

Improving your margins

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A restoration's margin marks the transition between the restoration itself and the finishing line of the adjacent tooth tissue. This is a critical area and when careful tooth preparation is combined with an appreciation of the needs of the technician, in terms of the physical requirements and limits of the chosen restorative material, the resulting restoration can be both like-like and durable (Figure 1). Unfortunately, crown margins are all too often considerably less than satisfactory (Figure 2) with tooth/restoration interface representing a significant clinical weak point for the following reasons:

- Any marginal discrepancies disrupt smooth tooth surfaces and hence render the site vulnerable to plaque accumulation while microleakage at the margin allows the passage of ions, molecules, fluids or bacteria between the prepared tooth and the restorative material (Taylor 1992).
- In the case of tooth-coloured restorations, visible margins often detract from the overall aesthetic result by highlighting relative differences in shade, translucency and surface finish of the restorative material and the adjacent tooth structure. After a period of time this is often exacerbated by staining of the junction.
- The restoration is often at its thinnest in the marginal region and hence at its most vulnerable to failure, depending on the material used, and the forces being exerted on the margin.

Finishing line/restoration margin design

This is largely dictated by the choice of restorative material (Figure 3). For example, margins for all-ceramic restorations differ from those recommended for all-metal restorations

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Figure 1: Excellent clinical technique allows the technician to produce beautiful restorations with excellent marginal fit and correct emergence profile.

and finally for porcelain-fused-to-metal (PFM) restorations which in turn may require different margins within the one preparation depending on whether metal or porcelain is required at the restoration/tooth interface.

Full veneer metal crowns

The knife-edge finishing line is commonly used in these situations because of its simplicity and conservative nature. The resulting feather edge on the crown is possible because of the metal's strength and ductility. Chamfers and shoulders (see below) are also possible although problems may arise should shrinkage of the metal during casting lead to a gap between tooth and preparation.

Porcelain-fused-to-metal (PFM) restorations

PFM restorations are far and away the most commonly-prescribed of all indirect restorations worldwide owing their popularity to their acceptable aesthetics, strength, durability, simplicity and versatility. When planned and executed properly, the PFM restoration is capable of providing a reasonable aesthetic outcome although



Figure 2a



Figure 2b



Figure 2c

Figure 2: Microleakage is clearly visible within the chamfer margin of this ceramic veneer (Figure 2a) while gross deficiencies result in extremely unaesthetic restorations (Figures 2b and c).

without due care and attention all too many appear lifeless and unnatural. The most common cause of this is inadequate tooth reduction leaving the technician with insufficient space for sufficient thickness of veneering porcelain to block out the metal substructure. The result is usually an overbuilt dull, opaque-looking crown (Figure 4). For PFM restorations to have any chance of appearing lifelike, sufficient tooth structure must be removed to accommodate both metal and ceramic (Barghi 1982). Chiche (1995) recommends a facial reduction of between 1.4mm and 1.7mm (as recorded at the junction of the incisal and middle thirds of the crown where the opaque layer is likely to be most visible as a result of insufficient tooth reduction.) This degree of reduction is, however, simply unrealistic in the cervical region.

A number of different designs of finishing line have been advocated for PFM restorations although a study conducted by Butel (1991) found there to be little consensus on the matter in U.S. dental schools. Some of the most commonly prescribed types of finishing line are as follows:

The beveled shoulder

When PFM restorations were first introduced in the 1960s the metal collar was considered to represent the ideal margin for reasons of marginal seal, periodontal health and rigidity (Stein 1987). The most commonly-prescribed finishing line to accommodate this type of margin was the beveled shoulder, based on the notion that its use would reduce the marginal opening of the gold casting. Bevels in excess of 70° were thought to be ideal although this all too often led to the unsatisfactory situation of margins being sited at the base of the gingival crevice (or even beyond that point) in an attempt to hide the metal collar necessary that accompanied such preparations. However,

even if the collars are hidden within the gingival sulcus, recession will eventually reveal them.

Knife edge

Discussed earlier in this article this design is still commonly used for PFM restorations where it clearly necessitates the use of a metal collar as the marginal porcelain would otherwise be too thin and unsupported and would be very prone to chipping. If a knife-edge finishing line is to be used then the butt joint necessary to accommodate the porcelain has to be created within the metal coping further coronally. Despite its theoretical conservatism, there is a tendency when this type of finishing line is used in combination with PFM restorations to under-prepare the axial walls leading to the resulting crown being bulky and unaesthetic. Conversely, in an attempt to create sufficient space for porcelain and metal the preparation is often over-tapered leading to an unretentive final restoration.

