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 ginvectomy prior to rubber dam retainer placement, cotton roll/saliva ejector isolation, and the use of clear matrix systems for anatomical contour.
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 lingual 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 chair-side 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).
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>
<thead>
<tr>
<th>Distance from pulp (RDT)</th>
<th>Restorative material</th>
<th>Amalgam</th>
<th>Composite resin</th>
<th>Indirect restorations</th>
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<tbody>
<tr>
<td>0.5–1 mm</td>
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<tr>
<td></td>
<td>Amalgam</td>
<td>DBA</td>
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<td>Indirect restoration</td>
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<td></td>
<td>DBA</td>
<td>MTA/CaOH(_2)</td>
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<td></td>
<td>GIC liner</td>
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<td></td>
<td>Pulpal protection: MTA/Ca(OH)(_2) (deepest portion)</td>
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<tr>
<td></td>
<td>DBA as sealer</td>
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<td></td>
<td>DBA as adhesive</td>
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<td>1–2 mm</td>
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<td></td>
<td>Amalgam</td>
<td>DBA</td>
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<td>Indirect restoration</td>
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<td></td>
<td>DBA</td>
<td>MTA/CaOH(_2)</td>
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<td>GIC liner</td>
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<td></td>
<td>Pulpal protection: MTA/Ca(OH)(_2) (deepest portion)</td>
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<td></td>
<td>DBA as sealer</td>
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<td></td>
<td>DBA as adhesive</td>
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<td>Pulpal protection: optional</td>
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<td></td>
<td>Liner: GIC</td>
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<td></td>
<td>DBA as sealer</td>
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<td></td>
<td>DBA as adhesive</td>
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<td>2 mm–more</td>
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<td></td>
<td>Amalgam</td>
<td>DBA (as sealer)</td>
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<td>Indirect restoration</td>
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<td></td>
<td>DBA</td>
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<td>DBA as sealer</td>
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<td>DBA as adhesive</td>
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<td></td>
<td>*Optional base layer</td>
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</tbody>
</table>

*Optional base layer

Note: DBA stands for dentin bond agent, MTA/Ca(OH)\(_2\) stands for mineral trioxide activator/calcium hydroxide.
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 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 (Δ - 1.58%) was low and significantly less than that of Dycal (Δ - 4.58%) and of ProRoot MTA (Δ - 18.34%). The amount of water absorbed by TheraCal (Δ + 10.42%) was significantly higher than Dycal (Δ + 4.87%) and significantly lower than ProRoot MTA (Δ + 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-Grönb erg et al., 2009) with the primary reasons for replacement being secondary caries and bulk fracture of the resin (Heintze and Rousson, 2012; Sunnegårdh-Grönb erg 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,
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.
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.
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 \(E = 18 \text{ GPa}\) (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).

![Figure 1.4](image_url) Ideal post length and post diameter for a post and core restoration.
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).
Chapter 1

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).
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 30µm (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 hypooclusion), 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 Leknious, 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:
• 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.
Deep fissures in ceramic inlays

Overly deep fissures may be created in ceramic inlays by technicians, and reduced material thickness increases the risk of the inlay to fracture (Milleding, Ortengren, and Karlsson, 1995).

Polymerization shrinkage of luting agents may lead to stresses, and due to microcracks in the tooth, shooting pain may be elicited (Milleding, Ortengren, and Karlsson, 1995).

Prevention and management

It is important to inform lab technicians to maintain at least 1 mm of inlay thickness at the base of grooves. Obviously, the restorative dentist will need to provide preparations of adequate depth to afford the technician with a bulk of ceramic which is resistant to fracture.

Poorly adapted indirect restorations

Marginal adaptation (fit) is considered to be a primary and significant factor in the prevention of secondary caries and is an important indicator of the overall acceptability of the cast restoration.

