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Posterior Composite Restorations including the Clark Cavity Design and Superior Class II Contacts Using a Novel Matrix System: Part 2

Abstract: In the second part of this series, we describe the use of the Bioclear Method for posterior composite restorations, including modern cavity design and techniques to achieve predictable contacts with Class II restorations.
CPD/Clinical Relevance: This article highlights a clinically relevant and modern method that can be used for placing anterior and posterior direct composite restorations.
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A routine part of general dental practice is the placement of composite restorations in posterior teeth, with hundreds of millions of posterior restorations being undertaken annually in general practice, of which more than 50% involve replacement of failed existing restorations.[1,2] After the Minamata Convention in July 2013, the number of 'white' fillings on posterior teeth has been increasing. In 2015, dentists placed nearly equal numbers of amalgam and composite Class II restorations.[3] The principles of engineering for successful composite resin materials are addressed in this article, along with the concepts of modern cavity design to help reduce tooth fracture, and a modern technique, 'the Spot Weld' to establish predictable contact points. Both of these factors have the potential to influence the success of posterior composite restorations.

Posterior composite resin restorations

Posterior composites are well established, but dentists can nonetheless struggle to produce predictable contact points, which can potentially lead to recurrent caries or periodontal problems.[4–6] This may be due to lack of training or issues with restorative materials.

What we want to achieve from our composite restorations are:

- Comfort for the patient;
- No sensitivity to temperature or pressure when eating or drinking;
- Good interdental contacts, with no food impaction interproximally;
- Good longevity;
- Same colour as teeth (ie not grey);
- Retention of a smooth surface texture;
- Stain resistance.

Amalgam restorations can have very good long-term success rates and the principles for successful posterior amalgam restorations are well established (Figure 1).

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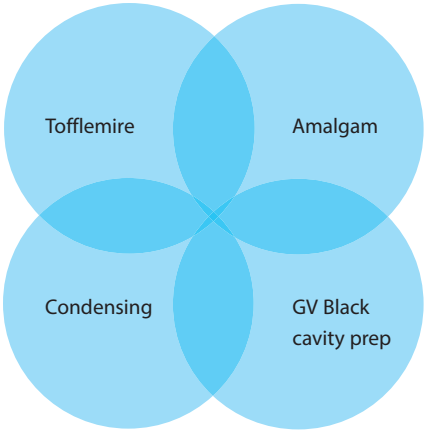

Figure 1. Venn diagram illustrating the balance between GV Black preparation shape, amalgam filling material, method of condensing and use of a Tofflemire matrix (courtesy of Dr David Clark).

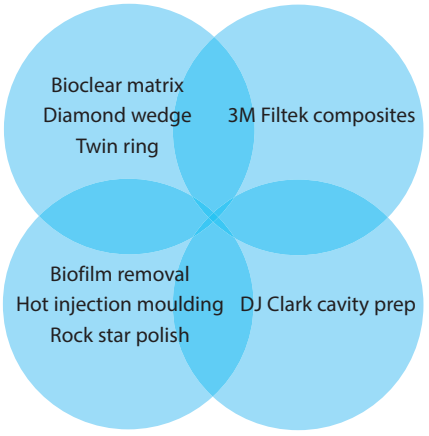

Figure 2. Venn diagram showing the components of the Bioclear Method (courtesy of Dr David Clark).

When composite resin materials were introduced, similar principles were applied that had been used for amalgam restorations. The resultant failures of posterior composite restorations included: wear; tooth and/or restoration fracture; marginal deterioration; staining; secondary caries; post-operative sensitivity; and open contacts.[6,7,9] More modern studies have shown that there can be comparable longevity between composite and amalgam posterior restorations.[6,8,10,11] Operator ability was found to have a profound affect. As clinicians, our aim is to predictably produce composite restorations with superior longevity when compared to amalgam restorations. Therefore, an overview of a modern approach to the procedure of posterior composite restorations is required.

