10 Restoration of teeth (complex restorations)

INTRODUCTION

Traditionally, more extensive restorations on teeth were performed using non-adhesive techniques. The materials of choice were gold, porcelain and metallic ceramics. These were placed either intra- or extracoronally and relied on the preparation having near-parallel walls, assisted by a luting cement to fill the marginal gap and help with the retention process. With the development of new materials and techniques for bonding to the tooth, there has been a blurring of the methods used and often restorations rely on a multitude of factors for retention which incorporate both mechanical and adhesive principles.

REPLACEMENT OF LOST CORONAL TOOTH STRUCTURE

Indirect restorations are frequently placed on teeth which have lost substantial amounts of tooth structure. Retention and resistance form are lost as the height of the tooth preparation is reduced in relation to the intended occlusal surface position of the final restoration. A foundation or core build-up restoration may be required to supplement retention and resistance form. The strength required of a foundation restoration will vary, depending on the location of the tooth in the dental arch, as well as on the design of the surrounding tooth preparation. Apart from acting as a transitional restoration in the management of a damaged tooth, a core build-up restoration must withstand crown preparation and impression-taking and contribute to the

Fig. 10.1 Core build-up of lost coronal tooth structure.

retention and support of a provisional crown before the definitive crown restoration is placed (Fig. 10.1).

When retention and resistance depend significantly on the core build-up, the strength of the foundation restoration and its retention to the underlying tooth tissue can directly influence the survival of the restoration. Some core materials lack sufficient strength and/or adhesion to tooth tissues to serve this function. Posterior teeth are exposed to greater forces than are anterior teeth and the direction of load differs. Teeth that have to serve as abutments for fixed or removable prostheses are subject to increased stress.

Almost one-quarter of all posterior crowns were provided with a pin or post retained core. The restoration of severely broken down teeth is an increasing problem for the restorative dentist, as more patients retain their natural teeth into older age. Clinical studies demonstrate an increased incidence of tooth fractures in teeth with large restorations compared with sound or minimally restored teeth.

Whilst advances in adhesive restorative materials and techniques may result in more predictable retention of restorations with compromised retention, the success of these techniques is still to be confirmed by clinical trials. Such techniques may be operator-sensitive as the success of an indirect restoration depends on the ability of the cement or resin lute to prevent dislodgement of the restoration from the tooth preparation; the latter must possess adequate retention and resistance form. Whilst resistance form is considered more critical than retention form, it is impossible to separate these two features. Retention will prevent dislodgement of the restoration along a direction parallel to its path of insertion, whilst resistance prevents dislodgement in any other direction. Minimal taper and maximum preparation height are critical features for good retention. The fit of the restoration, any surface treatments which facilitate adhesion, and the nature of the cement lute are also important variables. If adequate retention and resistance form can be developed from natural tooth structure, the strength of any core or foundation restoration is less critical and minor depressions or undercuts in the tooth preparation can be restored with adhesive restorative materials.

CHOICE OF CORE MATERIAL

Clinically, there are times when the remaining tooth structure is so reduced that the margins of the crown must be placed at or just below the core. It is under these conditions that the choice of core material may be critical.

Core build-up materials for direct placement include:

- dental amalgam
- resin composite
- reinforced glass ionomer cements
- resin-modified glass ionomers/compomers (polyacid-modified resin composites)

Gold alloys and ceramics have been used as indirect core build-up materials. Each candidate core material has advantages and disadvantages.

Box 10.1 Desirable properties for a core material

- Compressive strength to resist intraoral forces
- Flexural strength to prevent core dislodgement during function
- Biocompatibility with surrounding tissues
- Ease of manipulation
- Ability to bond to tooth structure, pins and posts
- Capacity for bonding with luting cement or having additions made to it
- Coefficient of thermal expansion conductivity similar to dentine
- Dimensional stability
- Minimal water absorption
- Short setting time to allow tooth preparation and core placement to be carried out during the same visit
- No adverse reaction with temporary crown materials or luting cements
- Cariostatic potential
- Low cost
- Contrasting colour to tooth tissue unless being used for anterior cores

Fig. 10.2 An amalgam core.

Fig. 10.3 A composite core.

Dental amalgam

Amalgam has adequate mechanical properties for many core build-up situations. It is radio-opaque and has been shown to have superior cariostatic properties to composites. It has high thermal conductivity and coefficient of thermal expansion. It is not adhesive to tooth structure, although methods of bonding amalgam using resin adhesives are available, and glass ionomer/resin ionomer cements show promise. Conventional dental amalgams set too slowly to allow tooth preparation during the same visit as core build-up. Modern fast-setting spherical alloys may allow preparation 20–30 minutes after placement. Silver amalgam has been reported to be the most reliable direct core build-up material under simulated clinical conditions because of its high compressive strength and rigidity (Fig. 10.2).

Resin composite

Composite core materials are becoming increasingly popular for core build-ups. Provided adequate moisture control is obtained, these materials may be reliably bonded to tooth substance, and their command set nature allows immediate tooth preparation. An incremental technique is required to ensure complete polymerisation unless specific light-activated core composites are used. Some of these materials offer depth of cure of up to 8 mm (Cavex Clearfil Photo-Core, Kuraray). Composite materials adapt well to pins and pin-retained composite cores. Some resin composite core materials possess similar compressive and tensile strengths to amalgam cores. Only radio-opaque composites should be considered as core materials. The high coefficient of thermal expansion of composite cores and their greater potential for water uptake are negative aspects of these materials. In addition, eugenol-based temporary cements may soften their surface or impede bonding of resin-based luting cements. Composite is best as a direct core material when substantial coronal tooth structure remains for bonding and where reliable moisture control may be obtained. Several composite core materials contain fluoride which is released in trace amounts for up to 5 years but no clinically relevant cariostatic property has yet to be established for these materials (Fig. 10.3).

Glass ionomer cements

Conventional glass ionomer restoratives are popular with many dentists as core materials because of their adhesive properties and ease of handling. They are relatively slow-setting and their early resistance to moisture is poor. Many products are not radio-opaque. Although they may be considered to have adequate compressive strength for use as core build-up materials, their flexural strength and fracture toughness are low. Conventional glass ionomer cements are therefore only suitable where there is substantial tooth substance remaining to support the material and where adequate resistance form may be obtained on natural tooth tissue. Cermet cements do not provide advantages over conventional glass ionomers and often have poor adhesion to tooth structure. Recently introduced condensable glass ionomer cements may prove a better alternative as these materials can be bonded more reliably and are stronger.

Resin ionomers and compomers

Resin-modified glass ionomers (RMGIs) and polyacid-modified resin composites (compomers) are attractive candidates for core materials because they are considered to offer the advantages of both glass ionomers and resin composites. These materials offer improved flexural strength in comparison to conventional glass ionomers whilst the high coefficient of thermal expansion of composite has been reduced. Light activation offers speed of set. Some concerns have been expressed about the risk of fracture of all-ceramic crowns when resin ionomers or compomers are used as core build-up materials and/or luting cements, and there is in vitro evidence to support this. Glass ionomers, resin-reinforced glass ionomers and most compomers are significantly weaker than tooth structure. They should be limited to situations where only minimal tooth structure is missing, and where increased tooth strength and abutment retention are not required.