Prevention and management

Methods of improving marginal adaptation and seating of restorations (Schwartz, 1986) include:

- Intentional over-waxing the margins of the wax pattern
- Removing wax from the internal surface of the wax pattern prior to fabrication
- Internal relief of the cast restoration by sandblasting
- Adjusting the intaglio with burs after using a disclosing technique (PVS or occlusal indicating sprays)
- Mechanical milling with burs with or without disclosing wax
- Internal relief of the ceramic restoration by acid etching
- Electrochemical milling (stripping, deplating) gold restorations
- Occlusal venting for escape of excess cement of fall gold crowns
- Devices to apply and maintain seating force (bite sticks)
- Vibration during cementation (with ultrasonics or hand malleting)
- Internal relief of wax by application of a die spacer to the die before fabrication of wax pattern

Inadequate retention and resistance form

What is the best method to mitigate inadequate retention and resistance form of the cavity preparation?

Prevention and management

The correction of inadequate retention and resistance form of cemented (not bonded) restorations may usually be addressed by decreasing taper and increasing preparation length. When neither of these modifications are possible, secondary fractures may be employed (Gilboe and Teteruck, 2005).

Secondary auxiliary retention features include proximal boxes, axial grooves, and the use of integral pins (parts of the casting). Adding proximal boxes will give superior results over grooves. Although cast pins are helpful, they require impression and waxing analogues, and these are difficult to locate today. An alternative to a pin is a slot, made into the pulpal or gingival walls with a 169L bur to a depth of 1.5–2.0 mm. Impressions may be easy to obtain with slots by using a small instrument (or 30 gauge needle to vent out air) to adapt the PVS impression material to the internal retentive features during the impression making (Stevenson and Patrice, 2013) (Table 1.2).

Resistance to fully seating crowns against the prepared margin due to heavy proximal contacts

Prevention and management

Insert a precision single face diamond dental strip (ContacEZ diamond dental strip) into the distal interproximal space with the abrasive side facing the crown. Pass the strip buccolingually a few times to check interproximal pressure against the strip. Repeat this procedure in the mesial interproximal space.

When more pressure is detected in the mesial than the distal interproximal space, pass the strip buccolingually a few more times (5–6 times), through the mesial space until there is light resistance in the interproximal space.

When light resistance in both the mesial and distal interproximal spaces is equal, the ideal proximal contact adjustment of the crown is complete. The proximal surface may then be highly polished with a ceramic polishing wheel.

A finished crown from the dental laboratory may present with a heavy proximal contact. Dentist should test both contacts, with dental floss to determine which contact is heavier. Many times the assumption is wrong, causing an open proximal contact on one side with the heavy proximal contact left intact on the other side. The crown then has to be sent back to the dental laboratory for porcelain addition to the open contact, or sometimes, the restoration must be remade.
Polishing

Damage to cementum at cervical area of restorations due to polishing
Prevention and management
Avoid rotary instruments over the cementum area as it may remove a layer of cementum at the cervical area (Carranza et al., 2006).

The best method to avoid damage to the cementum is to control the restorative material during placement. If small amounts of composite resin extend on to the root surface, careful removal with a curette or scalpel is preferred to rotary instrumentation. Mopper recommends that finishing and polishing should be achieved with a low-speed, high-torque handpiece, typically anywhere from 7 000 to 30 000 rpm. A high-speed handpiece may be used to precontour, but using anything over 30 000 rpm during finishing and polishing is too high. Low-speed, high-torque is preferable, because it gives the operator complete control and the side of a composite cup style polisher may be used to polish subgingival areas of class V restorations.

Dull finish on microfill composite restorations and nano-filled composite
Prevention and management
Diamond or aluminum oxide disks, rubber cups and points, and an aluminum oxide polishing paste are used to obtain the best polish on a microfill composite (Mopper, 2011; Türkün and Türkün 2004).

Finishing metal margins of porcelain fused to metal crowns
Prevention and management
Metal surfaces can be finished with finishing burs followed by rubber abrasive points (Kenda, Liechtenstein, and Shofu (brownie, greenie, and super greenie)). Abrasive disks (SofLex, 3M) are useful for flat areas such as proximal contact points and can be used on either metal or porcelain. Porcelain can also be finished with composite finishing diamonds (Premier: yellow and white stripe), but a light touch and water spray are needed to avoid stripping off the diamond coating. Further finishing is achieved with rubber abrasive points (Kenda: white) followed by a felt wheel or rubber cup with diamond polishing paste (Wassell, Barker, and Steele, 2002).

