General Introduction

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1.1 Dental Resin Composites

Like all composite materials, dental resin composites are composed of several distinct elements including an organic matrix, an inorganic filler, and a silane coupling agent. They contain several other constituents include initiators, inhibitors, and pigments. Initially they were developed to replace silicate cements and unfilled methyl methacrylate resins for restoring anterior teeth.

Dental composites materials bond to tooth structure, are relatively stable, are very aesthetic with acceptable clinical performance in an oral environment making them well-suited for restoring teeth.

The early composites were two paste chemically cured products containing a BisGMA resin matrix with macrofilled fillers of quartz, borosilicate or glass particles of up to 100 μm in diameter [1].

Over the next three decades dental composites went through several modifications including changes to filler size; resin modifications; and curing methods resulting in materials with better handling properties making them suitable for restoring both anterior and posterior teeth.

Figure 1.1 Evolution of composites since the 1970s.

Despite these improvements polymerization shrinkage continued to be a major clinical challenge, especially when they were used in larger posterior restorations. This shrinkage is reduced when restoring anterior tooth as the outline of the cavities

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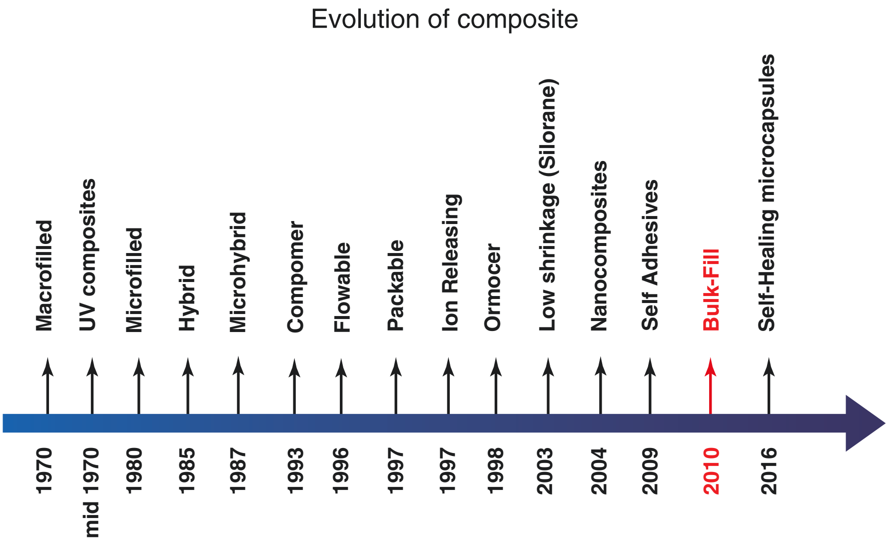

Fig. 1.1 Timeline of the development of major resin composites subgroups or categories

allows for better dissipation of the stresses along with incremental filling of the cavity. Furthermore, anterior cavities tend to be smaller than cavities in the posterior dentition.

Up to recently dental amalgam was the material of choice for posterior restorations.

Amalgam has been a very successful restorative material for decades notwithstanding the fact that it is unesthetic and inherently toxic. Using resin composite to restore posterior teeth is more complex than using amalgam.

With the endorsement of the Minamata Treaty in 2013 by several countries it became more urgent to address the reluctance by many clinicians to use resin composite posteriorly [2].

As more and more posterior teeth were restored or repaired with resin composites [3], research continued into the development of more suitable composite materials for posterior restorations. Various filler particles were added to improve the physical and mechanical properties of the material. These modifications did improve some properties of the material, however, polymerization shrinkage continued to be a major drawback, especially in cavities with multiple walls. Incremental placement of small quantities of the composite filling material posteriorly was recommended to dissipate the shrinkage. This technique was considered by some to be clinically difficult and to be more time consuming than when restoring with an amalgam material.

1.2 Cavity Design for Posterior Composite Restorations

Over the decades, dentists have used GV Black classification for cavities with the principle of extension for prevention concept. With the continuous evolution in dentistry and the introduction of new materials and techniques this classification of cavity preparations has been revisited several times.

