


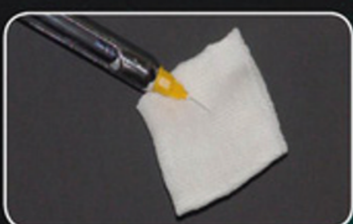


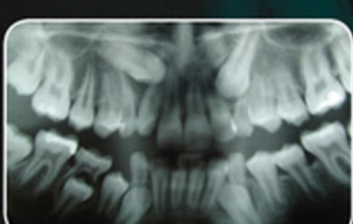

Avoiding and Treating Dental Complications

Best Practices in Dentistry

Edited by
Deborah A. Termeie

WILEY Blackwell

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CHAPTER 1

Best practices: Restorative complications

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Rubber dam challenges

Metal clamps damage tooth structure or porcelain surfaces of crowns

Prevention and management

The use of light cured provisional material can reduce the potential of metal rubber dam clamps to cause iatrogenic damage (Liebenberg, 1995). Prior to clamp placement, a small amount of composite based material may be added to the metal prongs of the clamp. Alternatively instead of metal clamps, the use of plastic rubber dam clamps is less likely to damage tooth structure or existing restorations (Madison, Jordan, and Krell, 1986).

Placing a matrix band on the same tooth as a rubber dam clamp

Prevention and management

One of the methods to solve this complication is to open the clamp with rubber dam forceps and then place the matrix under the prongs and then release the clamp on the band, securing it during the procedure. Another method is to use a sectional matrix secured with a wedge and compound, thus avoiding the clamp entirely.

Poor adaption of rubber dam to partially erupted teeth or a short clinical crown lacking a supragingival undercut is a common challenge leading to clamp instability

Prevention and management

Ford, Ford, and Rhodes (2004) advocate the use of the split dam technique along with a caulking agent to achieve an adequate seal. Morgan and Marshall (1990) recommend that a glass ionomer cement, like Fuji Plus, may be mixed according to the manufacturer's directions and loaded into a composite syringe. The material is syringed along the gingival margins of the tooth to be prepared to approximate normal tooth contours. A plastic instrument may be used to shape the material to create adequate facial and lingual undercuts. The material provides a circumferential surface against which the rubber dam may seal. After the procedure is completed, the glass ionomer/composite material may be removed with a large spoon excavator or curette.

Wakabayashi *et al*. (1986) recommend that a small amount of self-curing resin mixture be placed at the gingival margin on the reciprocal surfaces of the tooth and cured well, after which a standard clamp is set apical to the resin spots, as this will facilitate supragingival retention of a rubber dam clamp.

Class V cavity preparation and restoration complications

Lacerating gingival tissue and compromising periodontium due to poor gingival tissue management and isolation

Prevention and management

Isolation of class V cervical lesions for soft tissue displacement, moisture containment, and infection control can utilize several methods, including rubber dam isolation, placing retraction cord in the sulcus, minor gingival surgery using a radio-surgical laser, scalpel gingivectomy prior to rubber dam retainer placement, cotton roll/saliva ejector isolation, and the use of clear matrix systems for anatomical contour.

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Rubber dams help prevent operative-site exposure to blood and crevicular and intraoral fluids. In order to isolate a class V lesion, the hole in the rubber dam for the tooth to be restored is positioned approximately 3 mm facial to the normal hole position, slightly larger in size, and with slightly more distance between the adjacent holes. After the dam is placed, a 212-type clamp is engaged on the lingual side of the tooth and rotated into position in the facial, while stretching the dam apically to reveal the lesion. The beak of the 212-type clamp should be positioned at approximately 1 mm apical to the anticipated preparation gingival margin of the cavity preparation. This usually requires stabilization of the retainer with thermoplastic impression compound. In apically extensive lesions, the beaks of the 212-type clamp may be modified by bending the lingal beak coronally (not apically) and rotating the 212-type clamp facially during placement, securing with one hand while the compound is added to the bow of one side until it is hard. The decision to bend the facial beak apically will lead to a more restricted access to the lesion and thus should be avoided. The teeth must be dry for the heated compound to be secure. After one side is placed, the compound is placed on the other side of the bow. A safe alternative way to use heated compound is to take the Monoject syringe and trim back the tip so you have a wider lumen. Then take green stick compound, break it up into smaller pieces, and place it into the Monoject syringe. Immerse the syringe in hot water. The compound melts and you can then inject the compound into the desired area. It is much easier and safer than messing with a flame chairside and is much easier to direct into the desired location, especially if you are using one hand, which you often are in this situation since you are using the other hand to maintain the position of the 212-type clamp. When the restoration had been completed, rubber dam forceps easily break the compound loose upon retainer removal.

A recent technique to isolate the gingival margin of class V lesions employs a paste (Expasyl, *Kerr*, or Traxodent, *Premier*) that provides reasonable gingival retraction and hemostasis. These pastes consist of an organic, clay material (kaolin), mixed with aluminum chloride as a hemostatic agent. It is thick and firm yet viscous enough to be placed into the gingival sulcus. The paste is injected directly into the sulcus from a preloaded syringe at a recommended rate of 2 mm/s, using even pressure. If necessary, this can be followed by gently tamping on the paste with a plastic instrument or cotton pellet to ensure the paste is fully established or secured into the sulcus. Once the material has been applied and absorbs moisture and hemostasis is achieved, the material should be isolated from additional moisture and saliva. The paste is left in the sulcus for 1–2 min if the tissue is thin or 3–4 min if the soft tissue is thicker. The paste should then be removed by gently rinsing, followed with drying the site, prior to restoration placement. If necessary, the process can be repeated without traumatizing the tissue. Gingival retraction will last for 4 min after the paste has been rinsed and removed from the site.

Contouring class V restorations in the gingival area

When the lesion extends subgingivally, care must be taken not to damage the cementum with rotary instruments. If the restoration is not appropriately contoured and polished, it may lead to gingival inflammation due to food/plaque traps, secondary decay, and early failure of the restoration.

Prevention and management

A technique for better contouring and polishing uses a standard mylar matrix, which has been previously cut to fit the tooth to facilitate the insertion of composite resin into the cavity. Cutting the matrix is not always required. The matrix is inserted into one side of the cavity and fixed in place with a wooden wedge. It is then carefully inserted into the gingival sulcus, involving the entire cervical wall of the cavity (Figure 1.1).

Figure 1.1 A technique for better contouring and polishing uses a standard mylar matrix.