PREOPERATIVE ASSESSMENT (Table 10.1)

Restorability of tooth

The extent of caries and the existing restorations should be assessed. When teeth are prepared for crowns there is often amalgam remaining in proximal boxes, class V areas and other regions. All previously placed materials should be removed (unless the operator has recently placed the restoration and is sure it is reliably retained to sound tooth tissue), allowing teeth to be rebuilt without the risk of an insecure foundation or previous pulpal exposure remaining undetected. If more than 50% of the coronal tooth structure is remaining and there is no requirement for increased tooth preparation strength, then a bonded compomer or resin ionomer base may be used to restore the tooth to the ideal preparation form. If ≥50% of the coronal tooth structure has been lost and there is not a minimum of 2 mm sound tooth structure circumferentially gingival to the tooth preparation, a high-strength (bonded amalgam or composite) core build-up is required to increase tooth strength and aid crown retention/resistance form.

Mechanical retention in teeth may be increased by:

- grooves
- boxes
- dovetails
- converting sloping surfaces into vertical and horizontal components
- reducing/covering undermined cusps.

The use of pins and posts should only be considered as a last resort as they will further weaken already compromised teeth. In clinical situations, flat one-surface cavity designs occur infrequently and it is often possible to create steps or varying levels within a preparation increasing retention and resistance to occlusal forces. Other methods of increasing retention and resistance without having to resort to pins include circumferential slots, amalgapin channels or 'pot-holes' and peripheral shelves.

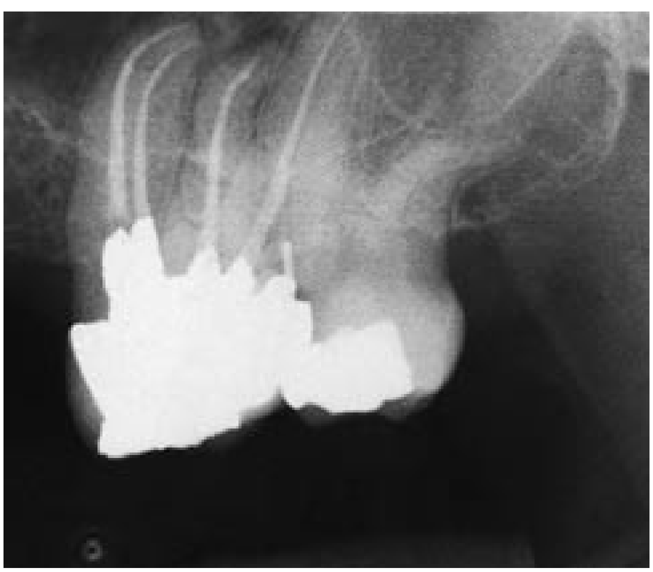
Table 10.1 Pattern of tooth destruction and type of restoration indicated

Pattern of tooth loss	Extent of tooth loss			
	Minimal	**Moderate**	**Moderate to severe**	**Total loss of coronal tooth structure**
Central/internal (i.e. occlusal dentine caries)	Amalgam or composite (PRR)	Cement base and amalgam	Pin core and crown	N/A
Peripheral/external (i.e. tooth surface caries)	Amalgam, composite or RMGI	Amalgam, composite or RMGI	Crown	N/A
Above combined	Amalgam, composite or RMGI	Amalgam (large tooth) or cast gold onlay (small tooth)	Pin core and crown	Pin core and crown (molars) or root canal therapy and core + crown (premolars)

PRR, pin-retained restoration; RMGI, resin-modified glass ionomer.

Spherical alloys are best suited to condensing into small retentive features of a cavity preparation and suitable small-diameter condensers are required. Slot-retained restorations are more sensitive to dislodgement during matrix removal than pin-retained restorations. Occasionally, when minimal tooth structure remains for mechanical retentive features, pins may be required to supplement retention. The amount of remaining coronal tooth structure (not undermined) is assessed after removal of caries and old restorations. Unsupported tooth structure may need to be removed if the build-up is to serve as a direct permanent load-bearing restoration. Retention of thin slivers of unsupported tooth structure may, however, be appropriate if the build-up is to serve as a foundation for a crown.

a)



b)

Fig. 10.4 Assessment of RCT molar tooth for crown.

Pulpal/endodontic status

Prior to core build-up, an assessment should be made of the pulpal status of the tooth in question. If the pulp is exposed or there are signs/symptoms of irreversible pulpitis, endodontic treatment should be performed. In the case of an endodontically treated tooth, the quality of the treatment should be assessed radiographically (Fig. 10.4). If the treatment is considered inadequate, a decision will need to be taken as to whether there is potential for retreatment or whether the tooth would be better extracted.

Periodontal/occlusal assessment

The periodontal status of the abutment should be assessed. If there is inadequate sound tooth structure apical to the preparation margin for satisfactory retention and resistance form, surgical crown lengthening may have to be considered. The occlusal relationships should be assessed, but not all teeth requiring build-up will subsequently need to be crowned and the occlusal relationship and the potential functional stresses on the tooth will influence this decision.

Greater strength is required for crowns in the following cases:

- patients with bruxism or clenching habits
- teeth that support crowns with heavy canine or incisal guidance
- abutments for fixed and removable prostheses.

PIN RETENTION FOR CORE FOUNDATIONS

The increased strength of the latest dentine/enamel bonding agents, coupled with the revived use of retentive slots, pot-holes, grooves and channels, has led to a reduction in the use of pins. However, pins may be useful for providing retention to the core, although they should be used carefully. There tend to be more disadvantages associated with

Fig. 10.5 Pins used in amalgam core build-up.

their use, and incorrect placement can lead to pulpal or root surface perforation. Other problems include crazing/tooth fracture or failure of the pin to seat fully, leading to looseness or fracture of the pin (Fig. 10.5).

Guidelines for the use of pin retention for core foundations

- Use one pin per missing cusp or marginal ridge, up to a maximum of four.
- Use large-diameter pins whenever possible.
- Use the minimum number of pins compatible with adequate retention (pins weaken amalgam).
- Pins should extend 2 mm into dentine and restorative material.
- Keep 1 mm of dentine between the pin and the enamel–dentine junction.
- Pins should be placed away from furcation areas and parallel to the external tooth surface.
- Coating of pins with adhesion promoters such as Panavia and 4-META materials improves fracture resistance of composite and amalgam cores.
- Pins rarely need to be bent.

Fig. 10.6 Gold post and core on anterior tooth.