A new cavity classification was published in 1998 in response to adhesive restorations by Mount and Hume [4]. This emphasized the principle of minimum extension. An FDI review of minimal intervention was published in 2000 [5]. Further publications in 2001 [6], 2002 [7], and 2003 [8] lead eventually in 2006 to a publication which introduced the SiSta classification of cavity design [9]. These publications emphasized that the main principle of restoring was to remove as little tooth material as possible. Only the caries part of the tooth required removal, leading to a minimal preparation.

Applying these principles when restoring posterior teeth with resin composite, the extent of the caries lesion will dictate the size of the cavity and not the physical properties of the material. No longer would the operator be required to cut a standard cavity design when restoring with a resin composite [10]. A minimal cavity preparation (Fig. 1.2) may leave unsupported enamel at the cavo-surface margin, at the proximal walls and on the cervical floor. This unsupported enamel need not be removed with a bur or chisel, making it easier to have a clean and non-bleeding surface to bond to, with no loss of healthy enamel (Fig. 1.3). Before restoring an interproximal cavity, the papilla can be protected by pre-wedging which will also assists in the development of a good interproximal contact [11].

The change to the modified cavity preparation is further supported today with a change in the disease process, the aesthetic demands of patients, and the heightened awareness by health care workers to retaining as much tooth structure as possible.

New clinical skills have been introduced into many undergraduate dental education programmes. Recent graduates are more experienced in placing resin composite in posterior teeth [12, 13].

Fig. 1.2 Minimally invasive cavities

Fig. 1.3 Residual unsupported cervical enamel in the proximal box

1.3 Composite Placement

Liners/bases are not usually required for most posterior composite restorations as their use may prevent the bond of the adhesive resin to dentine. There is evidence that there is no difference in outcome in terms of postoperative sensitivity when a posterior resin composite is placed with or without a lining material [14]. Placement of a liner for therapeutic purposes should be used when required in areas close to the pulp. If a pulpal exposure occurs, evidence suggests that MTA is superior to calcium hydroxide [15]. Newer products such as Biodentine (Septodont) have potential use in this situation [16–18].

The Cochrane Library stated in a review in 2019 on the use of liners; *that there was inconsistent evidence regarding the difference between resin-based composite restorations placed with liners and those placed without liners when considering postoperative hypersensitivity. Further, there is no evidence of a difference between the use of liners or not regarding restoration failure. Despite the low quality of the evidence, we feel that this evidence is applicable when placing routine composite-based restorations in adult posterior teeth and that placing a liner is an unnecessary step* [19].

The clinician should be aware that stresses produced during polymerization can be a leading cause of adhesive failure, resulting in postoperative sensitivity, marginal staining, and recurrent caries [20]. This polymerization shrinkage can create stresses as high as 13 MPa between the resin composite material and tooth interface exceeding the tensile strength of the enamel often resulting in stress cracking and fracturing of the enamel [21]. When a resin composite is cured, the surrounding tooth structure may deform [22] and deflection can be significant depending on the filling technique used [23]. The higher the intensity of the light source, the greater the contraction force at the composite–tooth interface and so the use of high intensity plasma lights is not recommended. Lower intensities lights improve the marginal integrity of the restoration because it permits dissipation of the polymerization stress [24]. To achieve a clinically successful posterior resin composite restorations, it is vital to maintain the integrity of the bond and the marginal adaptation to tooth enamel and dentin.

The incremental technique is the preferred technique for restoring posterior teeth with composite resin and is recommended to dissipate the forces of shrinkage. The thickness is limited to 2 mm maximum for optimal polymerization and degree of conversion [25]. However, combined with a three-step total etch bonding technique, the restoration of a posterior cavity with resin composite using this technique can take much longer to complete than an equivalent procedure using dental amalgam [26].

Several benefits have already been outlined for using composite resin to restore posterior teeth. Composite materials in posterior teeth have the potential of extended survival of the restored tooth [26]. They support the use of minimum cavity design [27]. When the restoration is bonded to the enamel and dentine, they reinforce the remaining tooth structure requiring no additional retentive features or excessive tooth structure removal [28].

1.4 Bulk Fill Resin Composites

In 2010 a new class of material was introduced [29]. This was classified as bulk fill resin composite and intended to streamline the clinical placement of resin composites by allowing curing of 4–5 mm increments. These materials have enhanced light transmittance and depth of cure compared to conventional resin composites [30, 31]. They are a more translucent material with enhanced curing capability through filler modifications, incorporating high molecular weight monomers, and new alternative photoinitiators [32, 33].

