

## Part I

### Rationale

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## 1

## The Traditional Mechanically Retained Restoration Paradigm: Subgingival Margins are Normal and a Necessary Byproduct of Restorative Needs



Four images showing periodontal inflammation caused by subgingival margin placement.

### Introduction

In traditional mechanically retained dentistry such as full crowns, subgingival margin placement is considered to be normal, necessary, and a byproduct of traditional restorative techniques. The over 37 million crowns placed every year by dentists in the United States [1,2,3]

show that it is by far the most popular indirect procedure, regardless of the material used, and is viewed as ideal for most cases, predictable and relatively easy to perform. However, familiarity must not be confused with simplicity [4,5]. Partial coverage supragingival adhesive techniques are often considered to have a more unpredictable outcome, to be more difficult to perform and



**Figure 1.1** Veneer and crown with deep subgingival margins, and poor periodontal health.

less successful in general. It is human nature to think that what we do every day and know well is better than something unfamiliar.

Yes, tooth-colored restorative materials are currently extremely popular, but often these new materials are being used in conjunction with traditional mechanically retained techniques, and some computer-aided designed and manufactured (CAD-CAM) restorations. This often leads to subgingival margin placement. When all ceramic full crowns, inlays, onlays, and veneers are performed using principles and techniques extrapolated from traditional mechanically retained principles such as unnecessary subgingival margin placement, there is a risk of increased failure, postoperative sensitivity, pulp injury, non-esthetic results, and a defective margin. All these outcomes will result in an unhealthy periodontium. This incorrect use of modern restorative and adhesive materials ultimately produces no net benefit to the patient or the dentist (Figures 1.1–1.4).

The negative consequences of periodontal disease are well understood, as they affect not only the longevity of



**Figure 1.2** Recently completed computer-aided design and fabricated IPS e-max® (Ivoclar) crowns. The patient had severe sensitivity, and the gums were inflamed and bleeding. Some of the margins were deep subgingivally, especially interproximally.



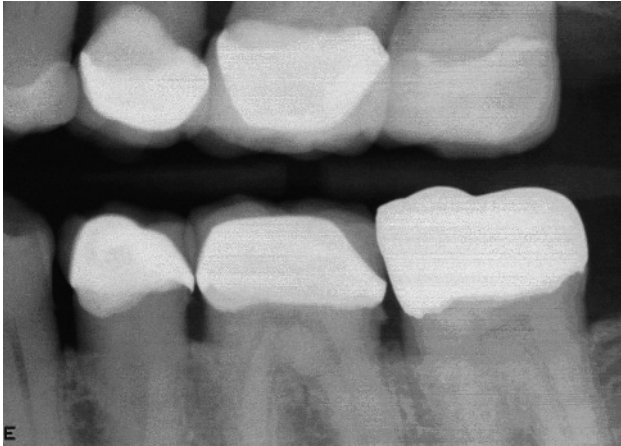
**Figure 1.3** Improperly aggressive preparation for a zirconia crown. Both lateral incisors required root canal therapy, owing to damage to the pulp.

the teeth but also the overall health of our patients. The negative consequences of subgingival deposits of tartar in the ultimate periodontal health of our patients are also understood [6,7]. Overhangs and open margins (in fact, any defective margin, when it is subgingival) have the same effect as permanent tartar on the periodontal health of our patients (Figures 1.5–1.8) [8,9,10,11]. Taking the above statement into account, supragingival restoration margin placement would be ideal, and most clinicians, if asked, would say that this would be their first choice [12]. This prompts the question why are so many crowns, onlays, veneers, and direct class II and many class III restorations being placed with a subgingival margin? The reality is that habit instills the idea that placing margins subgingivally is a “normal” and necessary adverse effect. Subgingival margin placement is so common that it goes undetected and unnoticed. When using traditional mechanically retained restorative principles, it is believed that subgingival margin placement has important advantages, which outweigh



**Figure 1.4** Bonded onlays with deep subgingival margins. The extreme difficulty of bonded cementation with bleeding subgingival margins led to catastrophic failure.