Box 10.2 Treatment alternatives for endontically treated teeth

Anterior teeth

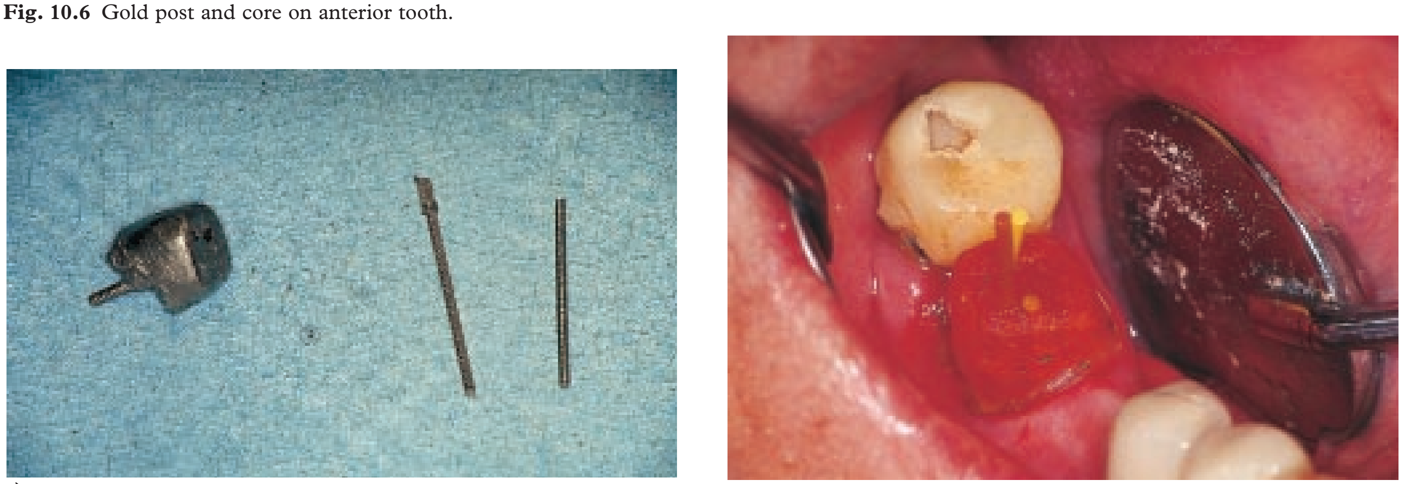
- Acid-etch retained composite
- Cast gold post/core
- Composite core/prefrabicated post with and without pin(s)

Posterior teeth

- Amalgam restoration (with or without cuspal overlay 2–3 mm) or acid-etch composite (semi-permanent) restoration. No post or pins
- Amalgam restoration using pulp chamber retention (molars only). The 'coronal-radicular amalgam core' (Amalcore)
- Pin-retained amalgam (molars only). One functional cusp missing
- Prefabricated post- and/or pin-retained amalgam (molars only) where the crown has two or more cusps undermined or missing
- Cast gold post and core where there are molar abutments or premolars with undermined/missing cusp(s)
- Prefabricated post (+ pin) retained amalgam or composite core where the crown is placed on premolar teeth with undermined cusp(s)

FOUNDATION RESTORATIONS FOR ENDODONTICALLY TREATED TEETH

For endodontically treated anterior teeth with moderate to severe coronal destruction, cast gold post and cores are the restorative method of choice (Fig. 10.6; see also Box 10.2). Root-filled molar teeth often perform satisfactorily with direct cores retained by extension into the pulp chamber together with a portion of the root canals. Core retention can be increased by bonding and/or place-



a) b)

Fig. 10.7 (a) Prefabricated intraradicular posts. (b) In situ on posterior RCT molar.

ment of one or more prefabricated intraradicular posts (Fig. 10.7).

Endodontically treated premolar teeth may be restored either with custom cast post and cores or prefabricated posts used with direct core build-ups. Direct pattern post cores allow better control over the fit and the shape of the final core. They result in a better-fitting final crown restoration because they are cemented before crown preparation and impression-taking. The disadvantage is that additional clinical time is spent at the chairside in comparison to an indirect technique. However, an accurate impression of the prepared post space that extends deeply into the canal of an endodontically treated tooth is also a challenge. Many post crowns fail because posts are made too short, and frequently the full length of the prepared post hole is not employed in the final restoration (Fig 10.8).

For optimal post preparation:

- Use a length equal to or greater than the length of the final clinical crown
- Maintain a minimum of 4 mm apical gutta-percha seal.

Shorter posts are undesirable because they:

- are less retentive
- produce unfavourable stresses within the root
- predispose to fracture
- result in loss of cementation.

A flat seat should be created at the occlusal end of the tooth preparation to prevent possible wedging effects, and

Fig. 10.8 A post that has been made too short.

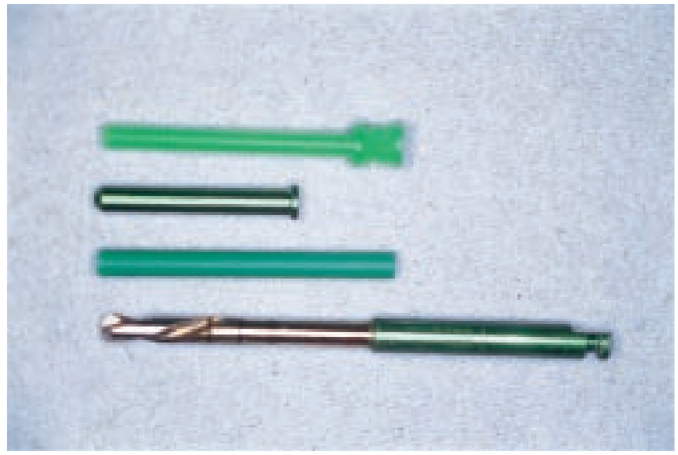


Fig. 10.9 Commercially available parallel-sided posts.

as much coronal and radicular tooth structure as possible should be preserved. Parallel-sided posts are more retentive than custom-made tapered posts; however, when a parallel-sided post is used in a thin tapered root there is an increased risk of perforation laterally towards the apex (Fig. 10.9). Parallel-sided posts with tapering apical sections are commercially available (TYNAX, Whaledent). Post width should be the minimum to allow for a close fit between post and root canal dentine wall in the coronal and apical 3 mm of the post hole.

Small-diameter posts are best made from wrought alloys or heat-treated type 4 cast gold alloys, otherwise there is an increased risk of displacement or distortion. Wider posts lead to excessive destruction of tooth tissue and reduce the strength of the radicular dentine. The thickness of the remaining dentine is crucial to avoid root fracture. A post and core can transfer occlusal forces intraradicularly, predisposing the tooth root to vertical fracture. The role of the final crown restoration in protect-

Fig. 10.10 The ferrule effect.

Table 10.2 Compensating for inadequate retention/resistance form in cast restorations

Extent of tooth loss	Clinical situation	Operative procedure	Final restoration
Moderate to severe	Short preparation or excessive taper One or two cusps missing but ≥ 50% coronal tooth structure remains Wall thickness/length ratio >1:1	Modify isthmuses/boxes Add grooves/pinholes Modify sloping surfaces into horizontal walls/horizontal planes Surgical crown lengthening	Non-standard partial or full veener
Severe	Loss of > 50% crown wall Thickness/length ratio <1:1 Short preparation for a long crown	Apply necessary pulpal protection Pin amalgam or composite core Surgical crown lengthening	Standard full veneer
Total loss of coronal tooth structure	All cusps undermined/lost Supragingival height < 1 mm	As above plus elective endodontics and post/core for premolars	Standard full veneer

ing the post-restored endodontically treated tooth is very important. Clinical experience and laboratory studies have shown that extension of the cast crown restoration at least 2 mm apical to the junction of the core with the remaining tooth structure provides extracoronal bracing and prevents fracture of tooth structure. This 'hugging action' of a subgingival collar of cast metal has been described as the ferrule effect (Fig. 10.10).