Table 1.2 Primary and secondary factors in retention and resistance form.

<table>
<thead>
<tr>
<th>1. Primary factors:</th>
<th>Correction</th>
<th>Compensatory factor (add)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Parallelism</td>
<td>Parallelism</td>
<td>Groove</td>
</tr>
<tr>
<td>b. Length</td>
<td>Length</td>
<td>Box</td>
</tr>
<tr>
<td>c. Surface area</td>
<td>Surface area</td>
<td>Pin</td>
</tr>
<tr>
<td>2. Secondary factors:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Groove</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Box</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Pin hole</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Combination of a, b, and c</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The application of principles and factors

Problem* Inadequate retention and resistance form
Parallelism
Length
Surface area

The application of principles and factors

Table 1.2

*Inadequate retention and resistance form.
Polishing of gold restorations that appear to be dull
Prevention and management
Bruce (2008) advocates the use of a system of disks and powders. The three disks recommended are paper disks of medium garnet, fine sand, and fine cuttle grit on a slow-speed straight mandrel. According to Bruce (2008) “The powders are applied using a soft rubber cup that is ribbed, not webbed, to avoid scratching the gold using a slow-speed latch-type contra-angle. The first powder is a No. 4 flour of pumice used wet; the second a 15-µm alumin.” Bruce (2008) states that this can be accomplished in small restorations using brownies, greenies, and super greenies with light pressure with higher speeds and always with an air stream to control heat.

Gingivally extensive composite restorations

Functional and esthetic failure due to inadequate contouring and polishing
Prevention and management

The initial contouring can be performed with a series of finishing burs to replicate the natural form of the tooth. For finishing the facial surface, a long, needle-shaped finishing bur is used to develop the proper anatomical contours of the facial aspect of the anterior tooth. To replicate natural form and texture, 16 and 30 fluted, needle-shaped finishing burs are used. These burs are used dry with light pressure to prevent heat buildup.

This short, tapered, needle-shaped finishing bur is used to develop the proper anatomical contours of the facial aspect of the anterior tooth. To replicate natural form and texture, 16 and 30 fluted, needle-shaped finishing burs are used. These burs are short, tapered, straight-edge finishing burs, which conforms to the straight emergence profile as the tooth emerges from the gingival sulcus. Care should be taken to avoid the cementum.

It is important to use a dry protocol and retract the gingiva with an instrument or placement of a cord, closely observing tooth structure and the gingival margin. It is important not to overheat the resin by using excessive pressure. It is also imperative not to ditch or scar the cementum at the gingival margin.

After the initial finishing procedure, the margins and surface defects are sealed. The restoration and all margins are re-etched for 15s with a 35% orthophosphoric acid, rinsed for 5s, and dried. A layer of composite surface sealant may be applied over the margins and the restoration. This will prevent leakage and seal any microfractures or microscopic porosities in the material that may have formed during finishing. The use of surface sealant has been shown to reduce the wear rate of posterior composite resins (Dickinson and Leinfelder, 1993), improve resistance to interfacial staining (Kemp-Scholte and Davidson, 1988), and decrease microleakage around class V composite resins (Estafan et al., 2000). Any excess resin can be removed with a No. 12 scalpel.

Impression problems

Improper capture of margins due to various factors such as saliva, oral fluid, and bleeding
Prevention and management

This can be solved by using gingival displacement paste like Expasyl which has been shown to have a better response in achieving horizontal displacement of the gingival sulcus than gingival retraction cord (Prasanna et al., 2013). Also, in cases of equigingival and subgingival (<2 mm) preparation margins, Magic FoamCord gingival retraction system is a less traumatic alternative method of gingival retraction than packing a retraction cord. However, when there are deep subgingival margins and a beveled preparation, the material is less effective than the single cord retraction technique (Beier, Kranewitter, and Dumfahrt, 2009). A two-cord technique works well in both vertical and horizontal retractions, with the top cord being removed prior to attempting the impression. One of the most important techniques is to dry the marginal area prior to injecting impression material in the sulcus.