The unattached side of the matrix is positioned by inserting another wedge into the opposite side of the cavity. A photocured gingival barrier (OpalDam, OpalDam Green, Top Dam/FGM, Joinville, Santa Catarina, Brazil) is injected around the mylar matrix to stabilize it. This procedure is not difficult to perform but has to be done with precision in order to form a large enough occlusal/incisal opening between the matrix and the tooth to allow the insertion of restorative material. This procedure also allows the necessary volume of restorative material to be inserted without any excess and adequate separation between the gingiva and tooth, forming an angle that provides an aperture, wide enough for the composite resin syringe tip insertion. Some authors recommend contouring of the gingival aspect of the matrix by stretching the middle gingival portion over the handle of an explorer to gain a shape consistent with the emergence angle on the cementoenamel junction of the tooth prior to securing the matrix against the tooth. Another option is the use of a metal matrix; however, due to the light barrier created by the metal, light curing must be completed in two or more steps, first curing the accessible portion, then removing the metal, and curing the deeper portion with the light applied directly to the exposed restorative material. Some authors think that it works better than the mylar matrix in terms of maintaining shape and stability. This option can be especially useful in situations with intrinsic anatomical difficulties, as in molar furcations. The plastic mylar matrix has a lower risk of damage to soft tissue during insertion into the gingival sulcus and better light transmission for curing and visualization of the preparation cavity (Perez, 2010).

Complications involving liners and bases

Inappropriate use and selection of liners and bases in different clinical situations

Prevention and management

The following recommendations will be based on three different cavity depths and three different restorative materials/techniques (amalgam, composite and indirect restorations) in terms of pulpal proximity:

1 Shallow preparations when the remaining dentin thickness (RDT) is greater than 2 mm
2 Moderately deep preparations when the RDT is 0.5–2 mm
3 Deep preparations when the RDT is less than or equal to 0.5 mm (Table 1.1)

Amalgam

For shallow amalgam tooth preparations (RDT > 2 mm), the use of a dentin-bonding agent may be applied as a sealing agent to the internal walls of preparation, avoiding the cavosurface margin before insertion of the restoration. The use of a self-etching adhesive system will not require a separate etching step.

For moderately deep preparations (RDT = 0.5–2 mm), a liner of glass ionomer may be placed for pulpal protection, followed by the sealing step described earlier. It is well understood that amalgam restorations are great thermal conductors, and placing a thick base has shown to predictably reduce the temperature changes at the base of the cavity (Harper *et al.*, 1980).

For deep preparations (RDT < 0.5 mm), a subbase may be placed on the deepest region in which infected dentin was excavated with a calcium hydroxide material (Dycal, LD Caulk) followed by a liner of glass ionomer on the deepest region in which infected dentin was excavated with a calcium hydroxide material (i.e., it is well understood that removal near the pulpal aspects of the preparation is not necessary to preserve pulpal health, as long as the tooth is asymptomatic or only mildly (reversibly) symptomatic, and a well-sealed restoration is placed (Maltz *et al.*, 2012b).

Glass ionomer restoratives

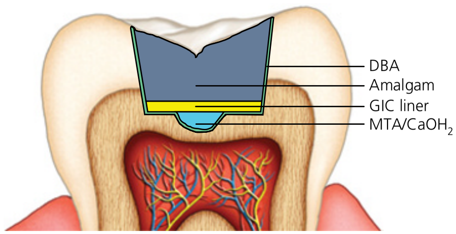
Since glass ionomer cements are poor conductors of temperature, no material is required to be placed except for deep preparations (RDT < 0.5 mm), in which case, a liner as described earlier should be placed (Roberson *et al.*, 2006).

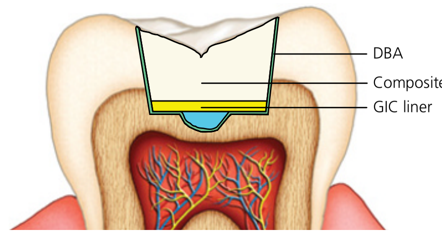
Composite resin

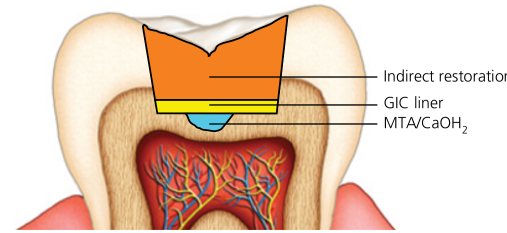
- For shallow preparations (RDT > 2 mm), dentin-bonding agents are the only necessary material to be placed.
- For deep preparations (RDT < 0.5 mm), a liner should be placed as with amalgam and glass ionomer restorations.
- For moderately deep preparations (RDT > 0.5–2.0 mm), since glass ionomer liners have shown to improve the performance of composite resins (Arora *et al.*, 2012), a thin liner of resin-modified glass ionomer (RMGI) may be used on the deeper dentin surfaces.

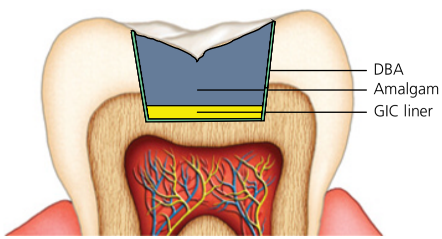
> CAUTION: Do not use zinc oxide eugenol as a liner underneath dental composites as it interferes with dental composite polymerization (Roberson *et al.*, 2006).

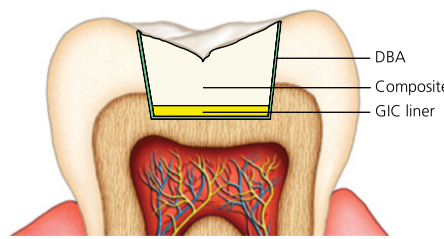
Table 1.1 Recommended and selection of liners and bases in different clinical situations.

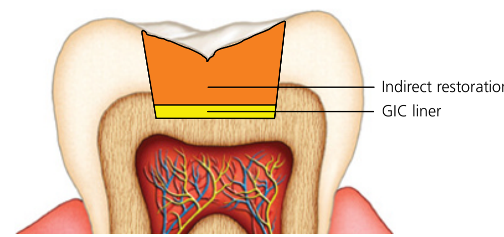
<table>
<tr><th>Distance from pulp (RDT)</th><th>Restorative material</th><th>Amalgam</th><th>Composite resin</th><th>Indirect restorations</th></tr>
<tr><td></td><td>0.5–1 mm</td><td>

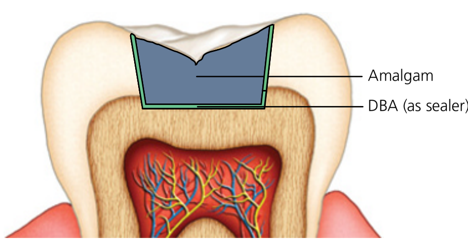
Pulpal protection: MTA/Ca(OH)$_2$ (deepest portion)
Liner: GIC
DBA as a sealer</td><td>