This element is more important than the design of the post if tooth fracture is to be avoided. In vitro fatigue studies have shown that failure of the cement seal of a crown occurs first on the tension side of the tooth, especially when the ferrule effect is small and the post is off-centre. Clinical studies indicate a high potential for post fracture when cemented crowns do not provide a ferrule effect (Table 10.2).

CROWNS

The placement of an indirect restoration requires preparation of a cavity with undercut-free cavity walls to allow a path of withdrawal and insertion of the completed restoration. This allows a pattern or impression to be removed from the cavity. The finished restoration should be capable of insertion into the tooth without the generation of stress. Preservation of remaining tooth structure is important because the restoration relies on the strength and integrity of the remaining prepared tooth substance for retention. The restoration can be used to protect and reinforce the remaining tooth structure to some extent, but the less remaining enamel and dentine, the greater the risk of mechanical or biological failure.

Indirect restorations must be cemented or bonded into place to provide retention and cavity margin seal. The degree of retention available for a non-adhesive indirect restoration depends upon the surface area of the opposing vertical walls of the cavity and their degree of convergence. Only when the restoration is adhesively luted with a resin-based luting cement combined with an enamel/dentine adhesive is the luting agent a major contributor to retention.

Indirect restorations may be:

- intracoronal (inlays)
- extracoronal (crowns)
- a combination of intra- and extracoronal (onlays).

Restorations may be:

- wholly metallic (precious or non-precious alloys)
- ceramic/composite
- a combination of the above (metal-ceramic crown)

Crowns may cover all available surfaces of the tooth (full veneer crowns), or they may be partial veneer (e.g. three-quarter or seven-eights crowns).

The stages in the clinical procedure involved in an indirect restoration are usually as follows:

1. Decision as to restoration type (full or partial coverage; intracoronal or extracoronal), materials and method of luting (conventional cementation or bonding with a resin-based luting material)
2. Discussion with patient before tooth preparation stage as to type of restoration and aesthetic implications
3. Tooth preparation (this may require prior occlusal adjustment or diagnostic wax-up to facilitate production of provisional restoration)
4. Fabrication of temporary/provisional restoration
5. Impressions and occlusal records
6. Shade selection
7. Try-in
8. Cementation or bonding.

PREOPERATIVE PLANNING

Before considering embarking on indirect restorations, patients should be assessed to ensure that their periodontal condition has been stabilised and their caries risk is low.

The restorative assessment of the individual tooth involves:

- sensitivity/vitality tests
- long cone periapical radiograph
- examination of the quality of any existing restorations
- assessing whether the remaining tooth structure after preparation will have sufficient strength
- assessing the need for crown lengthening prior to treatment
- occlusal considerations.

The occlusal assessment should involve consideration of the tooth position relative to the opposing as well as the adjacent teeth, as this will influence preparation design. If there are occlusal interferences, these may place such a crown under high functional stresses and will require removal at a prior visit. The surfaces of the crown will need to be duplicated so that either the group function or canine guidance occlusion is maintained.

The tooth may be a key unit in the arch, i.e. partial denture abutment, and the shape of the surface should be modified to allow the subsequent placement of the denture. In such situations, mounted study casts are a useful aid in planning the preparation design as well as carrying out the occlusal assessment.

Any tooth preparation for a crown should follow the appropriate biomechanical principles (Box 10.3), and when planning replacement of a failed indirect restoration, it is important to identify the cause(s) of failure so that this may be corrected at the time of preparation.

Common causes of failure include:

- poor preparation design/shape resulting in lack of retention and/or resistance form
- insufficient reduction or lack of support/thickness for ceramic or composite
- undercut preparations
- failure to identify and/or correct occlusal problems
- poorly fitting restorations resulting from poor impression procedures or faulty laboratory technique
- inappropriate prescription/planning; no preventive regime
- incorrect shade.

Box 10.3 Biomechanical principles of tooth preparation

- Preservation of tooth structure and pulp vitality
- Obtaining adequate retention and resistance form
- Obtaining adequate structural durability of the restoration
- Obtaining adequate marginal integrity
- Preservation of periodontal health
- Appropriate aesthetics

CHOICE OF MATERIAL FOR INDIRECT RESTORATIONS

There are four types of material that can be used for indirect restorations:

- gold
- porcelain
- indirect composite
- metal ceramic.

Gold

This is generally considered to be the most satisfactory extracoronal restorative material. It has a hardness similar to enamel, and occlusal and axial contours can easily be built up in the wax prior to casting. Cast gold alloy restorations include single and multiple surface inlays. The latter may include partial or complete coverage (onlays) of the occlusal surface. Extracoronal gold restorations include full veneer crowns and three-quarter crowns, in which only one surface of the tooth (usually the buccal) is left uncovered (Fig. 10.11).

Gold can be used in thin sections but it is not aesthetic. One millimetre of tooth reduction is required occlusally, with the exception of the functional cusp bevel where 1.5 mm is necessary. The choice of restoration and preparation design will depend upon the exact details of each clinical situation.

Indications for use

- In situations of severe occlusal stress
- Following endodontic treatment of posterior teeth
- Full or partial coverage of posterior teeth where there has been significant loss of coronal dentine
- In situations where other materials are not suitable for establishing proper proximal and/or occlusal contacts
- For restoration of adjacent and/or opposing teeth to avoid problems arising from use of dissimilar metals.

Fig. 10.11 Cast gold veneer crown at UL5.

Contraindications

- Evidence of active caries/periodontal disease
- Economic and social factors
- Aesthetics
- Where patient management requires short visits and simple procedures.

Porcelain (ceramic)

This is a brittle material which is liable to fracture in thin section unless appropriate fit surface treatment is performed (etching and silanisation) and the restoration is adhesively luted with a resin-based cement (porcelain veneers and dentine-bonded ceramic crowns). A minimum margin reduction of 0.8 mm is required with 1.5–2.0 mm incisally/occlusally. Crown margins are prepared just below the gingival margin (intracrevicularly) if aesthetics dictates that this is necessary (Fig. 10.12).

Adequate retention for non-adhesive ceramic crowns depends on near-parallelism of opposing walls, particularly in the gingival third of the preparation. Porcelain crowns are relatively weak restorations and are restricted to anterior teeth unless a high-strength ceramic (Inceram, Procera, or Empress II) is used.

Indications for use

- Large inadequate restorations on anterior teeth, provided there is enough tooth substance for a strong preparation
- Severely discoloured anterior teeth
- Over an existing post and core substructure.

Contraindications

- Teeth which do not allow ideal preparation form to support the porcelain
- Teeth with short clinical crowns
- Edge-to-edge occlusion
- When opposing teeth occlude on the cervical fifth of the palatal surface.

Porcelain jacket crowns are finished to a shoulder or butt joint margin design unless the preparation is to be bonded (dentine-bonded crowns). All-ceramic crowns are preferred to metal ceramic crowns on post-crowned teeth where there is a risk of trauma. In this case, the weaker porcelain jacket crown fractures rather than the stress being transferred via the post core leading to root fracture.