The modern direct composite procedure includes the following aspects:[12]

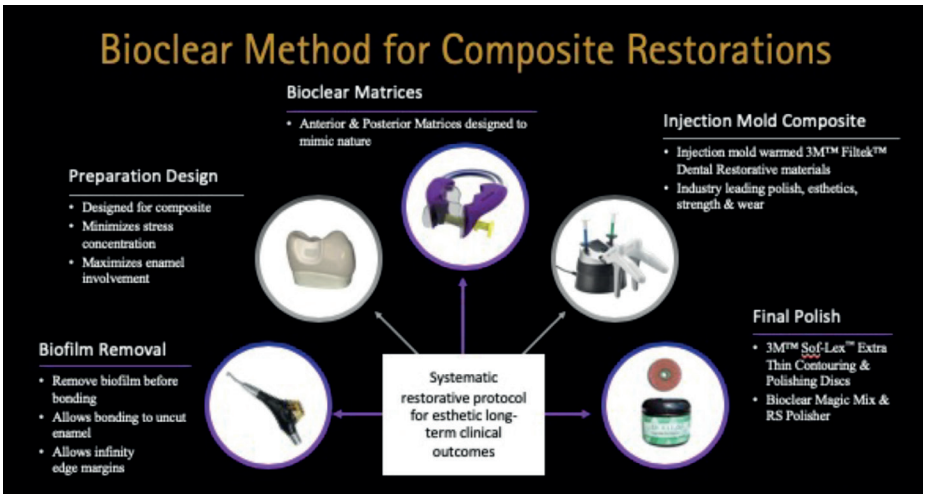

Figure 3. The five pillars of the Bioclear Method (courtesy of 3M and Dr David Clark).

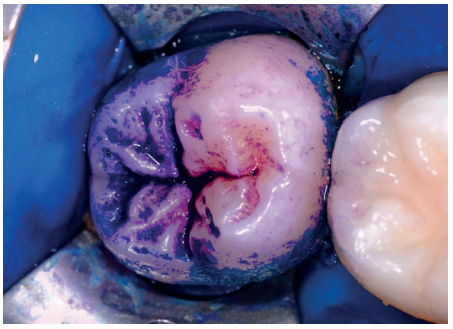

Figure 4. Biofilm on a molar shown after application of two-tone disclosing solution (courtesy of Dr David Clark).

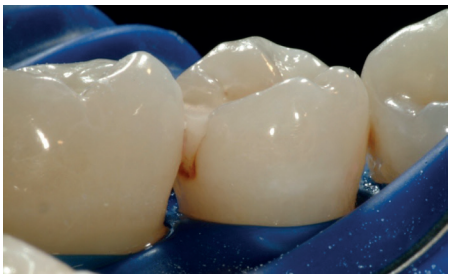

Figure 5. Brown stains where biofilm gathers at traditional cavity margins (courtesy of Dr David Clark).

- Adhesion versus mechanical retention;
- Preparation designs based on engineering principles;
- Joints based on compression rather than tension;
- Biofilm removal and the tooth restoration interface;
- Selective caries retention/modified Hall technique;
- Use of warm injection moulded composite to create monolithic restorations;
- Final surface finish of the rock star polishing system.

The Bioclear Method

The Bioclear Method (Bioclear, Tacoma, WA, USA) combines all aspects of the modern direct composite procedure, including Clark cavity shape, resin composites, warm injection moulding filling technique, and anatomical Bioclear matrices with twin-ring separation (Figure 2).

The five pillars of the Bioclear Method

The principles of the Bioclear Method can be used for all types of restoration, whether it be a Class I/II posterior composite, an anterior Class III/IV restoration, a direct veneer, black triangle restoration, or direct composite overlay. The Bioclear Method was explained in Part 1 of this series as having five key pillars (Figure 3):

- Biofilm removal;
- Modern cavity preparation;
- Anatomical matrices;
- Warm injection moulding of composite;
- Rock star polish.

Biofilm removal

Biofilm removal is essential for posterior teeth. This is especially important for fissures in which biofilm accumulates, and surfaces of the tooth on which the restoration margin will be formed (Figure 3). If the biofilm is not removed, then bonding will be compromised and the composite will be more liable to chip and stain in these areas, resulting in the classic brown lines that may be seen around posterior composite (Figures 4 and 5).

The Biofilm is removed by drying the tooth, disclosing the tooth with two-tone disclosing solution, then physically

removing it with particle abrasion using a combination of aluminium tri-hydroxide, with a particle size of 100 microns, and water at a pressure of 90 PSI.