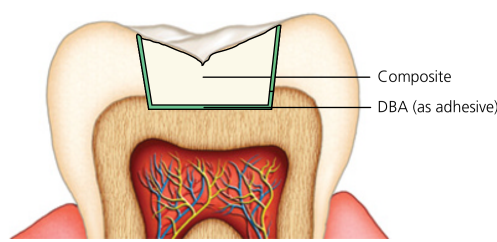
Pulpal protection: MTA/Ca(OH)$_2$ (deepest portion)
Liner: GIC
DBA as adhesive</td><td>

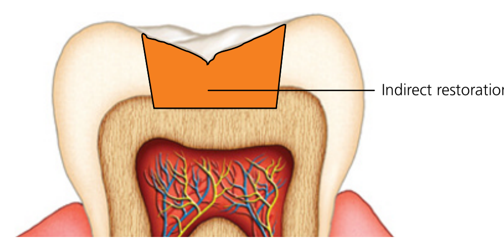
Pulpal protection: MTA/Ca(OH)$_2$ (deepest portion)
Liner: GIC</td></tr>
<tr><td></td><td>1–2 mm</td><td>

Pulpal protection: optional
Liner: GIC
DBA as a sealer
*Optional base layer</td><td>

Pulpal protection: optional
Liner: GIC
DBA as adhesive</td><td>

Pulpal protection: optional
Liner: GIC</td></tr>
<tr><td></td><td>2 mm–more</td><td>

DBA as a sealer
*Optional base layer</td><td>

DBA as adhesive</td><td>

Nothing; consider blockout for undercuts</td></tr>
</table>

Ceramic and cast gold restorations

- For moderately deep preparations (RDT = 0.5–2 mm), a base is recommended under the restoration in order to create flat walls and uniform restorative material thickness. Wax patterns are more accurately fabricated if they are smooth and uniform.
- For deep preparations (RDT < 0.5 mm), to protect the pulp, a liner is placed and then a base is applied (Roberson *et al.*, 2006). Placing bases under ceramic and cast gold restorations also will aid in preserving tooth structure by blocking out undercuts in dentin, which would otherwise require overlying tooth structure removal.

Managing the integrity of calcium hydroxide liners

Prevention and management

Since calcium hydroxide liners are highly soluble, they are lost during acid etching and are subject to dissolution over time. The best way to seal calcium hydroxide liners is with the use of RMGI. The RMGIs should line the cavity preparation, covering the calcium hydroxide material, thereby securing it to improve pulpal protection and minimize bacterial microleakage (Rada, 2013).

Bacterial contamination

Prevention and management

Apart from selecting the right material for the procedure, performing it in a clean environment with the use of a rubber dam is one of the most important factors for success (Maltz *et al.*, 2012b).

Techniques to improve marginal quality include:

1. Utilizing resin-modified glass ionomer cements in a sandwich technique (Dietrich *et al.*, 1999).
2. Beveling of enamel margins prior to etching to improve adhesion by exposing the ends rather than the sides of the enamel rods to improve adhesion and reduce leakage.
3. Incremental filling with composite resin to reduce polymerization stresses.
4. The use of water-cooled tungsten carbide finishing burs as dry polishing disk techniques increases leakage (Taylor and Lynch, 1993).
5. In a study by Schwartz, there was significantly less leakage detected in glass ionomer/composite sandwich restorations (Schwartz, Anderson, and Pelleu, 1990).

In all cases, a sterile procedure is the most ideal environment to work in, and it also positively affects the outcome of most procedures (Stockton, 1999). Therefore, clinicians should practice rubber dam isolation whenever possible.

Deep caries

Comparison of the three major caries removal modalities:

1. Direct complete excavation
2. Stepwise excavation
3. Partial caries removal

Prevention and management

Performing stepwise excavation for extremely deep caries lesions is associated with fewer exposed pulps, sustained vitality, and a lack of apical radiolucency compared with performing direct complete excavation. Stepwise excavation may be a preferable management technique for these deep caries lesions (Bjørndal *et al.*, 2010).

However, it is not necessary to remove all carious dentin before the restoration is placed, because over time, sealing of carious dentin results in lower levels of infection than traditional dentin caries removal. Also, the stepwise technique incurs a second intervention, with resultant trauma to the pulp and increased time and expense for the patient (Maltz *et al.*, 2012b). The retention of carious dentin does not interfere with pulp vitality (Maltz and Alves, 2013). In another study conducted by Maltz *et al.*, partial carious dentin removal showed a statistically significant improvement with regard to the maintenance of pulp vitality as compared with stepwise excavation after a 3-year follow-up period (Maltz *et al.*, 2012a).

Sealing of carious dentin arrests the lesion progression irrespective of the dentin protection used (Corralo and Maltz, 2013). It is important to note that all of these techniques require that the DEJ and the first 2 mm from the external cavosurface margin in a pulpal direction be caries-free. Ideal caries removal end points generate a peripheral seal zone that can support long-term biomimetic restorations (Alleman and Mange, 2012). In all cases, it is critical to obtain a completely caries-free zone at dentino-enamel junction and 0.5–1.0 of remaining dentin thickness.

Pulp exposure

Prevention and management

The size of the exposure, the quality of the isolation, the age of the patient, and the presence of caries at the periphery of the preparation have a significant influence on the success of direct pulp caps. Pulp exposures, which elicit hemorrhage, must be controlled prior to attempting a direct pulp-capping procedure.

The degree of bleeding on pulpal exposure is related to the success rate of direct pulp-capping procedures (Matsuo *et al.*, 1996). Numerous agents are used for hemostasis with pulp exposures: a 0.9% saline solution, ferric sulfate, 2.5% NaOCl, $Ca(OH)_2$ solution, and 2% chlorhexidine digluconate (Silva *et al.*, 2006a). An alternative to 2.5% NaOCl is 5.25% NaOCl (Silva *et al.*, 2006a). Usually bleeding is controlled within 10 min of application; however, when it cannot be stopped, within this time frame, endodontics is likely.

