slowly wears away over time. =

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- However, the large particle size has one major advantage over small particle size. You can pack them more tightly into the resin matrix without the paste becoming too thick for the dentist to handle. This becomes more difficult to accomplish with small particle size = More glass in the mixture reduces setting shrinkage.
- A composite restoration wears exclusively because the glass particles are slowly dislodged from the surface leaving more of the soft resin matrix exposed to wear factors. If there were a way to keep the particles in place forever, the restoration would never wear down.
- The tendency for large glass particles to dislodge from the surface of macrofilled restorations makes them unsuitable for posterior restorations, since the occlusal (top) surfaces of the back teeth receive a lot of abrasive challenges. Any filling that wears excessively would allow the bite to change, and the teeth will move over time. In persons who brux (grind their teeth), this could cause a collapsed bite and TMJ issues.
- The first macrofills appeared on the market in the mid 1960's. Most older dentists affectionately remember them by their brand names, Adaptic and Concise. They also appeared radiolucent in radiographs making them difficult to determine if the area was decayed.

2. Hybrids

- Hybrids contain a range of particle sizes. First formulated in the 1980's, they include about 75% conventional size particles (1-3 micron) and about 8% sub micron size (.02-.04micron)
- They do not retain a high polish for long, due to the tendency of the largest particles to pop out of the surface, but they retain their easy working characteristics due to the high percentage of larger particle sizes. They are also much more resistant to wear than the older macros because of the smaller size of the particles overall, and because of the presence of the submicron particles, which are more difficult to dislodge than the larger particles. Also, they can be filled to a much higher density with glass particles than those composites containing only micro sized particles.
- The larger particles are necessary to keep the consistency of the paste from becoming too stiff, while the relatively small percentage of sub micron size particles take up the space between the larger particles. The highest particle density attained with hybrids is 90% by weight. Because of the high particle density, hybrids were the first composites that were promoted for posterior use, and they remain one of the most wear resistant posterior composite types on the market.

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- Regarding consistency, the great majority of microhybrid composite resins present medium viscosity; however, some other types of composite resins can be classified as high-viscosity ("packable" composites) or low-viscosity ("flowable" composites)
- High-viscosity composite resins (also known as "condensable" or "heavy-body"), possess a greater amount of load (above of 80% in volume), which makes them more resistant and easier to apply because of their excellent sculpt ability. The use of these composite resins is especially indicated for the reestablishment of the contour and proximal contacts in class 2 restorations and for the precise definition of occlusal anatomy features.

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- On the other hand, flowable composite resins present much less load (about 50% in volume), possess inferior mechanical properties, and present a greater degree of polymerization shrinkage.
- Recent studies have demonstrated that the use of flowable composites does not improve the marginal sealing of adhesive restorations; however, its use is indicated in areas of difficult access and irregular cavity preparations because it favors the insertion and adaptation of the subsequent increments.

3. Microhybrids (Nanofilled)

- MicroHybrids were the next step in hybrid evolution. They use up to three distinct particle sizes for more efficiency, and a much smaller size range of larger particles (0.6 -0.7 microns) than the older hybrids . The microhybrids achieve greater polish ability but suffer from lower particle density due to the small size of the largest particles in the mix.
- They also achieve superior color optics by using uniformly cut small filler particles between the larger particles, as well as resin hardeners which help to maintain a surface polish during prolonged function. Microhybrids also have unique color reflecting characteristics which gives them a chameleon-like appearance. Their working characteristics are about as good as the hybrids, and their superior esthetics make them especially useful for anterior restorations. Unlike the hybrids, **microhybrids are not generally recommended for posterior fillings** owing to their lower particle density. However, strong enough for rebuilding incisal edges on anterior teeth, and a few, such as Herculite XRV are even marketed for posterior use. Their particle size and esthetic qualities make them especially attractive for any anterior restoration.
- In dentistry, microfillers are particles that are smaller than 1 micron, while nanofillers are particles that are smaller than 0.1 micron. In reality, most of the older microfilled composites use particles that vary between .04 and .2 micron, while nanofilled composites are those that contain filler particles no larger than 0.1 micron (more generally .04-.05 micron).
- Thus nanofilled composites are technically just a category of microfilled composites. The smallest nano particles are in a form called a colloidal silica, which is produced by burning silica compounds such as $SiCl_4$ in an oxygen atmosphere to form spherical macromolecular structures which fall into this size range.