**Figure 1.5** Periodontal tartar in proximity to defective crown margins, with similar unhealthy effects.

the negative consequences. Subgingival margin placement should no longer be considered normal or necessary. The continued use of mechanically retained traditional restorative dentistry principles has many disadvantages, and the solution is supragingival minimally invasive adhesive dentistry, which is discussed in subsequent chapters. First, it is important to understand how unnecessary subgingival margin placement happens, and the consequences of such placement.

## Subgingival Restorative Margin Placement

Subgingival margin placement is a byproduct of traditional restorative techniques. The majority of these types of restoration include subgingival margin placement, and it often goes unnoticed. There are four primary reasons why the margin is placed subgingivally, and a fifth which is based on misinformation:

- 1) Mechanical retention and lack of trust in adhesion
- 2) Traditional restorative techniques, boxes, and cervical clearance



**Figure 1.6** This patient was happy and unaware of unhealthy gingiva.

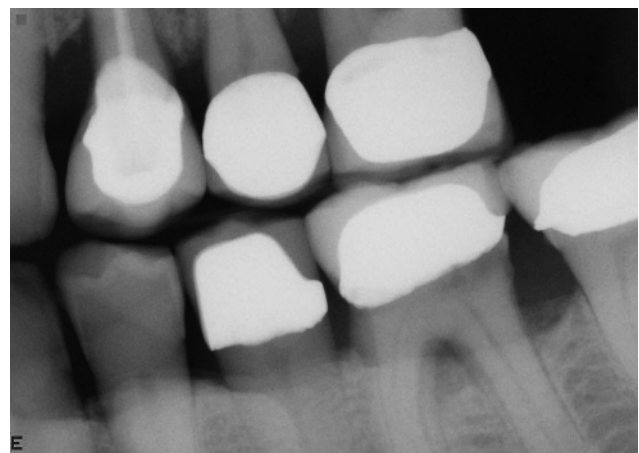


**Figure 1.7** Inflamed gums, and poor margin.

- 3) Subgingival margin placement for esthetic purposes
- 4) Actual subgingival caries or existing restoration
- 5) Belief that the tooth will be better off and less likely to have recurrent caries if the margin is placed below the level of the gingiva.

## Mechanical Retention and Lack of Trust in Adhesion

Historically, mechanical retention with traditional direct and indirect restorations, amalgams, composites and crowns was necessary [13,14,15,16,17]. For over 100 years, dentistry has relied on mechanical retention to hold restorations in place: axial walls with certain minimum heights, usually 3–4 mm, offsets, boxes, shoulders, and additional mechanical features. Restorations were retained in the tooth primarily by friction before the benefits of adhesion became available. Unfortunately, many dentists still do not fully trust adhesives to support and retain their restorations, and thus they continue to prepare teeth using traditional mechanical features. Even when the caries is supragingival, the need for axial wall and mechanical retention forces a degree of preparation that will invade the gingival sulcus (Figure 1.9). This is most common after the removal of mesial and distal



**Figure 1.8** X-ray showing severe periodontal damage likely caused by poor fitting subgingival restorations.



**Figure 1.9** Before and after finished adhesively retained onlay preparations. This is most commonly followed by axial reduction for mechanical retention with deep subgingival margins as a byproduct.

caries and old restorations that leave the cavosurface margin already close to or at gum level. A common scenario is when a patient has a short clinical crown, without enough supragingival tooth remaining for a long retentive axial wall. Extension for retention will inevitably lead to a subgingival margin placement (Figure 1.10). An adverse effect of axial reduction is the increase in the amount of tooth reduction. A full crown requires approximately 70% of the clinical crown to be drilled off (Figure 1.11); partial coverage restorations require a fraction of this amount [18,19]. The damage to the pulp by the additional unnecessary drilling (considering that

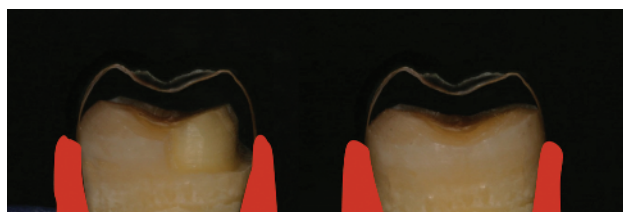


**Figure 1.10** Flat tooth showing the inevitable need for subgingival axial walls if resistance and retention are the goal.