There are three techniques for tissue displacement: mechanical, chemico-mechanical, and surgical. Mechanical displacement of the gingiva can be done either by the use of copper bands or with a plain retraction cord. By combining chemical action with packing of a retraction cord, a chemico-mechanical displacement of the tissue can take place. The surgical retraction is possible by laser, electrosurgery, or rotatory curettage (Levartovsky et al., 2012), where excess tissue
which impedes access to the finish line may be removed. Sulcular bleeding can be solved by using racemic epinephrine cord or aluminum sulfate cord, which are more effective than non-medicated cord. Hemorrhage control with a cord saturated in Hemodent is more effective than water-saturated or dry cords (Weir and Williams, 1984).

**Voids and bubbles in the impression**

**Prevention and management**

Addition of polyvinyl siloxane impression materials can solve this. They exhibit low contact angle values and the least number of voids in the die stone cast when compared with polysulfide impression materials (Reddy et al., 2012). A key principle in reducing voids is to thoroughly dry the teeth and preparations which will be impressed. The technique of impressing the preparation where every area of the surface is completely covered with a low-viscosity syringed material helps to reduce axial wall voids and creases caused from the difference in syringe and tray viscosities.

**Gag reflex experienced by the patient during the impression taking**

**Prevention and management**

If the patient has a gag reflex, try to mix thick alginate, so it does not flow in the sensitive area in the back of the throat and posterior aspects of the soft palate and faucial pillars. The patient should be made to sit upright, and legs should be raised. Salt on tongue has proven effective, while some indicate topical analgesia in the sensitive areas for the same (Farrier et al., 2011).

Audiotapes of relaxation procedures that include imagery, progressive muscle relaxation, and self-suggestion components should be given to the patient with instructions that the constant practice of listening to them might reduce his/her arousal level sufficiently to decrease or eliminate the gagging response (Neumann and McCarty, 2001). The use of acupuncture in controlling the gag reflex is an effective method of controlling severe gag reflex as well, during dental treatment including impression taking (Rosted et al., 2006). Also, the fears related to dental procedures should be discussed with the patient, and the patient should be advised to practice relaxation several times a week.

With routine single tooth posterior crowns/inlays/onlays, a double bite tray may often be used to eliminate gagging, versus using a full-arch impression technique.

**Bleaching**

More than 100 million Americans whiten and/or bleach their teeth and spend an estimated $15 billion (Krupp, 2008). Bleaching/whitening of teeth is a very demanding procedure now, and clinicians should be aware of the complications and challenges that might be attached to it.

**Difficulties/challenges before bleaching**

**Special cases**

Tetracycline-stained teeth: Tetracycline is an antibiotic, which causes permanent discoloration of teeth which vary from yellow or gray to brown. Tooth staining/discoloration with tetracycline is influenced by the dosage used, length of treatment or exposure, stage of tooth mineralization (or calcification), and degree of activity of the mineralization process. It has been found in a study that “when used daily for 6 months, a 6.5% H₂O₂ bleaching strip can be effective in whitening tetracycline stains. The professional strip was well tolerated throughout the 6-month period” (Kugel et al., 2011).

Fluorosis: Endemic dental fluorosis is usually known as mottled enamel and can be defined as enamel hypoplasia characterized by moderate to severe staining of the tooth surface. Fluorosis becomes clinically significant when the patient has a prolonged history of ingesting water that contains more than 1.0 ppm of fluoride ion. The more the concentration of fluoride ion, the more severe the condition becomes (Bailey and Christen, 1968).

Sundfeld et al. indicate the use of enamel macroreduction, enamel microabrasion, followed by home bleaching with carbamide peroxide (Opalescence, Ultradent Products) to remove the texture of the intrinsic white enamel stain of hypoplastic areas and mild erosion due to dental fluorosis (Parinitha et al., 2014) (Table 1.3).

**Complications during whitening treatment**

**Sensitivity**

It has been found that the most common side effect of tooth bleaching is sensitivity of the teeth, and we can observe that in 15–78% of the patients (Dahl and Pallesen, 2003). If a patient experiences more than a
moderate degree of tooth sensitivity, stop the treatment and place potassium nitrate as a desensitizing gel for about 20 min on the sensitive teeth (Zekonis et al., 2003).