The two most widely used materials for pulp capping are mineral trioxide aggregate (MTA) and calcium hydroxide. Calcium hydroxide is widely used and has been found to perform better than single-bottle adhesive system (Silva *et al.*, 2006b) and self-etch (SE) adhesives (Accorinte *et al.*, 2007). MTA has been found to be better than a single-bottle adhesive system calcium hydroxide in the following ways:

- Pulp healing with MTA is faster than that of calcium hydroxide (Accorinte *et al.*, 2008; Chacko and Kurikose, 2006).
- Dentin bridge formation with MTA is more homogenous and continuous with the original dentin when compared to the pulps capped with calcium hydroxide (Chacko and Kurikose, 2006).
- Calcium hydroxide shows tunnel defects and irregularity in the calcified bridge formed beneath it when used as a capping material (Parirokh *et al.*, 2011).
- A large randomized clinical trial (Hilton *et al.*, 2013) provided confirmatory evidence for superior performance with MTA as a direct pulp-capping agent as compared with calcium hydroxide when evaluated in a practice-based research network for up to 2 years. The probability of failure at 24 months in this trial was 31.5% for calcium hydroxide vs. 19.7% for MTA.
- Resin-modified calcium silicate-filled liner (TheraCal, Bisco), a recently introduced material, displays higher calcium-releasing ability and lower solubility than either ProRoot MTA or Dycal. TheraCal had a cure depth of 1.7 mm. The solubility of TheraCal ($\Delta - 1.58\%$) was low and significantly less than that of Dycal ($\Delta - 4.58\%$) and of ProRoot MTA ($\Delta - 18.34\%$). The amount of water absorbed by TheraCal ($\Delta + 10.42\%$) was significantly higher than Dycal ($\Delta + 4.87\%$) and significantly lower than ProRoot MTA ($\Delta + 13.96\%$) (Gandolfi, Siboni, and Prati, 2012).
- Resin composite and resin-modified glass ionomer materials can optimize healing following pulp capping, because they appear to reduce the number of defects in comparison with $Ca(OH)_2$ alone (Murray and Garcia-Godoy, 2006). After placement of $Ca(OH)_2$ over the exposed pulp, it is important to secure the material with a liner of RMGI prior to continuing with the direct restoration.

Composite complications

There are two basic techniques for the placement of composite restorations: bulk fill and incremental insertion.

With the bulk-fill technique, the entire amount of composite resin is placed into the preparation at one time and then trans-enamel polymerization is used to cure the composite. The composite material then shrinks toward the light source. This creates internal stresses in the composite material leading to increased polymerization stresses, which may challenge the bond to dentin leading to microleakage. This can also lead to significant temperature and biting sensitivity (Marangos, 2006).

Potential advantages of bulk filling are:

1. Fewer voids may be present in the mass of material, since all of it is placed at one time.
2. The technique is faster and easier than placing numerous increments when curing times are identical.

Potential disadvantages of bulk filling are:

1. Creating adequate proximal contact areas may be challenging unless adequate matrices are used.
2. Effects due to shrinkage stress may be more pronounced when bulk filled than when placed in increments, since the entire mass polymerizes at one time rather than in small increments.
3. Polymerization of resin in deep preparation locations may be inadequate.

Prevention and management

Incremental placement of posterior composites has been advocated for a long time as a means to partially mitigate polymerization contraction. Many methodologies have been suggested, including using no liner, the use of a low modulus flowable composite, or self-curing glass ionomer cement. Since there are many viscosities of composites available with various degrees of polymerization contraction, the adaptive quality of the composite or its flow as well as inherent volumetric properties will affect the final marginal adaptation and leakage patterns with these placement techniques. Currently, incremental placement is the most researched and supported filling and curing method. Current bulk-fill resins show potential improvements in some properties, but the following challenges still exist for most materials:

- Volumetric shrinkage and stress are not less than other conventional restorative resins.
- Light cure may not reach the bottom extensive (over deep 5 mm) restorations.
- Fast curing lights do not deeply cure bulk-fill resins.
- Some flowable resins cannot be used on occlusal surfaces.
- Making tight proximal contacts can be difficult.
- Preventing voids in crucial locations is unpredictable. At this time, bulk filling as a concept may have promising potential and may perform well in certain situations, but material improvements are necessary to overcome the described challenges (Christensen, 2012).

Polymerization shrinkage

Prevention and management

Incorporating commercially available fiber systems within the composite restorations has shown to reduce the polymerization shrinkage. The fiber materials are available as transparent fiber meshes which can be placed into the cavity and composite material is allowed to flow around the mesh. It is shown that marginal microleakage significantly decreases when composites are applied by the incremental technique with the incorporation of fiber meshwork (Ozel and Soyman, 2009).

As described in the previous section, incremental placement of composite resins remains the most predictable method to decrease the effects of polymerization shrinkage stresses on the tooth.

Open contacts

Prevention and management

Tofflemire matrices will not predictably establish anatomically correct physiologic contacts when used with composite resins. Due to low resistance to deformation, these matrices result in a poor contour and point contacts (Strydom, 2006). Some clinicians re-prepare such proximal surfaces, adding more composite, and a plaque and food retentive area may develop.

Light curing complications

Common complications

1. Premature failure of resin restorations is a commonly encountered problem. The median longevity for posterior resin-based restorations placed in dental offices is only about 6 years (Sunnegårdh-Grönberg *et al.*, 2009) with the primary reasons for replacement being secondary caries and bulk fracture of the resin (Heintze and Rousson, 2012; Sunnegårdh-Grönberg *et al.*, 2009).
2. Undercured resins are a significant cause of restoration failure due to fracture, secondary caries, or excessive wear of the restoration (Ferracane, Berge, and Condon, 1998; Hammouda, 2010; Shortall *et al.*, 2013).
3. When composites resins are not optimally cured and thus do not reach a sufficient degree of monomer conversion, they are more likely to leach toxic substances (Chen *et al.*, 2001).
4. Light curing delivers energy that causes a temperature increase in the tooth and surrounding oral tissues (Oberholzer *et al.*, 2012; Shortall *et al.*, 2013). Arbitrarily, increasing exposure times in an effort to prevent undercuring may damage the pulp and surrounding tissues.

Improper positioning of the curing light may contribute to these failures. Appropriate light curing of the entire restoration is a basic requirement when placing composite resins (Price, 2014).

Etiology

Contemporary light cure units (LCUs) deliver a wide range of spectral emissions and irradiance levels (Leprince *et al.*, 2010; Rueggeberg, 2013). These differences are often not detectable by the eye (El-Mowafy *et al.*, 2005), neither accurately by a dental radiometer,

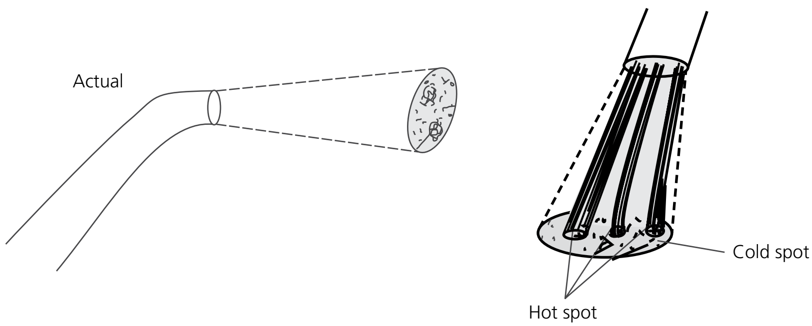


Figure 1.2 Transverse section of a fiber-optic tip of a light curing unit and light passing across it demonstrating hot and cold spot.

but they can affect the polymerization of the composite resins (Figure 1.2).