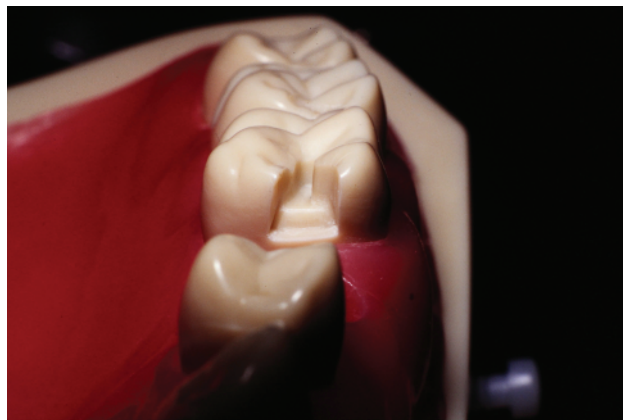
bonded restoration does not require axial reduction) ranges from increased postoperative pain to irreversible pulpitis and pulpal necrosis, correlating with remaining dentin thickness [20,21,22,23,24]. Trust in adhesion and proper supragingival minimally invasive restorative techniques renders mechanical retention unnecessary.

### Traditional Restorative Techniques, Boxes, and Cervical Clearance

Traditionally, in both direct and indirect restorative dentistry, there has been a need to create clearance with the adjacent tooth facially, lingually, and gingivally, to place a matrix band, take an impression, confirm restoration seal, and so on. Facial and lingual clearance is of concern because of excessive tooth removal, but traditional gingival clearance techniques are the source of subgingival margin placement (Figure 1.12). To gain gingival



**Figure 1.11** The need for mechanical reduction will create subgingival margins; a fully adhesive restoration without axial reduction will stay supragingival.



**Figure 1.12** A traditional geometric box (courtesy of Dr Boris Keselbrener).





**Figure 1.13** Gingival clearance created by dropping box technique (courtesy of Dr Boris Keselbrener).

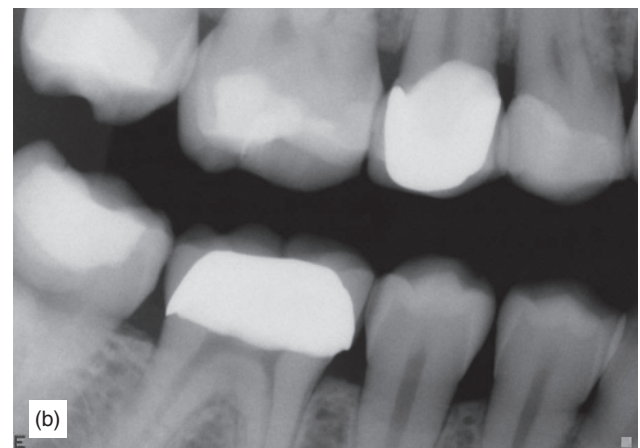
clearance from the adjacent tooth, dentists have been taught to drop the gingival floor of the box for direct restorations, and the gingival interproximal margin for indirect restorations (Figure 1.13). This technique is extremely counterproductive for any adhesive dentistry procedure, as it leads to subgingival margin placement and causes the loss of the enamel margin, with negative consequences in both cases (Figure 1.14a,b). Techniques such as the “cervical margin separation” can replace the need to drop the margin and go subgingival, as subsequent chapters illustrate.

### Subgingival Margin Placement For Esthetic Purposes

The commonly accepted necessity for subgingival margin placement exists purely for esthetic reasons (Figure 1.15a,b). When using porcelain-fused-to-metal (PFM) or any other opacous material, including full or layered zirconia, subgingival margin placement became the norm to hide the esthetically displeasing gingival margin. It is also commonly done when color change is desired, for example in cases of dark teeth, when color change is effected solely with a restoration (Figure 1.16). Although there are currently many highly translucent restorative materials with the ability to blend at the margin area, opacous material continues to be the most popular (Figure 1.17). The placing of subgingival margins for esthetics is mostly habit, even in areas which do not need them (Figure 1.18). The proper use of translucent restorative materials renders subgingival margin placement unnecessary, as the following chapters demonstrate.