Gingival irritation

High hydrogen peroxide concentrations are caustic to gingiva and oral mucosal tissues, which might cause burns and bleaching of the gingiva. To prevent an insult to the tissue, design a stiff tray that has contact solely with the teeth (Dahl and Pallesen, 2003).

Complications post whitening treatment

Posttreatment temperature sensitivity after bleaching is a common complication in up to half of vital tooth cases. However, the mechanism is not fully understood, but it is believed that the sensitivity results from pulp reaction to the bleaching agent in the early stages of treatment and it could last for 2–3 days (Li and Greenwall, 2013).

Prevention and management

To prevent this scenario, you should evaluate the tooth before bleaching by assessing the tooth vitality using the cold test and the electric pulp test; also looking at the periapical radiographs is important to rule out any possible sensitivity due to compromised situations (e.g., a cracked tooth) that already exist. If the teeth become sensitive after the treatment, the dentist can advise the patient to use a desensitizing toothpaste, and if this approach does not relieve the discomfort, after multiple applications, the dentist can start with the fluoride gel or any special desensitizing agent (Croll, 2003).

Postoperative hypersensitivity

Postoperative hypersensitivity (POH) refers to the pain associated with mastication or sensitivity to hot, cold, and/or sweet food or beverages, which is present from a few days to weeks after the tooth has undergone restoration. Pain that occurs during clenching only, indicating a restoration in hyperocclusion, usually is excluded from the definition of POH. Sensitivity can be measured clinically or by the participant’s own report or both. (Strober et al., 2013).

Bonding failures

The longevity of resin-based composite restorations is compromised when bonding between the resin and interior cavity walls fails to prevent marginal microleakage. The passage of water and other species (microorganisms) into the space between the resin material and cavity wall may give rise to postoperative sensitivity, secondary caries, and further physical deterioration of the marginal seal (Christensen, 1996; Kohler, Rasmusson, and Odman, 2000; Van Nieuwenhuysen et al., 2003).

Inadequate air drying may also cause sensitivity after restoration. To be more precise, an explanation of the reduction in bond strengths seen with no air-drying was that solvents, such as water and ethanol, might act as inhibitors for the polymerization of resin components in adhesive (Cho, 2004).

Some self-etching primer bonding systems show dentin bond strengths that are less than adequate if the enamel surface was not air-dried or if air-drying was prolonged for more than 5 s after application of self-etching primer. Clinicians using these simplified systems
must be aware of technique factors that can influence bond strengths (Chiba et al., 2006).

**Prevention and management**

Apply two or more coats of bonding agent, air thinning, and curing each layer individually according to the manufacture instructions. Air thinning was advantageous with a 3 s blast of air as compared to 1 s (Bonilla et al., 2003).

Changing material: The SE resins are the most foolproof way to eliminate postoperative sensitivity.

**Large restorations can cause greater sensitivity**

Al-Omari, Al-Omari, and Omar (2006) showed that short-term (2–30 days) postoperative sensitivity was affected by lesion depth (27% of the middle-third lesions, 58% of the inner third lesions), whereas medium-term (>30 days) postoperative sensitivity was affected neither by the method of cavity treatment nor by the depth of lesion. Furthermore, the larger the cavity preparation, the greater the area of dentinal tubules exposed. Likewise, the deeper the cavity, the wider the dentinal tubules. These morphological factors could explain why deeper cavities had more reports of postoperative sensitivity and pain (Auschill et al., 2009). This might also help to explain why class II cavities had more postoperative sensitivity than class I cavities.

**Management**

1. Sandwich technique (Figures 1.7 and 1.8):
   Resin-modified liner + glass ionomer as a body + layer of composite

2. Incremental layering of composite to rebuild the dentin and then place cusps individually to eliminate cross tooth shrinkage (Deliperi and Bardwell 2006a, b).