Nonuniform irradiance

Nonuniform light beam show areas of variation across the tip end of the LCU delivering more irradiance in some areas and delivering less irradiance in others. If the light is held steady, this may result in some of regions of the resin receiving an inadequate amount of energy when light curing.

Preventive measure

1 Light exposure time will have to be increased at the risk of overexposing some of the oral tissues, unless carefully managed (Rueggeberg, 2013).
2 The spectral emission from the LCU and the spectral requirements of the composite resin should be matched both to ensure optimal polymerization (Jandt and Mills, 2013; Price, Fahey, and Felix, 2010) and to minimize intrapulpal temperature increases (Leprince *et al.*, 2010).
3 Polywave light-emitting diode units (with two or more spectral peaks) have been introduced that use two or more different colors of LED, meaning that their spectral output ranges from blue (460 nm) to violet (410 nm) wavelengths of light. These lights can polymerize composite resin containing both conventional and alternative photoinitiators.

Management

The light tip should be moved around by a few millimeters when light curing (Rueggeberg, 2013). This movement should compensate for the nonuniform irradiance and spectral distributions from the LCU.

Differing irradiance

With some LCUs, the irradiance may be high close to the tip but declines rapidly as the distance from the tip end increases (Price and Ferracane, 2012). Most class II resin restorations fail at the gingival portion of the proximal box (Mjör, 2005). This is the region that is the most difficult to reach with the LCU and is furthest away from the light source (Price and Ferracane, 2012). Consequently, the resin here will receive the least amount of light and will be undercured (Shortall *et al.*, 2013). Increasing the distance decreases the dentin shear bond strength (Xu, Sandras, and Burgess, 2006) (Figure 1.3).

Prevention and management

Increasing curing time will compensate for the decreased dentin shear bond strength. It is important to learn how to use the LCU to maximize the energy delivered to the composite. Place the central axis of the tip of the light directly over the restoration surface; the emitting end should be parallel to the surface being exposed.

When using an LCU with an inhomogeneous light output, move the light tip around and increase the exposure time. This should also be done where undercuts are present that prevent straight-line access to the composite. Additionally, in this situation, use supplementary buccolingual curing (but beware of overheating). Another consideration is the distance from light tip to composite increment. If more than 2–3 mm away, then use thinner increments of composite, for example, 1 mm to insure a complete cure.

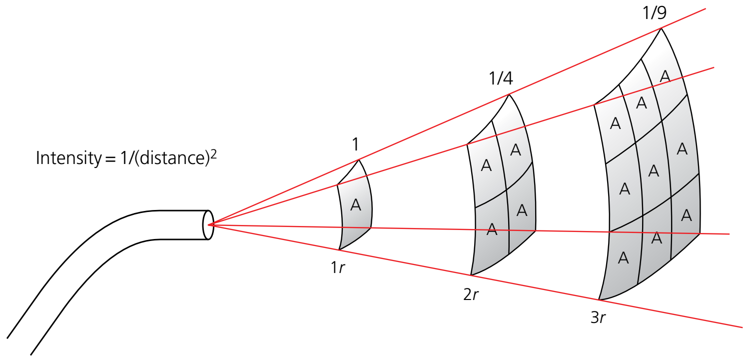


Figure 1.3 The relation between the intensity and distance of the curing light.

Post complications

Maximizing post and buildup retention without compromising tooth resistance form

Prevention and management

Post length

Length is an important factor that affects the retention of the posts in the root.

The determination of the appropriate post length and the remaining root canal filling after preparation has been studied extensively. Some studies recommended that the post should be longer than the crown length, halfway between the root apex and the crest of the alveolar bone. Other studies suggest that posts with three quarters the length of the root are less likely to debond (Leary, Aquilino, and Svare, 1987). Kessler and Peters' findings showed no perforations with a size 2 or 3 Gates Glidden bur in mandibular molars and that the danger of creating thin or perforated walls was much greater toward the bifurcation.

Increasing the post length is associated with a significant enhancement in post retention (Macedo, Faria e Silva, and Marcondes Martins, 2010) while keeping in mind maintaining of 4–5 mm of the gutta-percha seal. However, in cases of curved root canals where the desired length may not be achievable, greater length into the root canals is not necessary to enhance the retention of bonded fiber posts (Braga *et al.*, 2006).

A safe and well-recognized rule to follow is to make the post at least equal to crown length however, never removing the remaining 5 mm of endodontic filling material (Figure 1.4).

Post diameter is too large

Maintaining the remaining tooth structure is an important objective while restoring endodontically treated teeth. However, an increase in post diameter may result in more reduction of root dentin. At the same time, some studies did not find any significant increase in the post retention by using a large post diameter (Hunter, Feiglin, and Williams, 1989).

Prevention and management

Studies have shown that post diameter should not be more than one third of the root diameter at any locations and at the post tip the diameter of post should be 1 mm or less (Standlee, Caputo, and Hanson, 1978). Another study suggests that the posts should be surrounded by 1 mm of sound dentin.

Complications related to post design

Post design can be classified according to two categories: shape and surface configuration.

1. According to shape, there are parallel-sided and tapered posts.
2. According to surface configuration, there are threaded, serrated, cross-hatched, and smooth surface posts.

One clinical study found that parallel-sided, serrated posts have more retention than tapered and smooth posts. Standlee and Caputo in their study reported that endodontic posts with transverse serrations or cross-hatching were retained better than posts with longitudinal threads (Standlee and Caputo, 1993). However, another study indicated that threaded posts are the most retentive (Cohen *et al.*, 1999), as threaded posts engage into the root

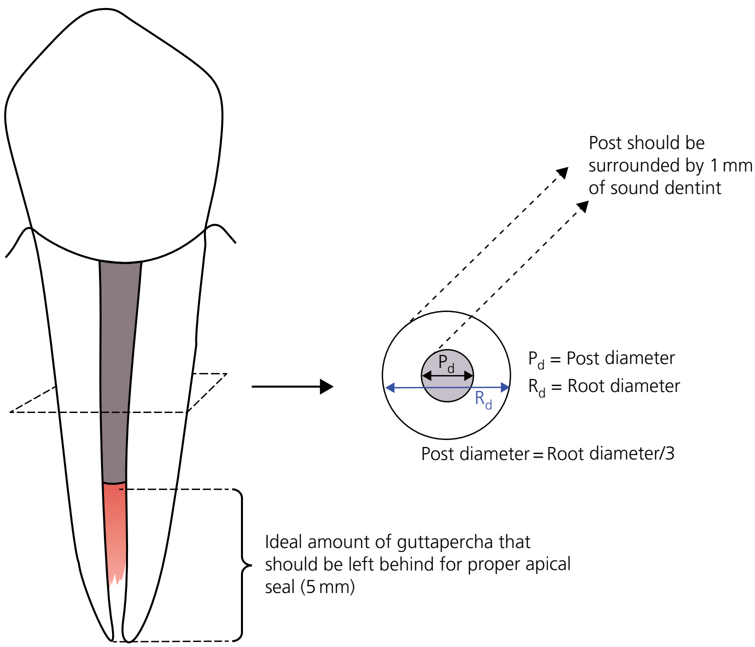


Figure 1.4 Ideal post length and post diameter for a post and core restoration.

dentin compared to smooth surface posts that depend mainly on the cement for retention.