### Actual Subgingival Caries or Existing Restoration

The only valid reason for a subgingival restorative margin today is when the caries or old restorative materials are already below the gingiva. Nevertheless, subgingival caries and even old restorative materials are usually limited to a small section or sections of the tooth (Figures 1.19–1.21). If only a small area of the tooth is subgingival, managing this area is usually simple and will not usually compromise the ultimate quality or results of the restoration. Unfortunately, the generally accepted concept is that full subgingival margin placement is normal. If one section of the tooth is already subgingival, it may be easy to say “well, it is subgingival



**Figure 1.14** (a) Historical progression x-ray showing a small class II cavity on a first premolar, which was diagnosed for direct composite in 2010. (b) In 2015, the patient was seen again with an aggressive subgingival crown on the same first premolar (direct composite on the second premolar was performed by the author 5 years earlier).



**Figure 1.15** (a, b) Crown preparations with traditional subgingival margins.



**Figure 1.16** It is clear how unsuccessful it is to bury dark margins below the gum. Sooner or later they come out again, revealing uneven gums.



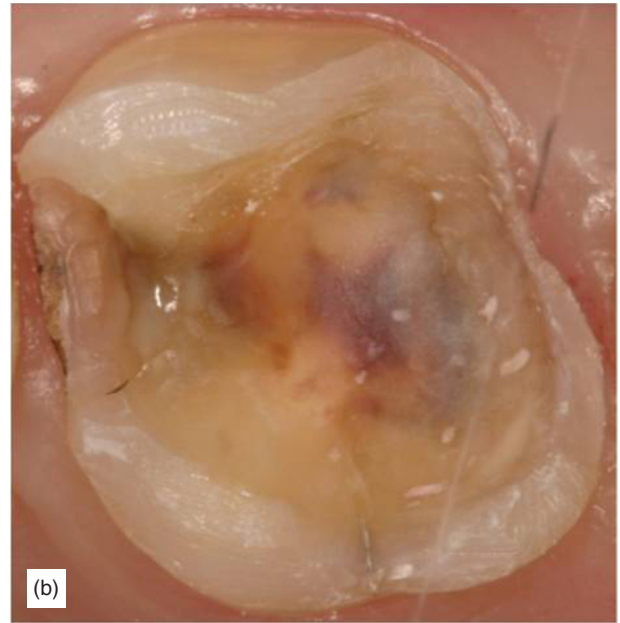
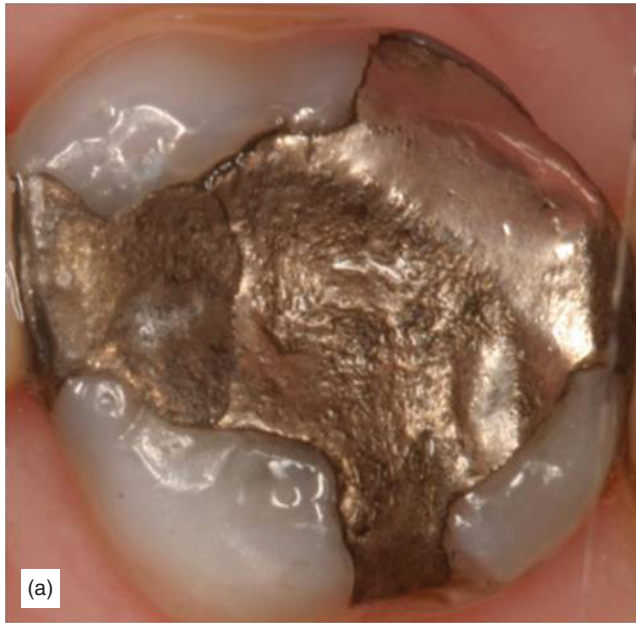
**Figure 1.17** A well-known 23-year-old celebrity with recent veneers, showing the effect of unnecessary subgingival margins. Permanent mild periodontitis.

already, let's place the entire margin subgingivally," and although it is not reasonable, this appears to be a common approach. Additionally, sometimes what appears to be a deep subgingival margin can, with high magnification and careful technique, be found to be less subgingival than initially thought (Figure 1.21). Again, the preconception of "it is subgingival already" and subsequent aggressive and careless subgingival preparation can make matters much worse. The first supragingival rule goes a long way towards limiting the use of subgingival margin placement, as is discussed in subsequent chapters.