Indirect composite

Laboratory composites with improved strength and wear resistance are now commercially available and are increasing in popularity. Coupled with improvements in resin-based luting cements and dentine bonding systems, indirect composite restorations (with or without fibre reinforcement) may be considered appropriate for single unit inlays, onlays and crowns (Fig. 10.13).

Laboratory composites are generally preferred to porcelain restorations for inlays, whereas the latter offer more

Fig. 10.12 An all-porcelain crown at UL5.

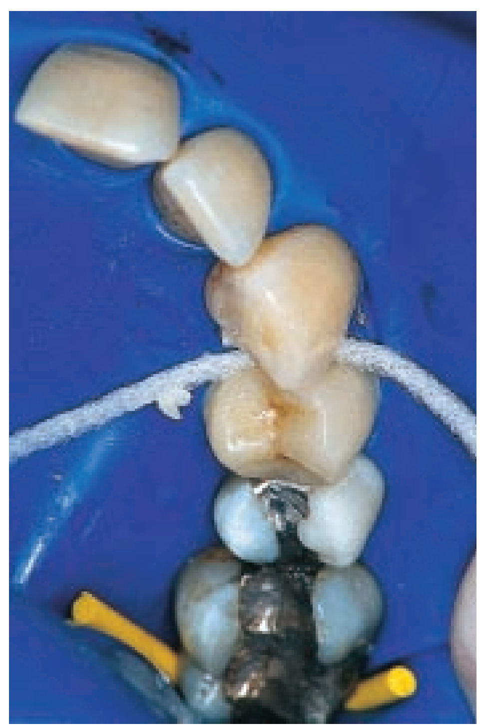


Fig. 10.13 An indirect composite crown at UL4.

permanent form stability in onlay and crown situations. Some prefer a material which is less wear-resistant and as such is sacrificial in nature to a highly wear-resistant ceramic restoration which may ultimately cause excessive wear of the opposing dentition.

Metal ceramic

Metal ceramic crown restorations offer a combination of strength and good aesthetics. Additional tooth preparation (1.5 mm) is required to allow for both the metal substructure and metal overlay. These crowns are frequently overcontoured due to inadequate tooth reduction. Heavy tooth preparation to achieve adequate thickness for both materials may result in an increased incidence of pulp death. If this is a risk then a bevelled shoulder or cervical chamfer may be preferred to the conventional full 1.5 mm axial reduction in cases where the tooth preparation has to be extended down onto root surface or where there is a large pulp. Metal occlusal coverage is generally preferred to maximise retention and resistance form and to minimise tooth reduction. Metal occlusal contacts are easier to create and adjust. Porcelain occlusal surfaces are more aesthetic but demand additional tooth reduction and create the risk of excessive occlusal wear of opposing tooth surfaces (Fig. 10.14).

Indications for use

- Anterior teeth where there is insufficient space for an all-ceramic restoration
- Repeated failure of porcelain jacket crowns (identify reason first)
- Posterior crowns where aesthetics is important and full or partial veneer gold crowns are contraindicated on this basis.

Fig. 10.14 Metal ceramic crowns on posterior teeth with (left) and without (right) occlusal porcelain coverage.

Contraindications

- Where excessive wear of teeth opposing porcelain occlusal surfaces may be expected. Either a sacrificial indirect composite approach is preferred or permanent night-time protection with a Michigan splint may be indicated
- Where pulpal damage risk is high, particularly in a young patient. Dentine-bonded ceramic crowns have provided a more conservative viable option in many of these cases.

TOOTH PREPARATION GUIDELINES FOR INDIRECT RESTORATIONS

All preparations should have the maximum height and minimum taper for optimal resistance and retention form consistent with the chemical situation. To achieve this and to permit an adequate thickness of restorative material without over-contour, the surface of the preparation should mimic that of the intended restoration, both occlusally and axially.

Features of preparations for indirect restorations

- Undercut-free preparation – there must be one point above the preparation from which all the margins and internal line angles can be seen.
- A single path of insertion over as great a distance as possible – this is achieved by preparing opposing walls to be near-parallel to give maximum retention. The position of the adjacent teeth should be considered as they may overhang the margins of the prepared tooth. The path of insertion is therefore dictated by the adjacent teeth.
- Resistance form needs to be provided by restoration to displacing forces which are usually occlusal in origin.
- The opposing walls in the gingival half of the preparation should be made near-parallel. The occlusal third to half will usually be more tapered as a result of the two plains of labial reduction required to provide sufficient room for the restorative material within the original tooth contours.
- With short clinical crowns there is an increased risk of failure because of the short insertion path. Preparation length can be increased by crown lengthening, and resistance form may be improved by the use of grooves, slots or boxes and by converting sloping surfaces into vertical and horizontal components.
- Occlusal reduction should follow cuspal outline to maximise retention and minimise tooth reduction. For porcelain fused to metal crowns and for gold crowns these distances are 2 and 1 mm, respectively.

- The finished margin position and type are determined by the gingival contour, the nature of the restorative material, the presence or absence of a core margin and the choice of luting agent. Whenever possible, the margin should be supragingival following the natural gingival contours. Finish margins should ideally extend at least 1 mm past core margins to rest on sound tooth tissue.

Types of finish margins (Box 10.4, Fig. 10.15)

Chamfers and shoulders give definite finish margins which may be identified on preparations, temporary crowns and dies. Occasionally, knife-edge preparations may be indicated for full veneer crowns where there are deeply subgingival margins (however, periodontal surgery may be more appropriate here), bulbous teeth or pins close to the preparation margin. Metal ceramic crowns may be constructed with metal collars, especially on long preparations on posterior teeth. Lipline on smiling may indicate whether this is a practical proposition. A chamfer or knife-edge finish may avoid excessive tooth reduction in this situation.

Preparation stages

The following sequence is usually adopted:

- Occlusal reduction using depth grooves as a guide to the amount of tooth reduction. Grooves are only of use when the shape of the restoration is intended to match the original tooth.
- Gross buccal and palatal/lingual axial reduction. The preparation is kept near-parallel cervically and the labial reduction is made to mimic the contour of the final restoration in two, or occasionally three, planes.

Box 10.4 Types of finish margins

- Full veneer crown – chamfer
- Metal ceramic crown – buccal shoulder/palatal chamfer normally
- Porcelain jacket crown – shoulder

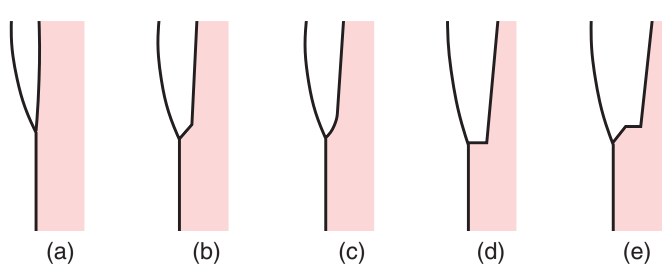


Fig. 10.15 Types of finish margins. (a) Knife edge; (b) bevel; (c) chamfer; (d) shoulder; (e) bevelled shoulder.