The flat shoulder

This design has, over time, replaced the beveled shoulder as the resulting butt joint permits the use of a bulk of porcelain at the margin, thus removing the need for a metal collar (Figure 5).

A shoulder width of 1mm to 1.5mm at a 90° to 100° angle to the root surface is ideal, offering optimal rigidity (by virtue of support provided by the underlying metal coping) and resistance against porcelain shrinkage (Campbell 1992).

The axial line angle should be rounded to reduce stress concentration in that area.

The chamfer

This is now the finishing line of choice for most cast veneer preparations and hence recommended for any part of a

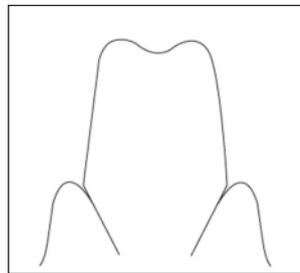


Figure 3a: Knife or feather edge

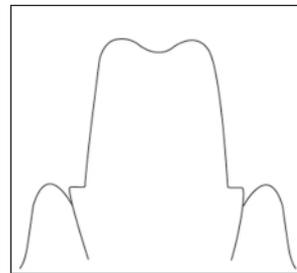


Figure 3b: Shoulder

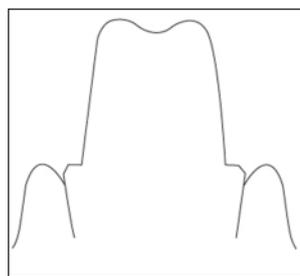


Figure 3c: Beveled shoulder

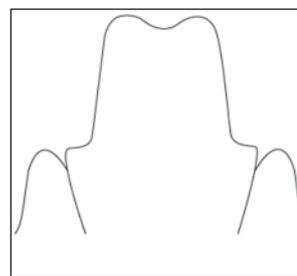


Figure 3d: Chamfer

Figure 3: Commonly prescribed finishing lines include the feather- or knife-edge (Figure 3a) flat shoulder (Figure 3b) beveled shoulder (Figure 3c) and chamfer (Figure 3d). These diagrams may appear very basic but it is the author's experience that many dentists often fail to create appropriate finishing lines.

PFM restoration with a metal margin. Chamfers are less likely to have undercuts and are generally considered to be more conservative than shoulder preparations although a similar degree of tooth reduction is required. If chamfers are to be used in conjunction with a porcelain margin then they must be deep enough to ensure sufficient bulk of marginal porcelain to resist fracture and to resist the tendency of porcelain to shrink towards its greatest bulk during firing.

Whichever design is chosen, proper finishing of the preparation is essential to ensure the smoothest possible transition between tooth and restoration. End-cutting burs, rubber points and hand instruments have all been advocated for this purpose.

All-ceramic restorations

Non zirconium-based all-ceramic restorations such as the pressed ceramics e.g. Empress (Ivoclar Vivadent) and Procera Alumina (Nobel Biocare), are far more translucent than any PFM restoration and nowadays are the restoration of choice for anterior crowns and simple three unit bridges. Once again though, adequate tooth reduction, permitting sufficient ceramic thickness, is vital and for these restorations to function correctly the

porcelain must be fully supported and be of adequate thickness (Figure 6). Ideal finishing line design is therefore a 1mm (minimum 0.8mm) wide 360 degrees deep chamfer with no sharp internal line angles which might induce stresses in the ceramic material leading to fracture. The finishing line should follow a smooth curvature that remains relatively shallow interproximally to avoid a deep V-shaped notch, which could result in a split between the labial and lingual aspects of the crown (Lehman 1962). Care should be taken to avoid flattening this area too much as this may, in extreme cases, lead to damage to the transeptal fibres. All margins must be carefully smoothed for the same reasons described earlier.