**Figure 1.18** Subgingival margins placed unnecessarily on far posterior teeth, showing typical inflammation.





**Figure 1.19** (a) Large amalgam filling suggestive of existing subgingival margins. (b) After removal of a large amount of amalgam, showing mostly supragingival margins.



**Figure 1.20** A common situation: A tooth with only one area of subgingival decay; the rest of the tooth will be supragingival.



**Figure 1.21** (a) A badly decayed tooth, which would suggest extensive subgingival margins. (b) Apparently subgingival margin was supragingival with careful removal of caries.



### An Erroneous Belief

The fifth “reason” is the belief that if we place the margin below the gingiva, the tooth will be better off and will be less likely to have recurrent caries. Many patients, and a small percentage of dental professionals, may hold this erroneous belief, but it is important to clarify that it is not based on scientific data. There is no literature available which shows a decrease in recurrent caries, but a great deal of information showing an increase in pathogen levels, inflammation, and plaque accumulation [25].

Familiarity can be confused with simplicity and quality. The following section outlines reasons why traditional mechanically retained dentistry and subgingival margin placement are no longer “normal”, necessary, predictable, easier, or more healthy for our patients.

### Mechanically Retained Dentistry with Subgingival Margins is More Difficult

Against common belief, traditional mechanically retained dentistry with subgingival margins is far more complicated than modern supragingival dentistry. For example, a full crown preparation starts with a difficult preparation procedure requiring exact taper and the need to place a preparation margin subgingivally. When performed correctly in an atraumatic way, the first step requires that an initial equigingival margin and then a retraction cord be placed, to expose the subgingival tooth structure. The tooth margin is then prepared (drilled) and placed subgingivally, maintaining a correct taper at all times. After this difficult procedure, the second cord must be placed to take a proper impression of this subgingival margin. This procedure is also very difficult. In fact, it is one of the most difficult and unsuccessful procedures in dentistry, as laboratories around the country can attest from the number

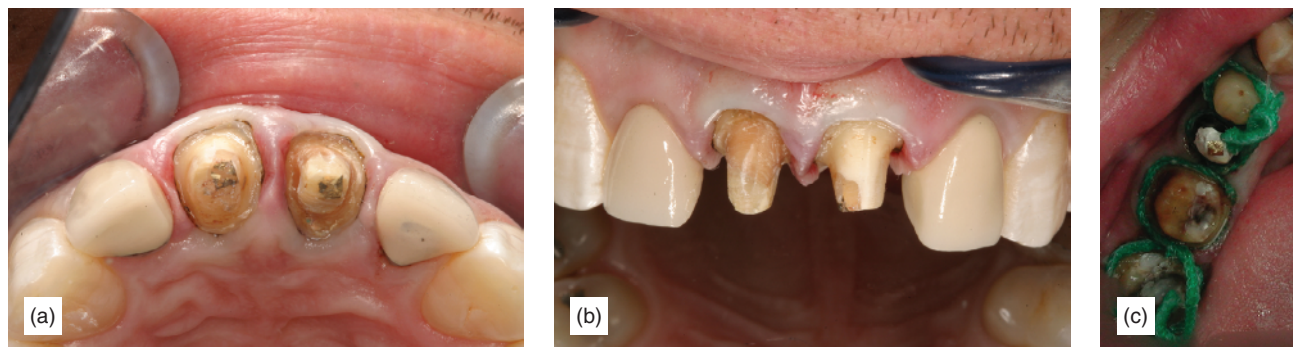


**Figure 1.22** After the removal of an old bridge, it is easy to see how difficult the tissue management will be, given the deep subgingival margins.

of inaccurate impressions they receive (Figures 1.22, 1.23a–c) [26].