Modern cavity design

Modern cavity design is an essential step in protecting teeth and helping to prevent tooth fracture. Fractured teeth are related to a third of tooth loss in industrialized nations. A large part of this may be related to traditional cavity design, which may predispose the tooth to fracture (Figure 6).[5,13] Studies demonstrate no difference in fracture rates between amalgam or composite restorations with the same traditional cavity design.[14] Cavity size (especially traditionally designed larger cavity sizes to aid retention) has a strong correlation with the incidence of tooth fracture.[15] Changing cavity tension joints to compression joints may support and protect the tooth. If this is done with a combination of modern cavity design, especially occlusally, and where possible, using additive dentistry, this may reduce the incidence of tooth fracture. This could be especially relevant as 50–71% of restorations worldwide are replacement restorations.[7,15]

Anatomical Bioclear matrices

Anatomical matrices are a key aspect to forming good anatomical contacts with restorations. Contact deficiencies can present as either open contacts (where there is a space between the restoration and the adjacent tooth, especially if the matrix has been burnished to try to match the shape of the adjacent tooth), a point contact (where there is a small high contact between the restoration and the adjacent tooth, which allows food packing under the small contact), or overhangs (where there is a contact between the restoration and the adjacent tooth, but the emergence of the restoration has a ledge where inflammation results). The choice of matrix is an essential step in providing the correct emergence profile (without overhang), which should be a long and broad contact area (no point contact) and having correct marginal height of the restoration. However, usage of sectional matrix systems has been adopted by less than 10% of practices, despite being taught at the majority of dental schools.[9]

Metal and Mylar sectional matrices have more anatomy than the traditional Tofflemire metal bands. Mylar has advantages over metal matrices because

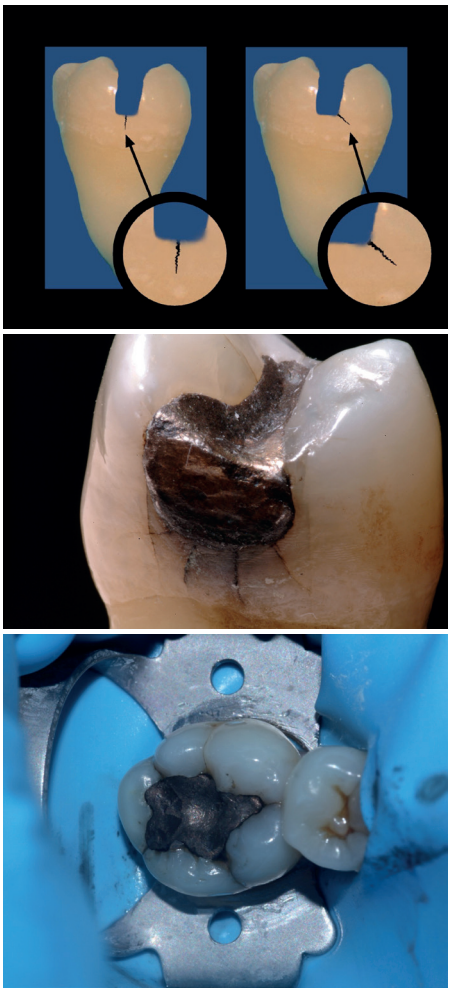

Figure 6. (a) Traditional cavity design and **(b,c)** cracks on restored teeth with tractional cavities (courtesy of Dr Claire Burgess and Dr David Clark).

the surface of a restoration that has been placed against Mylar is shown to be incredibly smooth, and the resultant build-up of biofilm is less, a great advantage interdentally on posterior teeth where access for oral hygiene measures can be more difficult. A clear matrix, in comparison to a metal matrix, also allows for three-point curing. This gives a further advantage as the composite can be cured to a greater depth. The Bioclear Method injection moulds restorations in a single increment where possible. When using 3M Filtek One Bulk Fill Restorative (3M, MN, USA) for Class II restorations, a 5-mm depth of cure can be achieved when three-point curing through the Bioclear Biofit Mylar matrix. If the Class II cavity is deeper than 5 mm in a Class II region, marginal elevation techniques are employed before bulk filling. Marginal elevation is the placement and curing of a small layer of bulk fill flowable composite

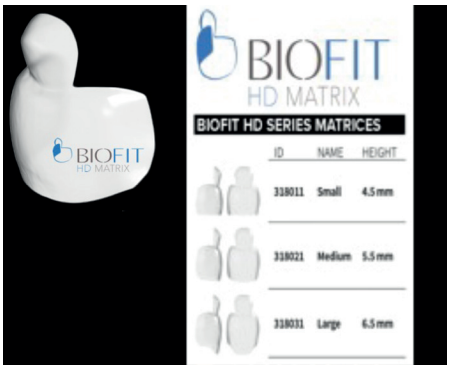

Figure 7. Bioclear Biofit anatomical mylar 75-micron matrices.

in areas of the cavity that are deeper than 5 mm.