Several currently available bulk fill materials have increased the filler size or have decreased filler content to minimize the scattering of light, thus encouraging light transmittance [34]. Adjustments have been made to the monomers and photoinitiators targeting improved optical properties, reduced polymerization shrinkage, and increased depth of cure [35].

Bulk fill materials are available in several formulations including flowable, full-body, and fibre-reinforced resin. Using self-adhesive bonding systems, the operator can shorten the bonding procedure and at the same time reduce postoperative sensitivity [36, 37]. When restoring posterior teeth with a bulk fill resin material, the total time taken to restore a posterior tooth is similar to that for a dental amalgam restoration [38].

Using bulk fill resin material to a primed tooth surface with less steps results in an enhanced bonded interface. Other clinical advantages include; less chance of contamination of the primed bonding surfaces with saliva or water droplets especially when most dentists do not use rubber dam isolation for placement of restorative materials [39]; in a time of airborne virus transmission, such as COVID-19 it is an advantage to the operator and other members of the health care team to minimize aerosol generation with the application of minimally invasive approach and prompt placement of the restorative material.

With bulk fill materials the resin matrix has been modified with fillers composed of non-agglomerated silica and zirconia particles. They have nanohybrid particles with up to a filler load of 77% by weight. Flowable materials generally have lower filler loading than the non-flowable products.

Fibre-reinforced composites are composite materials with three different components: the matrix (continuous phase), the fibres (dispersed phase), and the zone in between (interphase). FRC materials present high stiffness and strength per weight when compared with other structural materials along with adequate toughness [40].

Other modified bulk fill materials available to the practitioner include a sonically activated bulk fill material (Sonicfill, Kerr). Sonic energy contributes to increased fluidity with better distribution of inorganic particles which might be attributed to the amount and composition of the organic and inorganic matrix of this material [41].

Another modification to bulk fill materials include the use of thermo-viscous technology to heat the application gun which allows easier application of the material into the cavity followed by sculpturing of the resin (VisCalor, Voco).

Bulk fill restorative resins exhibit less polymerization shrinkage stress than conventional micro hybrid composites during and after light curing when used in Class II posterior restoration [42]. Teeth restored using conventional composite materials have significantly higher mean total cuspal movement values compared with teeth using bulk fill resin restorative material [43].

Cavity size and location may determine the choice of bulk fill material. Flowable materials may be suitable for narrow cavities or as a base for endodontic cavities. The lower viscosity materials allow adaptation to less accessible spaces due to plastic flow. Materials with higher filler load should be considered where resistance to wear and fracture are important [44].

It is difficult to compare different bulk fill materials currently available on the market. Research has identified a high variability in testing conditions, specimen dimensions, and curing protocols, combined with inadequate proprietary information concerning the materials' compositions. Instead of evaluating the individual properties of many materials, a comprehensive characterisation of a limited number of selected materials may be more beneficial for gaining insight into the relative strengths and weaknesses of the material [45].

Research does indicate that the use of high viscosity bulk fill results in a shorter clinical time when compared to conventional resins using incremental fill technique with no significant difference between the two groups in terms of postoperative sensitivity [46].

In a recent survey in the department of Restorative and Aesthetic Dentistry in the Lebanese University, the researchers compared the mean time taken by groups of operators with diverse clinical experience (fifth year students, specializing residents and clinical instructors in the restorative department) to restore posterior cavities. It was found that the bulk fill technique required the shortest time in comparison to the time required to perform the conventional layering technique.

The following chapters will update the reader on the current research and clinical techniques to achieve the highest quality posterior composite restorations. It will explore the differences between bulk fill and conventional composites and recommend the best adhesive regime to use with bulk fill resins. A major advantages of bulk fill materials is their depth of cure. It is crucial therefore that the operator understands what is happening within the composite resin when light is applied to the surface. Chapters will explore the various properties of bulk fill resin materials outlining their clinical challenges and recommend the best materials based on the literature/research and clinical experience of the authors. Finally, this book will address possible future developments for bulk fill resin restoratives exploring positive improvements for the clinician.

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