The cementation procedure is equally difficult. It is not uncommon to see that the gingiva is inflamed and bleeds easily after the provisional is removed from this subgingival preparation (Figure 1.24). This is usually the consequence of a less than ideal provisional and the patient’s poor oral hygiene. With this bleeding gingiva, hemostasis is difficult for cementation. Additionally, it is not uncommon to see the gingiva grow over the preparation, making proper seating of the restoration difficult without aggressive cord packing (Figure 1.25a,b). Cement removal is difficult and unpredictable with subgingival margins, and long-term periodontal trauma can be caused by excess residual cement that is not removed (Figure 1.26).

Subgingival margins are no easier with direct restorations. When using resin composite materials and adhesives, subgingival preparation margins have great disadvantages because, once we work subgingivally,



**Figure 1.23** (a) Preparations with subgingival margins after cord packing. (b, c) See how blanched and unhealthy the tissue looks, even with careful cord packing procedure.



**Figure 1.24** Gum after removal of the temporary restoration.

bleeding and moisture control are very difficult. Additionally, it is harder to place matrix bands and wedges with subgingival margins. Finishing and polishing are also considerably more complicated when margins are subgingival (Figures 1.27, 1.28).

### Mechanically Retained Dentistry with Subgingival Margins is Less Healthy

As already stated, the negative effects of subgingival margins are not usually considered in dentistry. Traditional mechanically retained dentistry uses multiple techniques and protocols which leave subgingival margins. But what



**Figure 1.26** Crown showing deep margins with cement.

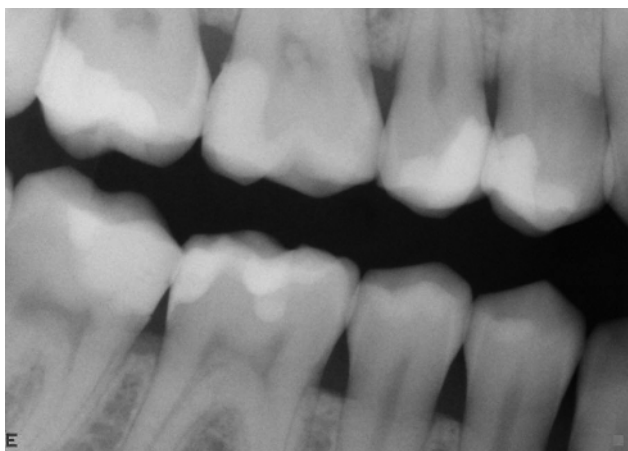


**Figure 1.27** Poor margin on deep subgingival class II on first maxillary molar 3, and poor crown margin on lower molar, with bad periodontal consequences.



**Figure 1.25** (a) Gingiva growing over preparation. (b) After removal of the temporary restoration, inflamed gums can be seen growing over preparation.





**Figure 1.28** Multiple deep margin on a class II composite, showing overhangs, sub-margins, open margins and excess material left behind. Deep subgingival margins are difficult to trim and finish.

are the consequences of these techniques? A subgingival margin will undoubtedly be a factor that will enhance subgingival plaque accumulation. Waerhaug showed, in research with extracted human teeth, that 9 of 10 restorations with subgingival margins were covered with plaque. The conclusion was that “restorations placed below the gingival margin indirectly are strongly involved in the etiology of destructive periodontal disease” (Figure 1.29) [27]. Of course, the worse the margin adaptation, the worse the plaque accumulation. Poor margins lead to what I refer to as “permanent tartar”. Permanent tartar is the overhang that traps bacteria and food, becoming destructive to the health of the gingiva (Figure 1.30). It is difficult to see and remove excess cement when it is



**Figure 1.29** A dentist who had some prior subgingival veneers done, clearly showing inflammation on veneers and healthy gums elsewhere.



**Figure 1.30** Severe gingival inflammation showing the effects of poor margin fit and accumulation of debris and tartar.

hidden below the gum line. In another human study, Müller showed that the location of the margin (supragingival, equigingival or subgingival) clearly affects periodontal health [28]. Larato, in a clinical study, found a difference of almost 1 mm in pocket depth between non-restored teeth and teeth with crowns with subgingival margin placement [29]. Beyond research, clinical experience clearly shows the severe damage that subgingival margins cause to the periodontium (Figures 1.31, 1.32). In addition, techniques such as cord packing used



**Figure 1.31** Observe the severe inflammation on tooth #9 caused by deep subgingival margin.



**Figure 1.32** Observe the healthy periodontal condition of all non-crowned teeth.

with traditional subgingival margin placement have the potential to be detrimental to periodontal health [30,31], especially when performed aggressively and incorrectly (Figure 1.33).