Box 10.5 Examples of tooth-coloured ceramic inlay materials

- Feldspathic porcelain
- Reinforced ceramics (such as Fortress: Chameleon Dental, KS, USA)
- Pressed ceramics (such as Empress II: Ivoclar-Vivadent, Leichtenstein)

The preparation is extended as far interproximally as possible without risking contact with adjacent tooth structure.

- Initial interproximal reduction is achieved with a narrow tapered diamond. A sliver of tooth substance/restoration may be left to protect the adjacent tooth at this stage.
- Complete axial reduction can determine final finishing line position. Finish margins at least 1 mm past any existing restorations and just below the gingival margin labially if required for aesthetics.

INDIRECT ADHESIVE RESTORATIONS

Tooth-coloured inlays (Box 10.5)

The increasing expectation of patients that restorations be tooth-coloured has led to an increasing interest in direct and indirect composite and ceramic restorations in posterior teeth. Ceramic and composite inlays are generally considered to be appropriate for larger rather than smaller cavities, given that direct placement resin composite restorations may provide good service in small- to medium-sized cavities.

Computer-aided design and manufacture techniques (CAD-CAM, e.g. Cerec, Siemens, Germany) are capable of producing increasingly accurately fitting inlays from blocks of ceramic material. These techniques have the distinct advantage of producing the inlay at the chairside in a short time (within 15 minutes), thereby obviating the need for placement of a temporary restoration and a second visit for placement.

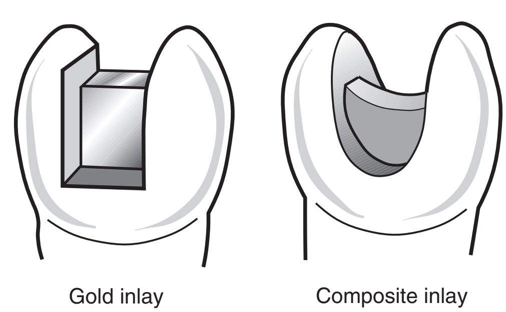


Fig. 10.16 Comparison between typical inlay cavities for gold and composite inlays.

Table 10.3 Clinical and laboratory techniques for aesthetic inlays (stages 1 and 2)

Operation	Rationale
Stage 1	
Impression technique	As for a gold inlay
Laboratory instructions	Request for etching of the fitting surface of ceramic inlays with hydrofluoric acid to provide a micromechanically retentive fitting surface The fitting surface of composite inlays are sandblasted as the achievement of a micromechanically retentive fitting surface is more difficult A silane bond enhancer should be applied to both ceramic and composite inlays both in the laboratory and also prior to cementation
Temporary restoration	The temporary restoration should be constructed in a light or chemically cured provisional material and cemented with a eugenol-free temporary luting material.
Stage 2	
Remove temporary and clean cavity with pumice	Removes contaminants such as eugenol
Handle inlay with care, try into cavity: do NOT check occlusion	Inlay is weak prior to cementation
If satisfactory fit, clean inlay fitting surface with phosphoric acid for 15 seconds	Fitting surface may have been contaminated with salivary pellicle
Apply silane bond enhancer to inlay fitting surface and allow to evaporate	Silane will improve adhesion of resin to ceramic inlay by circa 20%
Isolate, preferably under rubber dam	Saliva and/or blood contamination will reduce bond strength
Apply matrix, or organise alternative means for removal of excess luting material at gingival margin, such as floss and Superfloss	Excess luting material will cause gingival irritation
Mix luting material and apply to cavity	Application of luting material to inlay may result in fracture of inlay
Place inlay slowly and carefully	Rapid insertion of the inlay may result in its fracture
Remove excess luting material from accessible surfaces with sponge pellets or equivalent, and interproximal excess with a probe or floss if a matrix has not been placed	Removal of excess luting material is much more difficult when it has been cured
Cover margins with anti-air-inhibition gel	This will allow full polymerisation of the lute and prevent removal of the uppermost layer when finishing margins
Light cure from all directions in excess of manufacturer's suggested timing	It is not possible to overcure a composite and light is absorbed by the inlay, especially if a dark shade has been chosen. Physical properties of dual-cure materials are better when light-cured
Finish margins, check occlusion in all positions, and polish	Smooth margins will not retain plaque

Composite inlays are constructed from a variety of composite types and are 'supercured' using a mixture of heat and pressure, and heat and light.

Clinical technique for adhesive inlays

Despite the differences in the physical properties of composite and ceramic inlay materials, the suggested cavity preparation designs may be similar. The concepts described above for adhesive preparations may be employed. This type of restoration will normally be appropriate to larger rather than smaller cavities, and will often be a replacement for a failed amalgam or gold restoration. The aesthetic inlay cavity will therefore often have an approximal 'box' and occlusal key. The taper for the preparation should be greater than that employed for gold inlay preparations, i.e. at least 6°, given that the inlays are weak before cementation, and try-in or removal from a near-parallel preparation may result in fracture of the inlay (Fig. 10.16).

No bevels should be placed on the occlusal aspect of the cavity, as thin sections of composite or ceramic may be prone to fracture under occlusal loading. All cavity margins should be in enamel and they should be supragingival to permit moisture control during placement of the inlay. Cavities should be at least 2 mm deep occlusally. All line angles should be rounded.

Clinical and laboratory technique for aesthetic inlays are outlined in Table 10.3. Using these techniques, a satisfactory aesthetic result is possible (Figs 10.17 and 10.18).

The dentine-bonded crown

The dentine-bonded crown is a comparatively recent addition to the clinician's armamentarium. It has been described as a full-coverage ceramic restoration which is bonded to the underlying dentine (and any remaining enamel) using a resin composite-based luting material, with the bond being mediated by the use of a dentine bonding system and a micromechanically retentive ceramic fitting surface. Appropriate ceramics include feldspathic porcelain and aluminous porcelain, but any reinforced ceramic (e.g. Empress: Ivoclar-Vivadent, Leichtenstein) may also be appropriate provided that it is possible to etch its fitting surface with hydrofluoric acid or a hydrofluoric/hydrochloric acid mixture to produce a micromechanically retentive fitting surface. The bond between ceramic and resin luting material is enhanced by application of silane to the fitting surface. As with ceramic inlays, these crowns are weak until bonded to the underlying tooth. Indeed, since feldspathic porcelain is often used as the outer ceramic layer in many restorative modalities, such as metal-ceramic or aluminous porcelain, in the dentine-bonded crown technique, the tooth acts as the core, bonded to the ceramic by way of the dentine bonding agent and luting material (Fig. 10.19).

Advantages and disadvantages of dentine-bonded crowns are as follows:

Advantages

- Good fracture resistance
- Achievement of good aesthetics
- Minimal axial preparation result in less pulpal irritation (occlusal/incisal reduction is as for a PJC)
- Reduced potential for microleakage.

Fig. 10.17 Cavity preparation for a composite inlay to replace a failed gold inlay (patient requested tooth-coloured restoration).

Fig. 10.18 Composite inlay at placement visit.

a)

b)

Fig. 10.19 (a) Dentine-bonded all-ceramic crowns constructed in feldspathic porcelain on central incisor teeth. (b) Preparation for crowns illustrated in (a) shows minimal shoulder and less tooth reduction than for conventional crowns. (Reproduced by courtesy of Dental Update, George Warman Publications, Guildford, UK.)