The Bioclear Biofit matrices also incorporate additional features compared to sectional matrices (Figure 7). These include a more aggressive emergence profile that allows for the contact with the adjacent tooth to start lower apically. As the contact starts lower down, this allows for a sufficiently long contact before separating to allow space for an occlusal embrasure. The matrix incorporates the shape of both the occlusal embrasure and the marginal ridge, which can be a challenge for dentists.

The Bioclear Biofit matrices are available in 50- and 75-micron thicknesses. For the majority of restorations, the choice of a 75-micron/HD (heavy duty) matrix is ideal because they are stiffer than most metal matrices, and when pressed down to fully seat, they do not squash or distort. This is important when placing the wedge and separator ring.

Warm injection moulding of composite

Warm injection moulding of composite has been reported for many years, previously being referred to as the 'Lawnmower technique'. Pre-warming makes it easier to adapt the composite to the tooth.[16] This results in a reduction in microleakage, and an increase in surface hardness.[17,18] The Bioclear Method uses the Bioclear Heatsync heater that heats composite to 68°C (Figure 8). As composite has poor thermal conductivity, the temperature declines rapidly after removal from the heater. The warmer the composite, the easier it is to inject into the cavity, and the easier it is for the composite to fully adapt to the tooth, including in small areas.

Concern over injection moulding includes polymerization shrinkage. This may be overcome by a combination of

a

b

Figure 8. A HeatSync Heater, which heats multiple compules and flowables to a constant 68°C.

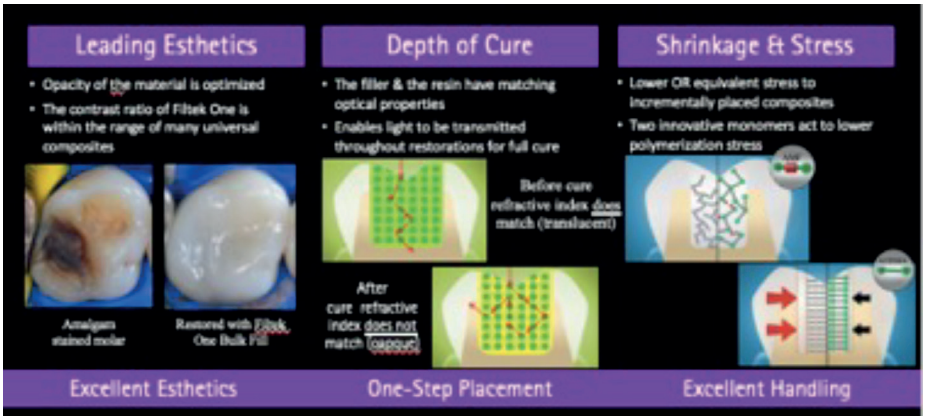

Figure 9. Improved aesthetics, reduced shrinkage and stress, and increased depth of cure of 3M Filtek One Bulk Fill Restorative (courtesy of 3M).

clinical technical factors and material factors. Previously, composite was placed in 2–3 mm increments using alternate walls to alleviate the shrinkage stress of the composite, and also help to prevent resultant cracks on the cavity walls. In studies comparing the total polymerization stress of layered composites (both placing increments horizontally and placing increments on alternate walls) to single bulk-fill placement, no significant differences in polymerization stress for bulk-fills was demonstrated.[19–21] Polymerization stress remains a concern however, and materials have been developed that have reduced material shrinkage to 2%. Studies concluded that the placement of several individual increments to mitigate polymerization shrinkage is not valid. Cuspal deflection was not found to be affected by different filling techniques.[21] Therefore, placement of composite in one section (ie bulk filling) is a valid technique.[22,23]

Other concerns with bulk-filling include the possibility for inadequate curing and inferior aesthetics. If a composite is inadequately cured, then the composite inside remains soft.[24,25] This may result in:

- Reduced material properties (marginal deterioration, reduced hardness, wear, fracture);
- Reduced bond strength;
- Post-operative sensitivity;
- Increased bacterial colonization (secondary caries);
- Potential increased staining/ discolouration;
- Potential long-term degradation.