Additionally, the more subgingival the restorative margin, the more tooth is reduced. As demonstrated by Shillingburg, “the effect of apical reduction” applies. This means that the more apically the margin is placed, the closer to the pulp the preparation becomes, since a taper in the crown preparation must be maintained (Figure 1.34) [14]. The effects of axial reduction and other mechanical features on the pulpal health are considerable.

### Mechanically Retained Dentistry with Subgingival Margins is Less Beautiful

It is interesting that one of the primary reasons given for placing margins subgingivally in dentistry fails so often. Historically, restorative margins have been placed subgingivally because of the desire to hide the unsightly margin of opacous crowns, usually PFM and, more currently, zirconia and IPS e-max® (Ivoclar). Subgingi-

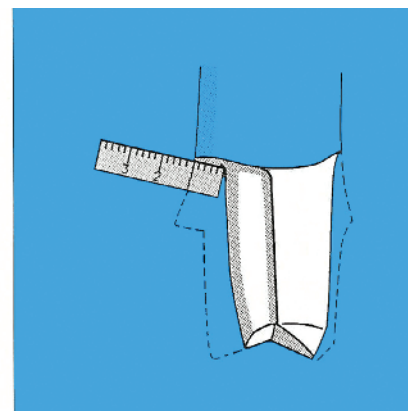
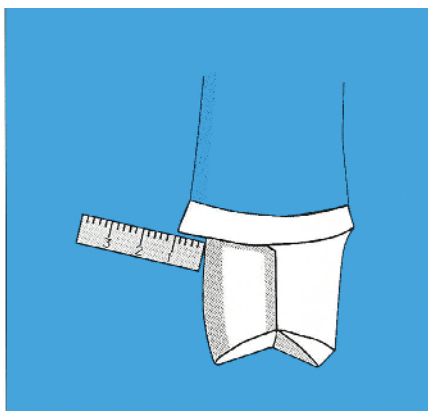


**Figure 1.33** Aggressive cord must be placed with deep subgingival margins, causing much irritation.

val margins are also placed when the color of the tooth is to be changed by the restorative materials, in cases of dark teeth, or endodontically stained teeth. Unfortunately, this technique seldom works well (Figure 1.35). First, in the short term, opacous materials are usually unnatural and not attractive; the typical “Chiclet” crown is rarely esthetically pleasing (Figures 1.36a,b, 1.37). Teeth have natural translucency, but when they are covered with an opacous restorative layer unnatural things happen. One effect is that the cervical area of the tooth appears dark because the opacous restoration blocks the light from entering the tooth. The lack of light inside the tooth makes it appear darker or more gray, so the blending of the restoration becomes less predictable. This is the primary reason for the dreaded gray gum around crowns (Figure 1.38). Unhealthy red gingiva is never beautiful.

In the long term, aging and periodontal conditions lead to gingival recession, accelerated by the unhealthy periodontium caused by subgingival margins. When the

**Figure 1.34** The effect of apical reduction.







**Figure 1.35** Very dark root canal treated tooth with opacous crown, with unesthetic results.

unsightly margin becomes visible, it often leads to early removal and replacement of the restoration (Figures 1.38, 1.39a,b). Proper use of translucent restorations will render this unnecessary, which is discussed in later chapters.

### Mechanically Retained Dentistry with Subgingival Margins is Less Predictable and Less Durable

Because of the long history of crowns and of traditional restorative procedures and rules, it is easy to believe



**Figure 1.36** (a) Root canal treated tooth restored with opacous crown, leaving a gray margin and "Chiclet"-like tooth. (b) Close-up view of the same tooth; this crown has been replaced three times and each time it ends up showing the margin again.