- Use in situations where preparation taper is large or crown height poor
- Luting material is virtually insoluble in oral fluids
- Use in patients who are sensitised to any constituent of casting alloys.
- Correctly finished, they should not cause irritation of the periodontal tissues
- No marginal gap as this is filled with the luting material

Disadvantages

- Problems of isolation for the bonding procedure if deep subgingival margins are present
- The luting procedure is more time-consuming than for conventional crowns, resulting in a higher chairside cost
- Lack of extensive long-term clinical data on effectiveness

Dentine-bonded crowns are indicated:

- as replacements for failed, conventional crowns
- in cases of tooth wear
- as alternatives to metal-based alloys.

They are not suitable where isolation is not possible, such as deeply subgingival margins or in patients with uncontrolled caries or severe parafunctional habits.

The placement technique for dentine-bonded crowns is outlined in Table 10.4.

PORCELAIN LAMINATE VENEERS

The advent of new tooth-coloured restorative materials and techniques within the last three decades has led to increased consumer orientation towards aesthetic dentistry (Fig. 10.20).

Fig. 10.20 Porcelain laminate veneers on anterior teeth.

Table 10.4 Dentine-bonded crown placement technique

Operation	Rationale
Remove temporary and clean preparation with pumice	Removes contaminants such as eugenol
Handling crown with care, try into preparation; do NOT check occlusion	Crown is weak prior to cementation
If satisfactory fit, clean fitting surface with phosphoric acid for 15 seconds	Fitting surface may have been contaminated with salivary pellicle
Apply silane bond enhancer to fitting surface and allow to evaporate	Silane will improve adhesion of resin to crown by about 20%
Isolate, preferably under rubber dam	Saliva and/or blood contamination will reduce bond strength
Organise means for removal of excess luting material at gingival margin, such as floss and Superfloss	Excess luting material will cause gingival irritation
Mix luting material and apply to crown	Must be handled carefully
Place crown slowly and with care	Rapid placement may result in fracture of thin margins
Remove excess luting material from accessible surfaces with sponge pellets or brushes, and interproximal excess with a probe and/or floss; run Superfloss through at gingival margin	
Cover margins with anti-air-inhibition gel	This will allow full polymerisation of the lute and prevent removal of the uppermost layer when finishing margins
Light cure from all directions in excess of manufacturer's suggested timing	It is not possible to overcure a composite and light is absorbed by the crown, especially if a dark shade has been chosen. Physical properties of dual-cure materials are better when light-cured
Finish margins, check occlusion in all positions, and polish	Smooth margins will not retain plaque

Three main discoveries have led to the evolution of the porcelain laminate veneer (PLV):

- etching of enamel
- introduction of Bis-GMA resins and the subsequent development of resin composite luting materials
- surface treatments which provide a micromechanically retentive ceramic fit surface.

These major discoveries, coupled with the continued evolution of laboratory techniques (platinum matrix build-up technique for porcelain laminates; refractory investments; new ceramics with optimised properties specific to porcelain laminates) and materials/clinical procedures (porcelain etching gels; stable silane solutions; veneer bonding composites/specific instrument kits for tooth preparation and establishment of appropriate preparation criteria), have made porcelain laminate veneers a well established and predictable treatment modality.

Indications

Porcelain laminate veneers can be used in a variety of clinical situations. For example, colour defects or abnormalities of the enamel, such as the following, can be masked:

- Intrinsic staining or surface enamel defects caused by:
  - physiological ageing,
  - trauma
  - medications (tetracycline administration)
  - fluorosis
  - mild enamel hypoplasia or hypomineralisation
  - amelogenesis imperfecta
  - erosion and abrasion
- Extrinsic permanent staining not amenable to bleaching techniques.

In addition, discoloured non-vital teeth that otherwise might require post crowns can be veneered (perhaps after internal bleaching has been attempted). Whilst PLVs may afford a more conservative alternative to post crowns in these situations, these restorations may appear darker in time as the root-filled tooth is liable to colour change. External bleaching through the palatal surface of the natural tooth (or internal bleaching) may reverse this situation (Fig. 10.21).

Porcelain laminate veneers may also be used to correct peg-shaped lateral incisors, to close proximal spacing and diastemas, to repair (some) fractured incisal edges, and to align labial surfaces of instanding teeth. Any closing of diastema must take the overhanging porcelain/occlusal guidance relationship into consideration, since this involves the risk of fracture. Converting a canine to the shape of a lateral incisor (in the case of a missing lateral) usually requires a partial veneer crown (reverse three-quarter) preparation. When major changes to the shape of the teeth are planned, it is advisable that a diagnostic wax-up on a study cast is carried out first. Alternatively, mock-up facings of composite or porcelain may be made on a cast of the unprepared teeth for chairside and/or intraoral evaluation by the operator or patient (Fig. 10.22).

Contraindications

Veneers are contraindicated when there is a poorly motivated patient with a high caries rate and appreciable amount of periodontal destruction. Recession, root exposure (with discoloration) and a high lip line are other contraindications.

PLVs are normally contraindicated if the preparation does not preserve at least half of the surface area remaining in enamel or if it has to be extended onto cervical root structure. A more extensive restoration such as a metal-free dentine-bonded ceramic crown or a conventional high-strength porcelain jacket crown may be more appropriate in these situations.

Labially positioned, severely rotated or overlapped teeth will prove difficult to restore with veneers (Fig. 10.23), as

Fig. 10.21 Discoloured teeth that will benefit from porcelain laminate veneers.

Fig. 10.22 Diagnostic wax-up of teeth.

Fig. 10.23 Severely rotated teeth not suitable for porcelain laminate veneers.

will teeth in which there is loss of substantial amounts of structure, including labial enamel, and those with interproximal caries or unsound/leaking restorations. The presence of small labial or proximal restorations may not contraindicate veneers.

When lower incisor teeth meet in close apposition to the palatal surfaces of opposing maxillary incisors, the occlusal forces are less favourable and the available bonding area is often considerably reduced. Where it is seen that veneers are more difficult to place, they should only be considered when all other alternatives are unacceptable to the patient.

Another situation in which PLVs may not be appropriate is when teeth are severely discoloured. Opaque porcelains and luting cements can be used but the end result may be a dull, 'lifeless' over-contoured restoration with poor cervical appearance because the veneer can only be extended onto the enamel-covered crown surface. It is difficult to achieve a good aesthetic result on a single, very discoloured tooth with a PLV and, in such cases, a crown restoration may be more appropriate.