Increasingly, zirconium-based crowns and bridges are being used in place of PFM ones. While the zirconium substructure is also opaque it is nevertheless much lighter in colour and therefore masking it is less of a problem than with a PFM restoration. Some systems use a very white coping material while, increasingly, manufacturers are offering multiple shaded copings. As with the PFM restoration, it is possible for the technician to trim the coping back in order to create a more natural cervical margin. For this reason it is likely that if and when gingival recession occurs the resulting visible margin will most likely



Figure 4: Under-prepared teeth coupled with inadequate and inappropriate margins have resulted in these over-built, completely unnatural looking, restorations.



Figure 5: Carefully prepared shoulders enable the technician to create aesthetic PFM restorations with sufficient bulk of porcelain at the margin.

be less offensive than the exposed margin of a PFM restoration. A deep chamfer is again the ideal marginal preparation to allow for the zirconium coping and overlying veneering ceramic.

Position of finishing line relative to gingival margin

The position of the margin relative to the gingiva (i.e. sub, equi- or supra-gingival) is driven by a variety of factors, for example position of the tooth in the mouth, height of lip line, periodontal status and stump shade of the underlying tooth. In an ideal world, all restoration margins would be placed supragingivally thus making preparations, impression-taking, cementation and finishing procedures easier as well as facilitating oral hygiene procedures for the patient. As we all know, there are a number of patients for whom the aesthetic outcome is of relatively minor concern and for whom longevity and function are more important. Such patients may not mind supragingival margins and may even tolerate PFM restorations with metal collars. Increasingly, however, patients are far more concerned than in the past about aesthetics and appearance. The question then becomes one of choosing the most appropriate material, balancing appearance with longevity. Certainly, there does seem to be less and less justification for using PFM restorations to restore anterior teeth given their lack of translucency and the widespread availability of highly aesthetic pressed ceramic systems. Even if the margins of PFM restorations were to be placed slightly subgingivally it is usually only a matter of time before the gingival tissues recede and the dark, unattractive, margins become visible (Figure 7). These days, anterior PFM restorations are therefore usually reserved for the following situations:

- in patients exhibiting excessive occlusal loading, tooth wear, bruxism etc or where insufficient interocclusal

clearance exists to accommodate porcelain. Here, a palatal metal surface is highly beneficial because of its resistance to fracture.

- where the degree of tooth discolouration to be masked is such that the restoration's inherent opacity becomes an advantage.

In the latter scenario, the translucency of pressed ceramics can, for once, be a disadvantage as the underlying tooth discolouration is likely to influence the shade of the overlying restoration. While the use of PFM crowns or opaque ceramic systems and luting agents help overcome this any visible transition between restoration and underlying tooth becomes extremely noticeable. It is likely that over time zirconium-based restorations will be used instead of the PFM restoration in such situations provided they exhibit the same degree of longevity and durability.

In many clinical situations however, the translucency of pressed ceramics is an advantage and permits the use of equigingival, or even supragingival margins. For a supragingival transition between restoration and tooth not to be observable the margin of the ceramic should be extremely thin and feathered and extreme care has to be taken when bonding the restoration to underlying enamel. It is important to stress that such restorations should be bonded to an enamel, as opposed to dentine, substrate because of the relative predictability and strength of the bond to the former. The procedure clearly requires very precise clinical technique (in terms of preparation and choice and use of luting cement) and excellent technical support. Such an approach does permit extremely conservative preparations and is useful in situations where it would be impractical to extend the margin to the gingival level for example, in the restoration of teeth affected by gum recession.



Figure 6: All-porcelain restorations, such as this zirconium three-unit bridge, require deep chamfers without any sharp internal line angles. Feather edge preparations are completely contra-indicated.



Figure 7: Wherever a finishing line is placed in relation to the gingival margin it will, in time, most likely appear supragingivally as a consequence of gingival recession.

Accuracy of fit

Marginal accuracy of fit is considered to be one of the most important criteria for clinical quality and success as increased marginal discrepancy can promote cement dissolution, microleakage, increase plaque retention and caries. The question is 'What exactly is acceptable accuracy?' Several authors have attempted to determine what constitutes clinically acceptable marginal openings that are not visible to the naked eye and are undetectable with a sharp explorer. Christensen (1966) evaluated the fit of subgingival and supragingival margins with a group of dentists and stated that the least acceptable marginal discrepancy in visually accessible surfaces was 39 microns. Lofstrom and Barakat (1989) used a scanning electron microscope to measure the supragingival margins of crowns that were considered clinically well-fitting by several dentists and reported marginal discrepancy values in a range of 7 to 65 microns. In-vitro studies (Sulaiman 1997) have revealed gaps of 64 to 83 microns in CAD/CAM-generated all-ceramic single tooth restorations, seemingly above the limit suggested by Christensen.