Even though tapered posts result in less tooth reduction, they create a wedging effect and stresses on the remaining root structure.

Asmussen, Peutzfeldt, and Sahafi (2005) and Cooney, Caputo, and Trabert (1986) and another study done by Yang *et al*. (2001) reported that parallel-sided dowels distributed stress widely in the dentin leading to more stable restorations in contrast to tapered posts, which showed the greatest stress concentration and displacement under horizontal forces. However, the threads in these actively fitting posts may produce a higher stress during placement resulting in root fracture (Cooney, Caputo, and Trabert, 1986). For these reasons, most studies suggest smooth surface posts and the enhancement of cements to reach the required post retention (Hagge, Wong, and Lindemuth, 2002).

Posts leading to root fracture

Prevention and management

Several points should be evaluated and considered to reduce the possibility of root fracture. A low modulus material (less stiff, more flexible) allows greater bending under load. When strain exceeds the yield point, the material is irreversibly deformed even after the load has been removed. The placement of endodontic posts creates an unnatural restored structure, because it fills the root canal with a material that has stiffness unlike that of the pulp and it is not possible to recreate the original stress distribution within the tooth (Ona *et al*., 2013). Nevertheless, it is necessary to have materials whose mechanical properties closely resemble the properties of dentin ($E = 18$ GPa) (Bateman, Ricketts, and Saunders, 2003). According to Galhano *et al*. (2005a), posts reinforced with fibers have an modulus of elasticity of approximately 20 GPa, while cast metal alloy posts and prefabricated metal posts have an E of about 200 GPa and ceramic posts about 150 GPa (Galhano *et al*., 2005b). Thus, posts reinforced with fibers have mechanical properties similar to dentin, which show a flexural modulus of about 18 GPa. Posts must also have adequate modulus to avoid distortion under load (Kinney, Marshall, and Marshall, 2003).

Akkayan and Gülmez evaluated the resistance to fracture of endodontically treated teeth restored with different post systems and concluded that teeth restored with posts that have properties closer to those of the dental structure, such as the glass fiber posts, showed favorable fractures; however, those restored with titanium and zirconia posts demonstrated catastrophic fractures (Akkayan and Gülmez, 2002).

Discoloration of the tooth with metal posts

Prevention and management

Discoloration can occur because of the metal post and it can be solved with the use of zirconia dowels (Meyenberg, Lüthy, and Schärer, 1995) and (Hochman and Zalkind, 1999), a tooth-colored ceramic. This avoids the discoloration of tooth structure that can occur with metal dowels, and the zirconia dowels produce optical properties comparable to all-ceramic crowns (Michalakis *et al.*, 2004; Toksavul, Turkun, and Toman, 2004), though retrieval of these posts can be difficult as they possess a hard surface and are very brittle.

Mechanical retention of the post

The zirconia dowel has a smooth surface configuration with no grooves, serrations, or roughness to enhance mechanical retention. As a result, the zirconia dowel does not bond well to composite resins and may not provide the best support for these dowels. They also have poor resin-bonding capabilities to dentin after dynamic loading and cycling due to the rigidity of the dowel (Dietschi, Romelli, and Goretti, 1998). Debonding and loss of retention are the most likely causes of failure associated with using fiber-reinforced posts (Segerström, Astbäck, and Ekstrand, 2006).

The relatively smooth surface of fiber-reinforced posts limits the mechanical bonding of resin cements into the post surfaces. Micro-abrasive surface treatments have been studied thoroughly to assess their effects on the bond strength between fiber posts and resin cements. The effects of these treatments depend on the hardness, size, and shape of the particles (Oshida *et al.*, 1993).

Prevention and management

Aluminum oxide (alumina) has angular surfaces that have the ability to create a rough surface on posts, allowing luting cements to interlock micromechanically with post surfaces. However, the volume lost from the fiber post surface might affect the mechanical properties of these posts (Goracci and Ferrari, 2011). It has been shown that micro-mechanical retention is improved greatly with the use of airborne alumina particles (Prithviraj *et al.*, 2010). Air abrasion should be used but with caution to avoid removing excess material from the post surface.

Pin complications

Dentinal failures and lateral cracks due to pin installation

Prevention and management

Lateral cracks in dentin may be caused if a dull drill is employed during channel preparation. Every time a drill is used, a small notch may be made on the drill shank, indicating the number of times it is used.

Limiting the use of presently available drills to the preparation of five channels will provide substantial assurance against cracking, although the force exerted on the drill may also be a factor (Standlee and Caputo, 1993; Standlee, Caputo, and Hanson, 1978). Using a stepwise approach may offer significant advantages in pin placement. The first step involves locating or creating a flat surface in dentin and then with stepwise approach may offer significant advantages in pin placement. The first step involves locating or creating a flat surface in the buildup or restorative material (0.5 mm minimum) and the pulp chamber. The initial drill should be smaller than the final pin drill. One technique recommended by the author is to use a drill with a 2 mm depth limiting shoulder and a diameter of 0.017 smaller than the final pin drill. A self-shearing pin (Max 021, diameter 0.023.02 Coltene–Whaledent) is then placed with a slow-speed latch-type attachment. This approach creates a straight pin channel and secure pin, and the Max 021 system uses a pin with a depth-limiting shelf to prevent pin overextension and a rounded retentively designed head to prevent untoward stresses in the final restoration or buildup material.

Periodontal problems from pin perforations into periodontal tissues

Prevention and management

Small perforations into the periodontal ligament may be repaired by the removal of the protruding pin portion. This is achieved by creating a gingival flap sufficient to gain access and cutting away the excess pin with a fine diamond bur used in an air turbine handpiece and cooled with water. The tooth surface is then polished with abrasive strips and topical fluoride applied before the gingival flap is sutured back into position (Figure 1.5).