Cosmetically, the most likely cause of colour change of composite is insufficient curing.[17] Therefore, the choice and maintenance of appropriate curing lights is essential for long-lasting composite restorations. While it is not possible to over-cure a composite, it is important to be cognizant of the heat generated from the curing light, which can have the potential to damage gingival tissues or the pulp. To lower the temperature while light curing, air should be blown from the triple syringe over the composite during the curing process.[17]

Placing composites in bulk has been found to be quicker and more viable to the operator.[26]

Warm injection moulding of bulk-fill composites, which uses the combination of wetting the tooth (3M Scotchbond Universal Adhesive), application of a flowable (3M Filtek Bulk Fill Flowable Restorative) then injection of paste composite (3M Filtek One Bulk Fill Restorative) results in fewer voids and marginal defects. It also allows for better adaption to the tooth. The aim of Bioclear injection moulding is to achieve a final restoration that consists of approximately 80% paste composite. This is beneficial for both functional strength and polish retention.

The 3M composites mentioned above are recommended for use in the Bioclear Method in part because they have been tested to ensure that they are safe and effective (both in regard to colour stability and mechanical properties) when warmed.

3M Filtek One Bulk Fill Restorative has several additional unique advantages (Figure 9). It contains two modern innovative monomers, aromatic urethane dimethacrylate (AUDMA) and additional fragmentation monomers (AFM), which reduce the polymerization shrinkage (<2% volumetric) and stress on curing. AFMs relieve stress because they cleave through a fragmentation process during polymerization, providing a mechanism for relaxation and subsequent stress relief. AUDMA decreases the number of reactive groups in the resin. This helps to moderate the volumetric shrinkage, as well as the stiffness of the material, both of which contribute to the development of polymerization stress.

The contrast ratio of the material changes during light curing owing to a refractive index mismatch. This mismatch allows the cured composite to have a greater final opacity for improved aesthetics.

It has a 4-mm depth of cure in a Class I cavity due to the translucency of the uncured paste and a 5-mm depth of cure when using three-point curing.

It is a true nanocomposite, 76.5% by weight, so it has good wear and fracture resistant properties, and a much longer polish retention.[27]

Rock star polish

The finishing and polishing process with the Bioclear Method is the same for all types of

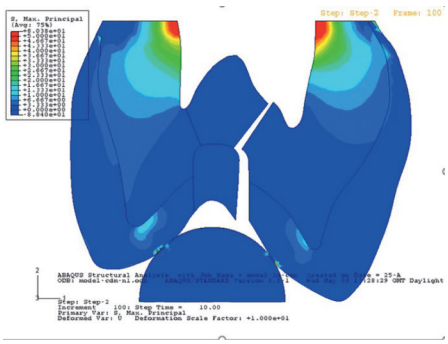

Figure 10. Presentation of a fracture of a tooth containing a composite restoration with marginal tension joints. Red and dark blue indicate the areas of highest and lowest stress concentrations, respectively. As the load is applied occlusally, the adhesive bond of the wall of the restoration fails, and the cusp is pushed away from the restoration, resulting in cusp failure (courtesy of Dr A Fok).

Figure 11. Diagram of a modern cavity with convex radius bevel occlusally extending through the enamel to the cusp tip. This convex bevel places the tooth and composite into compression (courtesy of Dr A Fok).

restorations. The final anatomy of Bioclear restorations includes wider and shallow fissure detail, which is stronger than narrow and deep fissure detail.[14] Patients may also be less interested in the micro-anatomy of the restoration and fissure details, such as staining on posterior teeth.

They all result with a rock star polish, which many patients comment on after treatment as the restorations feel very smooth. As the finishing process is the same for all Bioclear Method restorations, it is predictable and time efficient.

Modern cavity preparations

Traditionally Black's cavity designs were engineered for amalgam. Unfortunately, they predispose the tooth to fracture with a combination of cracks propagating from the base of the cavity and tension joints at the occlusal margins of the cavity. As the load is applied to the teeth, where the tension joint is between the restoration material and the natural tooth, the occlusal forces push

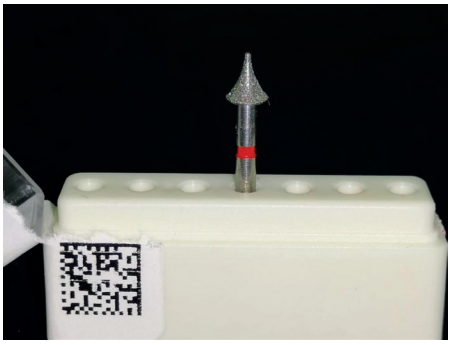

Figure 12. The 'Acorn' marginal trimming Komet bur.

the composite material and the tooth in opposite directions, which can predispose the tooth to fracture (Figure 10).