Lets Talk Flowable

- Older flowable composites are formulated with a range of particle sizes between 1 and 2 microns. The amount of filler is reduced (in the range of 50% by weight) and the amount of unfilled resin matrix material is increased. Newer brands are essentially "dilute" forms of nanofilled and nanohybrid composites at varying filler density to keep the mix flowable. Some brands contain Al-Fl-Si glass particles and release fluoride to the adjacent tooth structure. They are delivered into a cavity **using a syringe.**
- Flowable composites, as their name implies, flow freely over the inside surface of the cavity preparation. This material has made it possible to fill small cavities on occlusal surfaces (the tops of teeth) without a shot since the area of decay is often small enough to be removed with little or no sensation in the tooth, and the **flowable composite will bond even if there are no undercuts in the cavity preparation**. Flowable composites are often used to seal the dentin of a tooth prior to placing the filling material. Due to the low level of filler particles, flowable composites are more prone to shrinkage and wear, so they are generally not used in bulk to fill large cavities.
- They can also be used UNDER large preps as the composite used first (light cured or not light cured) and additional composite added on top as a sandwich technique. The flowable is used first to get into all little areas that may be hard to access with the additional resin.

Bad Contraction

- What happens with polymerization:
- Open margins and/or white lines around margins
- Debonding and open margins
- Enamel cracking, especially when using strong bonding agents and acid etching techniques
- Cuspal deflection, especially in well bonded restorations
- Marginal staining
- Secondary caries, especially in patients using a lot of sugar
- Note that microleakage is less dependent on the degree of shrinkage than on the effectiveness of the bonding technique. Studies show that the degree of microleakage varied from bonding agent to bonding agent, but not the composite restorative used.

Sensitivity Post-Op

- This is due both to cuspal deflection and the tendency of the composite to shrink toward the light source resulting in the composite debonding form the pulpal floor. This often leads to a small space into which water may enter, either by way of leakage, or by drawing fluid from the open dentinal tubules. This micro layer of water between the pulpal floor and the restoration accounts for much of the **temperature and pressure sensitivity** a patient may experience after a large cavity is bulk filled with composite.
- **This is one of the major reasons that glass ionomer is often used as a base under composite restorations.** Glass ionomer is much less prone to polymerization shrinkage than composite, and bonds quite well to the floor and walls of a cavity preparation.

Composite restorative	Type	Shrinkage %
Filtek LS	Nanohybrid	0.9
Reflexions XLS	Nanohybrid	1.5
Grandio	Nanohybrid	1.6
Kalore	Nanohybrid	1.8
Estelite Sigma Quick	Nanohybrid	1.9
Heliomolar	Microfil	1.9
Tetric EvoCream	Nanohybrid	1.9
Venus Diamond	Nanohybrid	2.1
Filtek Supreme Plus	Nanohybrid	2.4
N'Durance	Nanohybrid	2.4
Herculite Ultra	Nanohybrid	2.8
Esthet X HD	Nanohybrid	2.8

Flowable composite	Shrinkage %
Surefil SDR Flow	3.0
Clearfill Magesty Flow	3.1
Grandio Flow	3.1
Filtek Supreme Plus Flow	3.8
N'Durance Dimer Flow	4.1
Tetric EvoFlo	4.3
Gradia Direct Flo	4.4
Aeliteflo LV	4.8
Fusio	6.0

Restorative	Type	Stress (MPa)
Aelite LS Posterior	Hybrid	1.7
Durafill VS	Microfill	1.2
Esthet-x	Nanohybrid	2.6
Filtek Supreme Plus	Nanohybrid	2.5
Gradia Direct Posterior	Microfill	1.5
Grandio	Nanohybrid	2.4
Heliomolar	Microfill	0.7
Heliomolar HB	Microfill	1.7
Herculite XRV	Microhybrid	3.2
Heraeus Venus	Nanohybrid	2.5
Z100	Hybrid	2.1

Curing

- Depth of cure is extremely important to most dentists since it affects the length of time it takes to finish a large restoration. It also affects the long term properties of the restoration since all mechanical and thermal properties are degraded when the composite fails to reach a minimum of 80% of ideal cure hardness.
- The opacity of the filler particles
- The density of the filler particles
- The shade of the composite, darker shades having less depth of cure than lighter shades
- According to Clinicians Report March 2010, Vol 3, Issue 3, the depth of cure of the latest crop of micro and nano composites varies widely, between 1.9 mm and 4 mm.