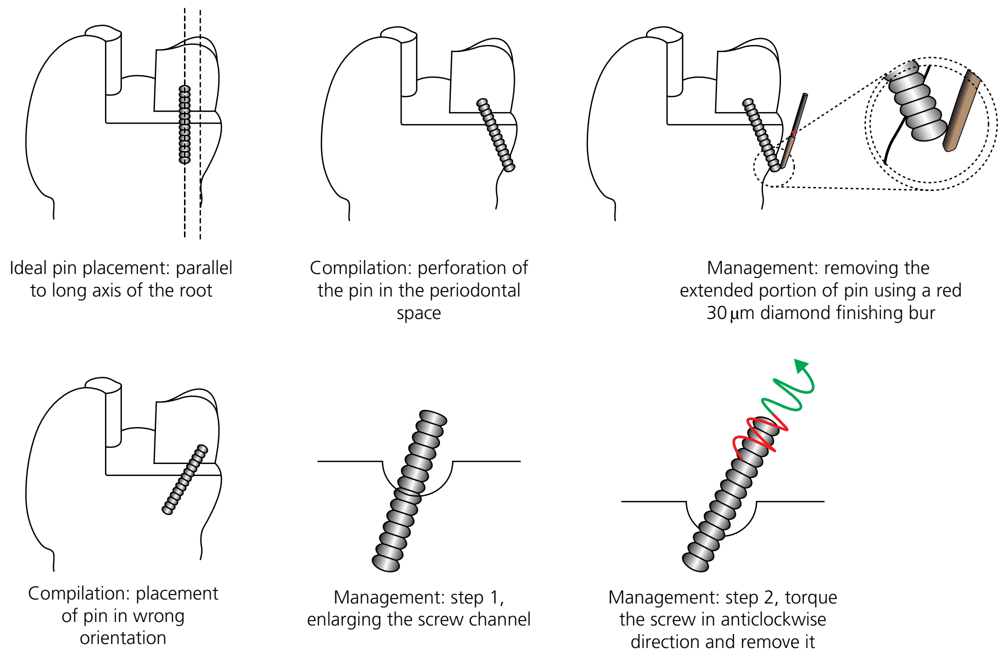


Figure 1.5 Approaches in treating pin perforation.

Proximal contact complications

The placement of direct composite restorations that involve posterior proximal surfaces is common in most dental patients. Unlike dental amalgam, which can be a very forgiving material technically and can be condensed against a matrix band to create a proximal contact, proper placement of composite restorative materials presents a unique set of challenges for the restorative dentist.

The adhesion process itself is well understood by most clinicians as far as isolation and execution; however, there are some steps in the placement process that cause difficulty and may ultimately lead to a compromised proximal contact. The following areas of concern will be addressed: management of the soft tissue in the interproximal region, creation of proximal contour and contact, and finishing and polishing of the restoration.

Improper proximal contact and contour

A major challenge for the dentist is to recreate a physiologic proximal contact with the adjacent tooth and, at the same time, restore proper interproximal anatomic form given the limitations of conventional matrix systems. It is widely accepted that proximal contacts are very important features in a properly functioning dentition. A lack of proximal contacts contributes to food impaction, secondary caries, tooth movement, and periodontal complications (Lacy, 1987).

Prevention and management

The thickness of the matrix band and the ability to compress the periodontal ligaments of the tooth being restored and the one adjacent to it can sometimes make the restoration of proximal tooth contact arduous at best. When separation is required for restorative procedures, such as placement of a class II resin composite restoration, special separation rings (G-Ring, Garrison Dental; V-Rings, Triodent; Palodent BiTine rings, Dentsply) are routinely more predictable than wooden wedges (Loomans *et al.*, 2007).

In three-surface class II MOD resin composite restorations, tighter proximal contacts were obtained when separation rings and sectional matrix bands were applied simultaneously for both proximal surfaces (Saber *et al.*, 2011).

The use of a sectional matrix band helps achieve a tight proximal contact, and the centripetal restorative technique can help to obtain contour and anatomy, minimizing the use of rotary instruments during the finishing procedures (Santos, 2015). The centripetal

Figure 1.6 Figure showing centripetal (wall) technique.

composite filling technique is a variation of the incremental buildup technique with composite for class II restorations. In the centripetal technique, the first layer of composite is placed at the site of missing proximal wall, against the band, and light cured. The matrix assembly is then removed, affording the operator greater access. Subsequent increments are then placed as if filling an occlusal restoration (Figure 1.6).

Anatomically, the posterior proximal surface is convex occlusally and concave gingivally. The proximal contact is elliptical in the buccolingual direction and located approximately 1 mm apical to the height of the marginal ridge. As the surface of the tooth progresses gingivally from the contact area toward the cementoenamel junction, a concavity exists that houses the interdental papilla. Conventional matrix systems are made of thin, flat metallic strips that are placed circumferentially around the tooth to be restored and affixed with some sort of retaining device. While contact with the adjacent tooth can be made with a circumferential matrix band, it is practically impossible to recreate the natural convex/concave anatomy of the posterior proximal surface because of the inherent limitations of these systems. In addition, they often create contact points rather than contact areas, making the marginal ridges more susceptible to fracture (Loomans *et al.*, 2008). Attempts to "shape" or burnish matrix bands with elliptical instrumentation to create an anatomic contact only "distort" or "indent" the band and do not recreate complete natural interproximal contours.

The best proximal contact areas in class II composite restorations were obtained using a sectional matrix system. The packability of the resin composite did not help to achieve better proximal contacts (Peumans *et al.*, 2001). Class II posterior composite resin restorations placed with a combination of sectional matrices and separation rings resulted in a stronger proximal contact than when a circumferential matrix system was used, due in part to the occlusal–gingival contour of the band that enhances proximal contact and contour (Loomans *et al.*, 2006, 2009). The use of circumferential bands paired with separating rings becomes more advantageous with larger restorations. A study (Loomans *et al.*, 2006) investigated the tightness of the proximal contact when placing posterior resin composite restorations with circumferential and sectional matrix systems in an in vitro model using a special measuring device (Tooth Pressure Meter). The use of sectional matrices combined with separation rings resulted in tighter proximal contacts compared to when circumferential (Tofflemire) systems were used. This new in vitro model, which uses the Tooth Pressure Meter to simulate clinical conditions when restoring class II resin composite restorations, seems to produce reliable, clinically representative results (Loomans *et al.*, 2008).

Inadequate finishing and polishing of the proximal restoration

After placing a class II composite restoration with an adequate contact, the restoration must be properly finished and polished. The posterior interproximal areas are particularly difficult to access, and special techniques must be employed to accomplish optimal restorations.

Prevention and management

After removal of the sectional matrix and BiTine (also called separating rings, G-Ring, and V-Rings) ring and wedge assembly, a sharp explorer may be used to assess the marginal integrity of the composite in the proximal areas. Dental floss is also very useful to evaluate the presence of overhanging composite material and BiTine (also called separating rings, G-Ring, and V-Rings) ring and wedge assembly, a sharp explorer may be used to assess the marginal integrity of effective in the removal of excess material interproximally. Following the gross removal step, the surface may be planed smooth with sequential (course to fine) composite finishing strips. Care must be exercised to avoid lacerating the gingival tissues and lips during this step. Ultrathin composite finishing disks may also achieve reasonable access to facial and lingual embrasures.