3. The use of indirect restorations in large restorations (inlay, onlay) or PFM:
   The indirect technique allows for the production of restorations in the laboratory after impression making. Appropriate proximal contour and contact and control of anatomic form can be easily achieved. In the direct inlay/onlay technique, the restoration is formed directly in the cavity; after an initial cure, it is removed from the cavity and post-cured in a heat and light oven. Improved mechanical and physical properties are expected, compared to the direct light-cured-onlay composite due to the overall increase in conversion (Wendt, 1987a, b).

   A higher stress relaxation and improved marginal adaptation are also expected. The amount of shrinkage is limited to the thin luting resin composite layer (Shortall and Baylis, 1991).

**Miscellaneous complications in restorative dentistry**

**Overheating of pulp**

The accidental overheating of the pulp during cavity preparation can cause sensitivity, especially when the remaining dentin thickness is less than 1.5 mm and when there is inadequate water coolant sprayed during cavity preparation with high and low torque handpieces.
Prevention and management
Sufficient water cooling is necessary, and if dry cutting is used, one must use it with light pressure and limit the bur-contact time to less than 20 s at a time during cavity preparation with high- and low-torque handpieces (Kwon et al., 2013).

Thermal hazard to pulp
The following are the potential thermal hazard to the pulp and supporting tissue that might result from routine clinical procedures:
1 Tooth preparation
2 Light curing of composite resin
3 Fabrication of provisional crown
4 Thermoplasticized root canal obturation
5 The use of ultrasonic devices in post or file removal

Prevention and management
Clinical guidelines are summarized in the succeeding text:
Tooth preparation: Sufficient water cooling is necessary, and if dry cutting is used, one must use it with light pressure and limit the bur-contact time to less than 20 s at a time during cavity preparation with high- and low-torque handpieces.
Light curing of composite resin: A 1–2 mm thick insulation layer of glass ionomer in deep cavities with residual dentin thickness of 0.5 mm and two-step curing or ramp curing are recommended for complete polymerization and less heat generation.
Fabrication of provisional crowns: In vital crown preparation, air-water spray must be used as a cooling technique. One can also use the putty matrix as a heat sink, and depending on the situation, the putty matrix can be refrigerated.
Thermoplasticized root canal obturation: The heat source activation must be limited to 3 s, and efforts must be made to limit the amount of heated GP injected at one time, especially in dangerous zones where the dentin wall is very thin, such as the mandibular incisors and mesial canal of the lower molars.
The use of ultrasonic devices in post or file removal: One must use the smallest ultrasonic tips for the lowest power, together with at least 40 ml/min of water cooling. The tip-contact time must be limited to 60 s at a time.

Excess cement removal during crown cementation
Prevention and management
Lowe (2011) suggests that at the smallest ultrasonic tips of the lowest power, together with at least 40 ml/min of water, cooling spray should be used to remove excess cement. Furthermore, a sonic or piezo scaler with water spray can also be used carefully to ensure complete cement removal from the sulcular areas.

Resin cements prone to postoperative sensitivity
Prevention and management
Using self-etching primers before cementation and avoiding the total-etch procedure on teeth receiving resin-cemented restorations can reduce or eliminate this problem (Christensen, 2002).
Improper seating of restoration during cementation of a crown
Prevention and management
If a restoration has been seated incorrectly and this problem is determined almost immediately after cementation, gently tapping on the restoration may help remove it (Christensen, 2002). Unfortunately, the more common occurrence is that the restoration may not be easily dislodged from the tooth and will require bur sectioning to remove it, thereby requiring the fabrication of a new restoration. If care is taken not to damage the finish line area of the preparation during removal, the original die may be used to fabricate a new restoration without the need for a new impression, assuming the die itself is also undamaged.

Set cement in the contact area
Prevention and management
Remove the most coronal portion of cement between the observable occlusal contact areas. After clearing the most coronal aspect with a sharp instrument or an explorer, the next step would be to clean the area around the contract. Apply gentle force between the teeth with a blunt instrument such as a beaver-tail burisher and push waxed dental floss through the partially open contact area to remove the cement (Christensen, 2002). Another technique is to use any of the interproximal stripping materials, like diamond-coated finishing strips. Some of these are available with serrated edges to facilitate cement removal.

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