Working Time

- You want a composite that is not too *sticky*. They want a composite that sticks to the tooth, but not their instruments! If the composite is too sticky, it is difficult to be sure that it will not pull away from the walls or floor of the cavity preparation when the packing instrument is removed.
- They want a composite restorative that flows easily enough to form a shaped bulk fairly easily, especially on anterior teeth, but does not *slump* too much.
- They want a composite with the maximum *depth of cure*. Using a composite based on other criteria may soon discover that the length of time it takes to place them is too great because of the number of increments they need to use, especially for darker or more opaque shades.
- The best composites for these qualities are probably the macrofills followed (in approximate order) by the hybrids, the microhybrids and the nanohybrids. Nanofills (also called microfills) tend to be too sticky and also slump more than the others.

Wear Resistance

- When it comes to wear resistance, the only things that really matter are the density of the filler particles, and the size of the particles. The more densely packed, the less the wear, and the smaller the particle size, the better.
- Hybrids do exceptionally well on density but less well on particle size. The more recently developed ones resist wear quite well because they are highly filled. These are still some of the most wear-resistant composites on the market.
- Microfills do better on particle size but less well on density of particles. They generally exhibit poor working characteristics and shallow depth of cure, but they have the best wear characteristics compared to any of the other categories.
- Nanohybrids, the newest addition to the composite pantheon (75% to 82% filled by weight, containing agglomerated nanofil particles interspersed with micro and nano sized individual particles). They have good working characteristics, and wear resistance nearly as good as the microfills. They also cure to a greater depth than the agglomerated nanofils and are less prone to fracture in unsupported areas.
- From the point of view of occlusal wear, amalgam beats all composites hands down. In a clean mouth with minimal sugar exposure, a well placed (posterior) amalgam can last 20 or 30 years showing minimal wear. In the same mouth, even the most wear resistant composite placed carefully may wear considerably within 5 to 10 years, especially if the patient bruxes or habitually eats very abrasive foods.

Glass Ionomer Restorations

- Not used in areas where esthetics is a concern
- Resin-modified glass ionomers greatly improve the appearance if the glass ionomer is the best option for a patient with xerostomia or an area where caries is high risk

Class 3 and 4 Restorations

- Remember that the prep doesn't need to go beyond the decay when using a composite restoration. The bonding materials used will help bond efficiently.
- True enamel is the most esthetic, do if the prep DOESN'T need to extend to the buccal or facial surface (coming from the lingual) it shouldn't
- Class 4 Restorations – usually involve injury. Class 4 restorations are an extension onto the class 3.
- PINS = will hopefully not be needed (to add strength) because they can darken the tooth and make it appear less esthetic. If pins are needed, perhaps a crown or another option is best to protect the appearance.

Placement Technique

- Myriad restorative techniques have been developed to avoid the limitation of depth of cure, reduce the effects of polymerization shrinkage, improve the marginal adaptation and seal, enhance esthetic results, and provide the clinician with maximum benefit for their application.
- Several of the incremental stratification techniques include: horizontal, vertical oblique, centripetal, three-sited light-cure, and centripetal build-up. These various methods are recommended according to the type and dimension of the cavity preparation.
- While it is commonly accepted that segmentally filling the preparation generates the least pull on the buccal and lingual cusps, not all literature agrees.:

Try This: (Continued)

- 1. A low-shrinkage hybrid resin system should be selected that has dentin and enamel shades. This modified placement technique uses one continuous increment (ie, hot dog shaped) that is placed and adapted in an oblique layer with a curved metal instrument (TINL-R, Brasseler® USA, Savannah, GA) against the cavity wall.
- 2. The increment is cured through the cusp, and the original cavity floor becomes part of the cavity walls. This process reduces the ratio of cavity volume to the area of the cavity walls, which results in a substantial reduction in the marginal contraction gap.
- 3. A second elongated increment is adapted in the same oblique manner against the opposing cavity wall and light-cured through the cusp. For small- to medium-size occlusal and proximal cavity preparations, the internal dentin core requires two incremental placements.
- 4. A final enamel layer is filled all the way to the occlusal margins. Any residual composite material is removed with a burnisher (PKT-3A, Brasseler® USA).
- 5. The composite condenser is pressed against the occlusal surface. Employing finger pressure, the instrument is used to trace the entire margin of the preparation. Such a technique not only eliminates all residual composite extended beyond the preparation, but it also fills in any region that may have been under filled.
- 6. Upon completion, the same burnishing instrument can be used to develop the central fissure, buccal, and lingual developmental grooves, and the incline planes.
- 7. After light-curing, the rubber dam is removed and the occlusion is evaluated in centric, protrusive, and lateral excursions.