In comparison to traditional cavity design, minimal intervention dentistry results in less tooth destruction, which in turn reduces the risk of fracture or pulpal problems.[15] Combining minimally invasive cavity design with selective caries removal conserves more tooth structure, which also helps further to support the definitive sealed restoration.[28] There are three main elements (ICE) that drive modern cavity design:

- **I**nfinity edges;
- **C**ompression based design; and
- **E**namel driven.

Composite does not require mechanical retention; therefore, the retentive element of the cavity design can be removed, and there is no need for individual walls or key/locks. The result is a cavity with a much lower C-factor. Therefore, when the composite is cured the composite shrinks onto the tooth, rather than shrinking away from the tooth causing stress on the cavity walls.

Initially, this was reported as the 'saucer shape' cavity. Nordbo *et al* suggested that the 'saucer shape' cavity represented a viable treatment modality for small cavities.[29]

Composite materials and teeth are much stronger in compression rather than tension. Therefore, when designing occlusal features of cavities, the composite and tooth should be in compression. This can be achieved with a convex radius bevel or wall that extends up to the cusp tip (calla lily-style flare shape). The convex shape of the radius bevel results in the composite being in a compression joint occlusally. Recent studies suggest that when loading a Clark Class I restoration, the tooth lasts eight times longer before the tooth fractures, in comparison to a traditional Class I tension joint cavity-based restoration (study results submitted for publication). The convex radius bevel is placed only within enamel, it does not include the dentine. Despite increased enamel removal with this cavity design, in combination with selective caries removal/modified Hall technique following volumetric analysis, overall, there is less tooth removal than with a traditional cavity design (study results submitted for publication). By increasing the area of the radius bevel, this also exposes more enamel prisms, which are then bonded to – a bond that has good strength and longevity (Figure 11).[30]

The convex bevel can be cut with traditional burs, but it is difficult because most burs will cut a concave bevel resulting in a tension joint occlusally, predisposing the composite to chipping/ditching at the margins. Cutting the convex bevel with traditional burs involves rolling the wrist to change the angle of the bur. The Acorn Komet bur (Komet, South Carolina, USA) is shaped to produce a convex bevel, which helps to produce a convex shape and is an essential part of modern cavity design (Figure 12).

When a Clark Class II cavity is cut, the radius bevel extends round the tooth. When injection moulding, it is important that enough space is left interdentally for the composite to fully inject around onto the buccal/lingual surfaces of the tooth. Therefore, the contact is cleared by a minimum of 1 mm. This also allows for the matrix to seat 1 mm off the tooth, allowing for sufficient thickness of composite interdentally. All areas of the cavity are rounded, forming a double-serpentine shape, so no sharp line angles are present – this reduces the C factor and helps to allow the composite to flow around the tooth. This in turn moves the tooth–restorative interface (TRI) towards the line angles, where it is more self-cleansing and can be monitored more easily during examinations.[31]

Traditionally, we are used to having cavity walls and margins (Figure 13). With the modern Clark cavity design, there are no individual walls or margins (Figure 14). Composite is finished at the TRI with an infinity margin buccally/lingually on clean abraded enamel. This point has not been cut by burs, rather, it is where the composite blends onto tooth.[30] The TRI that forms the peripheral seal prevents further histopathological progress of the

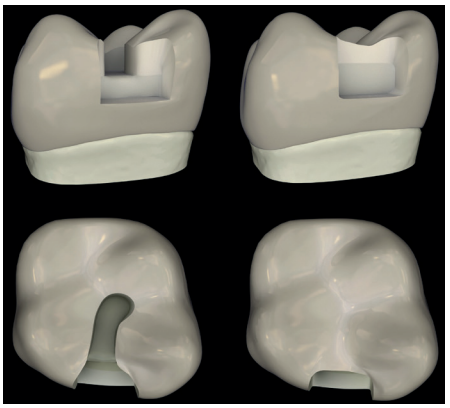

Figure 13. Traditional Black's cavity designs with key plus lock features on the left, slot preparation designs on the right (courtesy of Dr David Clark).