Overhanging margins

Prevention and management

Overhanging margins can be removed with interproximal gold knives or No. 12 scalpels. When overhangs cannot be removed, it is advised to replace the restoration. Finishing strips are usually unable to remove large overhangs.

Bulky indirect restorations with overhangs should be trimmed and polished to be flush with the tooth margins, without any overhangs prior to cementation. If not possible, a new restoration should be fabricated.

Poor registration of contacts on moist articulating paper

Prevention and management

To show occlusal contacts, tooth surfaces must be well isolated and dry (McCullock, 2003). Instructing the patient to bite on dry gauze may also further dry the teeth. Ink transfer to teeth and even highly polished restorations are facilitated with the use of even very thin articulating paper, if the paper is coated with a thin layer of petroleum jelly (Vaseline). The patient must also be positioned in the upright position in order to record more functional contacts typical with mastication.

Complications related to occlusal adjustments

False contacts on teeth caused by thick articulating paper

Prevention and management

When the excessive thickness of articulating paper exceeds the maximum recommended thickness of occlusal recording strips, it can result in false contacts (Sapkota and Gupta, 2014). To record the first point of contact, the author recommends thin strips lightly coated with Vaseline on dry teeth as noted earlier.

Perforation of crowns due to excessive occlusal grinding

Prevention and management

According to Wassell, Barker, and Steele (2002), the use of a Svensen gauge is invaluable for predicting areas vulnerable to perforation during occlusal adjustment of crowns.

A perforated crown must be sent back to the laboratory. Prevention of this complication is the only management. If the crown is perforated, the crown preparation should be reevaluated, and adequate clearance for the crown should be provided with a new crown fabricated and delivered for the best outcome.

Selecting best shaped and grit bur for occlusal adjustments with ceramics

Prevention and management

Wassell, Barker, and Steele (2002) suggest the use of a flame-shaped diamond in a high- or low-speed handpiece for occlusal adjustment. Other shapes may be employed as long as the diamond grit is 30 µm (red striped diamonds, Brasseler USA) or less, as more course grits may lead to deep scratches and crack propagation of modern ceramic materials.

Infra-occlusion

If the tooth is out of occlusion (in hypo-occlusion), the opposing tooth will supra-erupt. After supra-eruption, the proximal contacts might be lost in the opposing arch, leading to a mesial drift, which might disturb occlusal stability. If a crown is infra-occluded, a new crown should be delivered with proper occlusal contacts. In the case of direct composite restorations, proper occlusion should be built by adding material on the deficient spots. Amalgam restorations which are in infra-occlusion should be removed and replaced if occlusal stability depends on the amalgam surface.

Difficult to be certain when the mandible is in centric relation

Prevention and management

According to Long (1973) and as cited by Golsen and Shaw (1984), the use of a leaf gauge aids significantly in positioning the mandible in centric relation. The leaf gauge technique involves inserting thin plastic leaves between the anterior teeth, having the patient bite normally, and then asking them to squeeze with a centric relation. The leaf gauge technique involves inserting thin plastic leaves between the anterior teeth till the first point of contact is identified (by the patient), after which a few more leaves are added back to keep the teeth separated. At this point, centric relation may be recorded with a rigid bite registration material or hard wax.

Abfraction lesions may be a result of occlusal discrepancies

Prevention and management

Occlusal splints have been recommended to prevent the initiation and progression of abfraction lesions (Perez *et al.*, 2012); however, it is generally believed that these lesions are most likely multifactorial and may also involve abrasion from tooth brushing with abrasive dentifrices and corrosion from either intrinsic or extrinsic acid sources (Grippo, Simring, and Schreiner, 2004).

Loss of vertical dimension due to injudicious occlusal grinding

Prevention and management

Maxillary lingual cusps and mandibular buccal cusps are essential to maintain vertical dimension. It's a rule that the centric holding cusps are not adjusted unless necessary to allow for maximum intercuspal position (MIP) (Patel and Tripathi 2014). When extensive occlusal discrepancies exist, it is recommended that a centric relation record be taken and the diagnostic casts mounted. The occlusion may then be evaluated and a trial equilibration completed on the casts to use vertical dimension changes.

Inordinate amount of time is often required to adjust the occlusion of a newly fabricated crown

Prevention and management

Management required to adjust the occlusion of a new unit cast restoration may significantly decrease the chance of a lengthy clinical occlusal adjustment (Boyarsky, Loos, and Leknius, 1999). Prior to waxing the crown, for example, the technician or dentist should perform a minor equilibration of the casts to insure accurate MIP.

Complications related to gold/ceramic: Inlay/onlays

The most common technical reason for failure is loss of retention. Other reasons could be:

- Inappropriate seating of cast restorations
- Visible cement margin (Hollenback, 1943)
- Improper function and esthetics after restoring
- Inaccurate seating or fit
- Improper function and esthetics after restoring
- Secondary caries due to poor marginal fit
- Crown failures due to caries and defective margins

Corrosion of gold and amalgam

There could be corrosion of gold and amalgam placed in contact with each other. Contact of a gold surface with freshly placed amalgam will produce a silver-colored stain on the contact area of the gold.

Prevention and management

Cast gold restorations may be placed next to old or freshly placed amalgams without significant permanent corrosion of the restorations.

When these restorations are placed next to each other, it does produce silver staining; this may be polished away with pumice or allowed to wear away over time (Fusayama, Katayori, and Nomoto, 1963).

Fractured ceramic inlays

In many cases, fractures take place during the initial trying-in and cementation stage and are probably caused by the formation of local stress zone in the inlay (Dérand, 1991). Thin inlays are far more sensitive to fracture than thicker ones. Other factors that contribute to inlay fracture are the production of defects such as pores, cracks, and poor fit, as well as an exaggerated fissure system, which constitutes crack initiators and reduces the thickness of inlays.

Prevention and management

The thickness of a ceramic inlay in the direction of a load should be 1.5 mm minimum, and if it is not 1.5 mm, there could be fractures. Certain defects like pores, cracks, and poor fit may affect the strength of inlays. The occurrence of smooth supporting surfaces and softly rounded contours reduces the degree of tensile and bending stress and thereby reduces the risk of local stress concentrations. The avoidance of thin inlay edges and restricting the occlusal dimension of the inlay address these risks. Reduction of weak cusps not only reduces the risk of ceramic fractures (Milleding, Ortengren, and Karlsson, 1995) but also with the intentional extension of an inlay to an onlay will reduce the wedging effect observed with large inlays.