Continued

- This same duo-shade placement technique can also be used in direct anterior composite restorations. However, the magnitude of the shrinkage stresses generated from polymerization shrinkage is less for most anterior composite restorations because the ratio of bonded to unbonded surfaces is generally less for these restorations.
- Therefore, using stratification techniques to minimize the effects of shrinkage stress is a minor clinical consideration. The authors prefer to use a long-bladed interproximal carver for placement and adaptation, and a sable brush to smooth the surface. A curved metal instrument (such as the TINL-R) can be used to shape the lingual surfaces of anterior restorations.
- For Class III and IV composite resin restorations, an opacious dentin increment is placed as the internal core and a second enamel layer encapsulates this core.
- For the Class V, this same placement procedure can be used with a translucent or opacious dentin core, depending on the color of the substrate. Note: for deeper cervical restorations, placement of the dentin core in two sequential increments allows for an overall stress reduction by allowing more yielding of the free surface of the restoration to the underlying contracting bulk.
- Placing the occlusal dentin segment with higher bond strength to enamel first and then the gingival segment may reduce the potential for micro gapping at the gingival margin.

Finishing and Polishing

- Defined by surface morphology of the tooth and restoration, the successful finishing and polishing of any composite restoration are determined by the type of restorative material used and the shape of the finishing device.
- Thus, the surface quality of the composite is not only influenced by the polishing instruments and polishing pastes, but also by the composition and the filler characteristics of the composite. Newer formulations of small particle hybrids and microhybrids have altered filler components with finer filler size, shape, and orientation and concentration.
- These improved physical and mechanical characteristics allow the resin composite to be polished to a higher degree. The variation in hardness between the inorganic filler and the matrix can result in surface roughness as these two components do not abrade uniformly. Accordingly, because the gloss can influence color perception and shade matching of the restoration and tooth surface, it is imperative that the surface gloss between the restorative material and tooth interface be similar.

Continued

- Restorative materials of the past (ie, amalgam, gold) required finishing and polishing procedures to refine anatomical morphology, contours, marginal integrity, and occlusion while enhancing the surface smoothness of the restoration.
- The objectives of finishing and polishing techniques of tooth-colored adhesive restorations are the same today. However, the development of adhesive materials has introduced a new element to the restorative equation: esthetics. An optimally finished esthetic adhesive restoration should provide a smooth surface that will prevent plaque accumulation and resist stain. It should also possess ideal contours and emergence profile for improved tissue compatibility.
- Additional benefits of a proper finish are anatomical form for occlusal harmony, shade coordination to surrounding dentition, symmetrical surface texture to adjacent or opposing natural teeth, improved marginal adaptation and integrity, and longevity. Aside from the actual finishing and polishing, the final challenge for the operator is long-term restorative maintenance of the surface polish.
- An understanding by the patient and clinician of the importance of periodic and routine maintenance of composite restorations and the use of proper finishing devices, polishing techniques, and protective surface glazes at the maintenance visit may provide the benefit of increased restoration longevity.

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- **Finishing** focuses on contouring, adjusting, shaping, and smoothing the restoration; **polishing** concentrates on producing a smooth surface luster and highly light-reflective surface.
- The consideration factors for finishing and polishing any restoration depend on the instrument shape, the surface shape and texture of the tooth and restoration, the surfaces of the finishing and polishing instruments, and the sequence and amount of time allotted for the restorative treatment.

Steps

- Minimize finishing procedures through careful preoperative occlusal registration and composite shaping before curing. At least one study revealed that a reduction in finishing results in less damage to the composite and improved wear and clinical performance.
- Select finishing and polishing devices that have shapes corresponding to the anatomical contours of the restored tooth.
- Finishing diamonds may demonstrate resin matrix crazing and significant filler particle loss for hybrids, affecting the wear resistance of posterior hybrid composite resin restorations.
- High-speed finishing with multifluted carbide burs for a hybrid composite resin produces a smooth, flat, and undisrupted surface free from striations and grooves left by diamond burs.
- Wet finishing with diamonds is more appropriate for microfilled composites; carbide finishing burs are contraindicated for microfills.
- The use of a surface sealant has been shown to reduce the wear rate of posterior composite resins, improve resistance to interfacial staining, and decrease microleakage around composite resin restorations.
- Place composite surface sealant and cure before polishing with silicone points because silicone surface contamination may prevent adhesion of the sealant.

Resources

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