Management of the interface between restorative material and cavity is a critical factor in reducing the effect of microleakage. One of the most significant problems affecting restorative dentistry today is the failure of restorative materials to completely bond to enamel and, even more so, to dentine. The ensuing microleakage has been shown to result in a variety of sequelae (Taylor 1992) including hypersensitivity of restored teeth, discolouration at the margins of cavities and restorations, recurrent caries, pulp inflammation and failure of endodontic treatment.

Careful finishing of the preparation is essential if the

technician is to be able to visualise the margins clearly - it is not enough to say that the luting cement will fill any voids that exist between the tooth and the restoration. Prior to cementation, and once the fit has been assessed and corrected where necessary, the fitting surface should be cleaned, acetone being one of the most widely recommended agents for this purpose (Swift 1995, Della Bona 1994).

The aim is to minimise contamination of the margin as much as possible. The prepared tooth should also be cleaned prior to etching. Prophylaxis paste containing fluoride is contra-indicated as the presence of the fluoride has been shown to compromise bond strength. For many years, the etching of tooth enamel and dentine with phosphoric acid (the so-called 'total-etch') to create micromechanical retention of resin tags has been almost universally accepted by the profession. More recently though, the use of weaker acids, which do not require washing of the tooth surface after acid application and which leave the smear layer on the dentine and lead to a less aggressive etching of the enamel has gained popularity. Such self-etch systems are thought to produce much less post-operative tooth sensitivity as compared with the total-etch approach (Perdigao 2003). This may be linked to the finding that self-etch dental adhesive systems could contribute to the elimination of residual bacteria and hence reduce the risk of secondary caries at the restoration margin (Feuerstein 2007). This all begs the question Which etching technique is most appropriate? Christensen (2006) advocated the following approach for those preparations which involve both exposed enamel and dentine:

- 1) Selectively etch the enamel with a well-controlled,

viscous phosphoric acid gel.

2) Wash the phosphoric acid gel from the tooth with a significant amount of water spray. If it is washed slowly, the gel acid is spread all over the tooth preparation, thus etching it and reducing the sensitivity-prevention advantages obtained with self-etching primer application.

3) Place the self-etching primer and bonding agent on the entire preparation, including the enamel that has been etched with the phosphoric acid gel. Do not cure the primer/bonding agent before seating the restoration otherwise the restoration will not seat fully owing the film thickness of the self-etching bonding agent. Exceptions to this are with some of the newer generation self-etching primers which exhibit extremely thin film thicknesses.

Prior to seating the restoration, floss should be placed into the interproximal areas, the restoration is then seated and, with an assistant holding it in place firmly with an instrument, the floss moved in an occlusal/gingival direction thus removing excess luting agent at the gingival margin. The floss is then removed towards the buccal or lingual. With the restoration still firmly seated a fine brush can be used to remove 95% of the excess luting agent from the margins. Some operators prefer to cure the resin for a very short time, three to four seconds, and then carry out removal of excess resin as they find that the material peels away from the tooth more cleanly. Despite the earlier warning contraindicating subgingival preparations, should these occur, the latest research suggests that use of a resin-modified glass-ionomer cement leads to significantly less microleakage at the enamel margins compared to self-cure or dual-cure resin cements (St Germain, 2002).

While the goal is to reduce the amount of finishing required to a minimum there will always be situations, however, where some is necessary. The use of a series of finishing grit diamonds followed by a 30-fluted carbide bur and polishing pastes will produce highly satisfactory results. Polishing under water spray has also been shown to produce a smoother surface than dry polishing (Haywood 1989). Despite these apparently reassuring findings the general consensus is that the less finishing that needs to be done the better.

Conclusion

Crown margins play a critical role in determining the long term-viability of not only the restoration itself but also the adjacent supporting tissues. Thought must be given therefore to designing and creating appropriate finishing

lines depending on the restorative material being used, the desired aesthetic outcome, occlusal considerations and the condition of the underlying tooth structure. As with all things in dentistry, the old adage Fail to plan, plan to fail holds true. Adequate thought and planning combined with proper implementation radically improves the chances of a successful outcome.

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