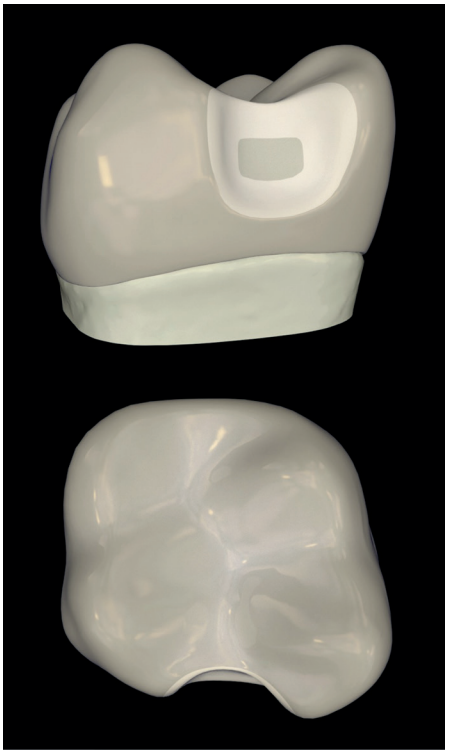

Figure 14. Modern Clark Class II cavity design (courtesy of Dr David Clark).

Figure 15. Class II restoration using the Bioclear Method (courtesy of Dr Young). **(a)** Pre-treatment with pre-wedge *in situ*. **(b)** After Clark Class II preparation and selective caries retention. **(c)** Biofit 5.5 Bioclear matrix with diamond wedge *in situ* before twin-ring placement. **(d)** Injection moulded UR6. **(e)** Immediately post-treatment of Class II mesial UR6.

disease. If carious enamel is retained at the TRI, then bacterial ingress will occur with resultant microleakage and secondary caries formation.[27] Consequently removal of biofilm is essential where the composite blends with the tooth. If not, then chips and brown lines can form.

With a modern cavity design that supports the tooth and results in the composite being in compression, the next aim is to provide predictable contact points with the adjacent tooth, a common challenge in practice.[33] For this reason, the Bioclear Method for posterior restorations follows a systematic process of seven steps that incorporates restoring the contact area and is as follows:

Pre-wedging

- The largest size of diamond wedge is placed after the removal of biofilm, before filling removal or cavity preparation begins;
- The aim is to start to separate the teeth;
- Ideally a separation force of 2lbs should be provided by diamond wedges.

Cavity preparation

- This includes a rounded double-serpentine shape, no direct retention, a radius bevel, and sufficient space interdentally to allow for sufficient thickness of composite;
- After completion of the cavity preparation, the pre-wedge is removed, and the tooth is once again particle abraded.

Adjusting the neighbouring tooth

- Examining and adjusting the adjacent tooth to leave a favourable shape for forming a long broad contact. This is undertaken using discs.

Selection and placement of anatomical matrix

- The matrix is selected that provides the correct marginal height level with the adjacent tooth when seated fully.

Placing a wedge

- Again, the wedge needs to have good separation power, but a low profile so as not to invade the emergence profile of the matrix/restoration gingivally;
- Apply pressure onto the matrix when placing the wedge to ensure the matrix does not rise up or move buccally/lingually;
- Confirm the position of the matrix from the occlusal and lateral aspect – checking the contact point is central with the adjacent tooth, and the marginal ridge height is correct.

Twin-ring separator placement

- Separates the teeth, enhances the contact point, and compensates for the matrix thickness;[16]
- Must be seated at gingival level to prevent slippage off the tooth;
- Ideally use the yellow twin ring as it has higher separation power (6lbs) in comparison to the purple twin ring (4lbs);

Spot welding

- To predictably ensure good contact is made with the adjacent tooth (it replaces burnishing).
- Flowable composite is placed inside-over-outside both corners of the matrix and cured while the matrix is pulled (mesial restoration) or pushed (distal restoration) against the adjacent tooth. This results in a fixed 'aquarium' that can be injection moulded;
- The flowable composite will either be removed on finish or be incorporated into the restoration.

The tooth is now ready for warm injection moulding as previously described (Figure 15).

With larger restorations, consideration must be given to the thickness of the cavity walls and the presence of existing cracks. When cavity walls are thin, especially in function, taking the opportunity to overlay and protect these cusps is ideal. With the goal of preventing future cuspal fracture, overlays are also recommended when cracks are evident.[34–36]

The cavity design for the overlay is beyond the scope of this article, but the process of the Bioclear Method as a form of restoring larger restorations remains the same. An advantage with the Bioclear Method is that injection moulding can produce strong, long-lasting monolithic restorations with fewer seams/voids (Figure 16). In some clinical instances, they can provide an ideal alternative to an indirect restoration because they are less destructive and have a similar failure rate to indirect cuspal protection restorations.[37] If there is failure, then either a replacement overlay or proceeding to indirect restorations is still an option.