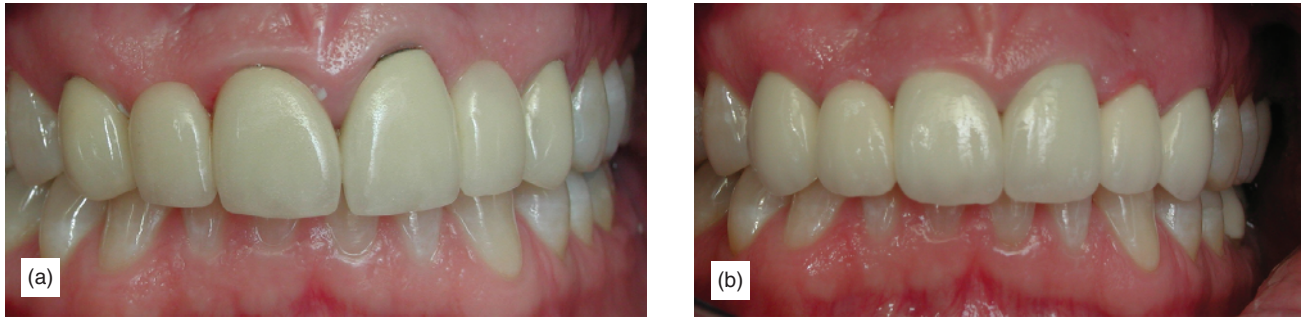
**Figure 1.37** This patient was very unhappy with the grayness of the gums on all her crowns.

that these procedures are better and more predictable. It is fair to say that almost any procedure, if performed by a master operator, will yield exceptional results. Nevertheless, there are procedures and techniques that are easier to reproduce, and some that are very difficult to reproduce successfully. Traditional crown procedures, such as atraumatic subgingival margin placement, cord packing, subgingival impressions, subgingival cementation cleanup and finishing, are among the most difficult and rarely successful procedures in dentistry. The fact that some of these crowns stay on the tooth for some years past their healthy life, does not mean that they are successful. In the long term, leaky, ill-fitting margins will damage the tooth and the periodontium, and the dentition will have a shorter, less healthy life (Figures 1.40, 1.41a,b). Furthermore, micro-leakage and recurring caries often go undetected with the more traditional opacous materials (PFM and full



**Figure 1.38** This patient complained that the margin used to be acceptable, but the gums have receded and now she does not like the appearance and wants the crowns replaced.





**Figure 1.39** (a) These are clinically healthy crowns, but the patient wanted them replaced. (b) After crown replacement – an extremely difficult case, and most likely the gingiva will recede in a few years.



**Figure 1.40** After crown removal, what was left of the tooth was not sufficient for a restoration.

zirconia), as opacity make it difficult to discover caries visually, and microleakage and radiopacity make it difficult to assess them radiographically.

Traditional class II and III restorations with boxes, retentive features, and traditional restorative rules which lead to subgingival margins become exponentially more difficult as the margins become more subgingival. Placing matrix (predictably bonding, filling, finishing, and polishing) becomes extremely difficult. Subsequent chapters discuss techniques to minimize and almost eliminate the need for subgingival margins.

Traditional preparation which requires axial wall, boxes, shoulders, and other mechanical retentive features, requires more tooth removal, leads to increasing closeness to the pulp, and increases heat and damage to the pulp. This can increase the need for root canal therapy on teeth treated with crowns, shortening the life of the restoration and the tooth (Figures 1.42, 1.43) [21,22,23,24]. The end result of this is more postoperative pain, unhappy patients, and, ultimately, decreased predictability and longevity. Shorter esthetic life increases the chances of pulpal reaction and necrosis, increases periodontal damage, and limits the ability to repair or replace in a timely fashion. With all of these



**Figure 1.41** (a, b) Crown failure needing root removal.



**Figure 1.42** There are many little holes on this crown, showing the usual unforeseen common consequence of aggressive preparation.

disadvantages, traditional full crowns can hardly be considered successful, predictable or long-lived, even if they can stay in the mouth for many years, well beyond their healthy stage.

Chapter 2 explores the benefits of supragingival minimally invasive adhesive dentistry as a substitute for



**Figure 1.43** Two gold crowns with root canal treatment access holes.

traditional mechanically retained dentistry with subgingival margins.

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