If patients present with early-stage cracked-cusp syndrome, a direct overlay may resolve symptoms and help to prevent cusp fracture or the need for endodontic treatment.[34,35] This is especially relevant for mandibular molars, maxillary molars and maxillary premolars.[34,35] Treatment with direct composite overlays can result in no endodontic treatment being required with a 100% restoration survival at 7 years.[34,35] If endodontic treatment is undertaken, it is also possible to immediately provide long-term cuspal protection with a direct composite overlay.

Cuspal overlays are also less costly and require no temporization, allowing treatment in a single visit, which is preferable to the patient.

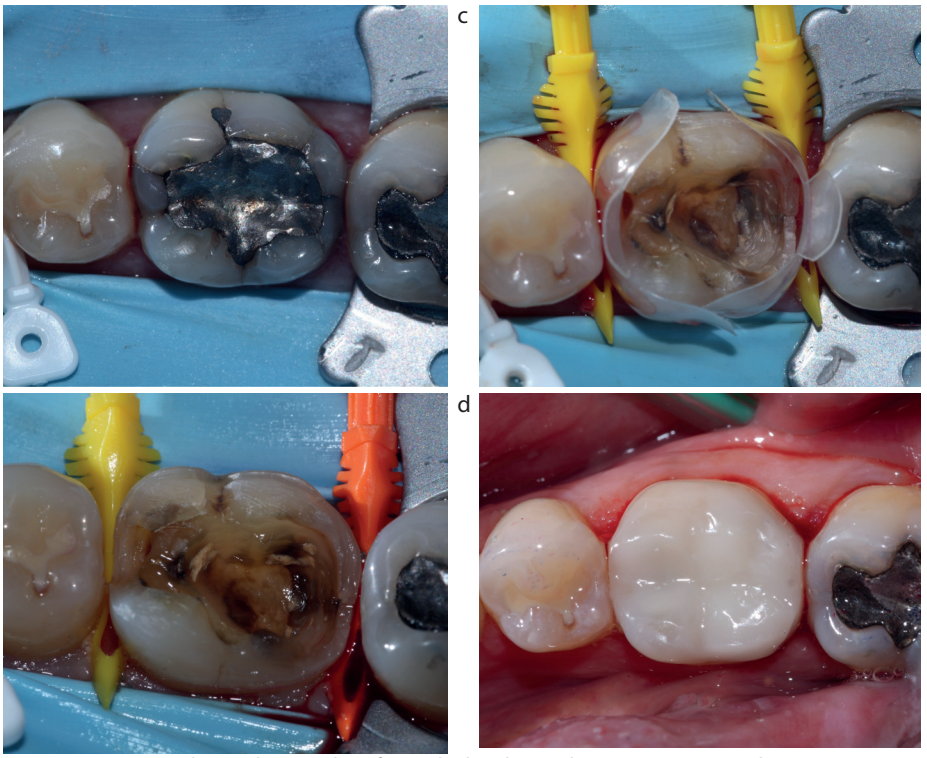

Figure 16. Direct molar Bioclear overlay of a cracked molar tooth. **(a)** Pre-treatment showing caries and open cracks. **(b)** Pre-wedge *in situ* after overlay preparation of the disto-lingual and buccal cusps. **(c)** Bioclear Biofit HD matrices and diamond wedges *in situ* prior to placement of the twin rings. **(d)** Immediately post-treatment of overlay on 46.

Conclusion

In conclusion, the Bioclear Method combines modern composite techniques with modern concepts in minimally invasive dentistry. It allows dentists to undertake minimally invasive, cost-effective dentistry, and create long-lasting and aesthetic Class II restorations.[38]

The contemporary cavity design allows both the composite material and tooth to be in compression, which is advantageous in prevention of tooth fracture, the third most common cause of tooth loss in the western world. The predicable method for the formation of Class II contacts could also help to reduce post-operative food impaction, recurrent caries and sensitivity. Both these factors have the potential to influence the success of posterior composite restorations.

Compliance with Ethical Standards

Conflict of Interest: The authors declare that they have no conflict of interest.
Informed Consent: Informed consent was obtained from all individual participants included in the article.

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