Design considerations

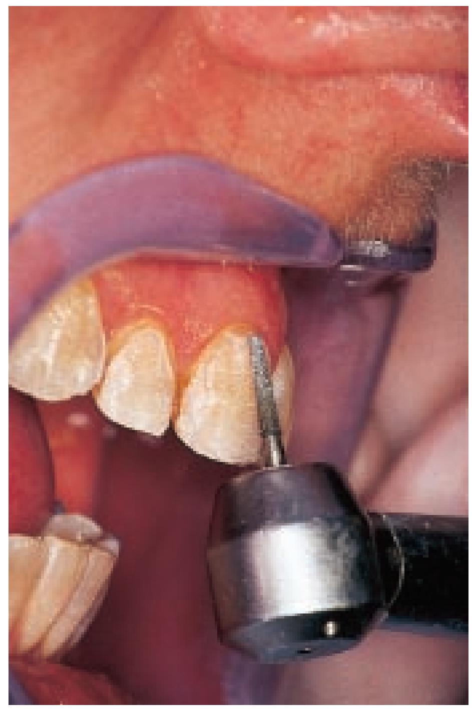
Teeth can be veneered without any preparation (e.g. an instanding upper lateral incisor) but this is generally not favoured as it will result in over-contouring (complicating plaque control) and the restoration may be difficult to locate accurately on cementation. Indications for a 'non-preparation' approach include patients who are averse to having any tooth preparation (they must have the implications of this fully explained to them in advance and this must be recorded in the notes).

Removal of surface enamel makes resin–enamel bonding more effective. The presence of small labial or proximal restorations may not contraindicate veneers. They may be incorporated into the preparation and they should be replaced before or during veneering to ensure caries removal, effective bonding and good marginal seal. Restoration with glass ionomer cement rather than composite resin may be indicated.

Tooth preparation

Labial reduction

A polyvinyl siloxane putty template of the tooth prior to preparation may be used to help the clinician measure the amount of reduction. Depth orientation grooves may be prepared using commercially available depth-limiting



a)

b)

Fig. 10.24 (a, b) Labial reduction for porcelain laminate veneer.

burs specially designed for PLVs. Alternatively, hemispherical depth orientation dimples may be prepared using a 0.5 mm radius round diamond bur (Fig. 10.24).

Great care must be taken to avoid perforation of thin cervical enamel (sometimes it is better to leave the cervical region minimally prepared or unprepared because the enamel is so thin). Lack of sensitivity during preparation (without local anaesthetic) is not a reliable indicator in this respect. Although small areas of the preparation can involve dentine without adversely affecting retention, it is best to avoid this if possible. Dentine bonding agents may be used to bond the resin luting cement to dentine but this is not ideal, particularly at the preparation margins. Labial reduction should finish with a chamfer margin at the proximal ‘stop’, thus preserving the contact area.

Cervical margin placement

Porcelain laminate veneers generally allow supragingival margins to remain visible (because of their optical properties) and tooth preparation allows a good emergence profile to be maintained. Supragingival or equigingival margins should normally be preferred for the following reasons:

- they are less likely to involve cervical dentine
- the margins are accessible for finishing and polishing
- plaque control is simplified
- assessment of marginal fit is easier
- moisture control during bonding is simplified.

About 0.3–0.5 mm of enamel should normally be removed (0.3 mm cervically) and the preparation should end proximally just short of the contact point(s) and level with the gingival margin (or supragingivally if the lip line permits) in enamel. A 0.3 mm chamfer creates a finish line which is easy to identify and reproduce in the laboratory. It allows correct tooth contour to be established cervically. It facilitates veneer placement and reduces the risk of margin fracture at try-in. Greater reduction, up to 0.7 mm in depth, may be required to mask heavy tetracycline discoloration, and if the lip line is high, the preparation may also have to be extended intracrevicularly to achieve satisfactory aesthetics. The surface produced by conventional medium grit diamond burs is adequate, as composite/enamel bonding is facilitated by the rough surface. A finishing bur is, however, preferred for margin refinement.

Proximal reduction

Although undercut areas should not be introduced in the preparation, care should be taken that the veneer extends adequately in the proximal subcontact areas (cervical to the contact points) to avoid an unsightly band of exposed tooth structure remaining (especially mesially). A labial or labio-incisal path of insertion helps to prevent this. The aim is to place the margin beyond readily visible regions. Provided the tooth does not have proximal restorations, placement of the proximal ‘stop line’ should be guided by aesthetic considerations. It is essential to extend the margin of the veneer beyond the visible area.

This is especially important when the colour of the tooth differs greatly from that of the veneer. Assessment of correct proximal margin placement should be determined from frontal and/or side-on views. Proximal extension of the veneer to the lingual proximal line angle may be required to achieve a favourable restoration contour when there are diastemas to be masked or when there is caries or an existing restoration proximally.

Incisal coverage

The veneer is extended to or taken over the incisal tip depending on the need to rebuild or lengthen this area (taking into account occlusal constraints). An incisal bevel is the preparation of choice when the tooth to be veneered is of the correct length and the anticipated functional occlusal loads will be low. If the occlusion permits, the incisal edge of the tooth should not be routinely covered as the preparation is then more conservative and does not alter the patient’s natural incisal guidance/tooth contacts. However, when the incisal edge of the tooth is not overlaid, the occlusal third of the PLV is often very thin (0.3 mm or less). If there is edge-to-edge occlusion or evidence of incisal wear then there is a greater risk of chipping or incisal fracture of the veneer from occlusal load (Fig. 10.25).

In addition, when the teeth are thin, the difference in resilience between the prepared natural tooth and the PLV can, under occlusal load, lead to cracking or fracturing of the ceramic. A similar consideration applies if extensive composite restorations are present.

Complete coverage of the incisal edge with a minimum thickness of 1 mm of ceramic (preferably 1.5 mm) will offer the following advantages:

- It restricts incisal fracturing in cases of heavy occlusal load.

Fig. 10.25 Incisal preparation for porcelain laminate veneer.

- It facilitates changes in tooth shape/position.
- It facilitates handling and positioning of the PLV at try-in and during bonding.
- It allows the veneer margin to be placed outside the area of occlusal impact.
- It facilitates achievement of good aesthetics in the final restoration.

An incisal edge overlap preparation is used when tooth lengthening is indicated, when it is necessary to cover/protect part of the palatal surface, or when the incisal edge is poor aesthetically due to minor chipping etc. Incisal reduction must provide a minimum ceramic thickness of at least 1 mm. A thicker layer should be used for canine teeth and lower incisors. The lingual margin placement for a lower incisor may be extended one-third of the way down the lingual surface, transforming the veneer in effect into a partial crown. With this type of preparation the ceramic will be exposed mostly to compressive stresses and less to flexural stresses. Despite the small preparation surface area, the failure rate is relatively low. The degree of extension onto the lingual/palatal surface will depend upon the particular clinical situation. The lingual finish margin should be prepared as a hollow ground champfer to a depth of 0.5–0.7 mm. This margin should be located away from centric stops or areas of direct occlusal impact.

Impression

A silicone impression taken in a full arch stock impression tray is adequate. Alternatively, a twin-mix single-stage addition-cured silicone impression taken in a special tray may be used. Occlusal stops should be placed on teeth away from those prepared. Retraction cord placement is rarely necessary and, if required, may indicate over-preparation.

Simply blowing with an air syringe should reveal the margin in the final preparation. Gingival retraction, however, is required to record the root emergence profile when the cervical margin is placed equigingivally or subgingivally for aesthetic or other reasons. Non-medicated retraction cords (small braided cords – Ultrapak No. 1 or No. 2, Ultradent) are preferred to reduce any risk of gingival recession. Any undercuts created by the cervical embrasure spaces may be filled in lingually with softened wax to avoid the risk of the impression tearing.

Temporary cover

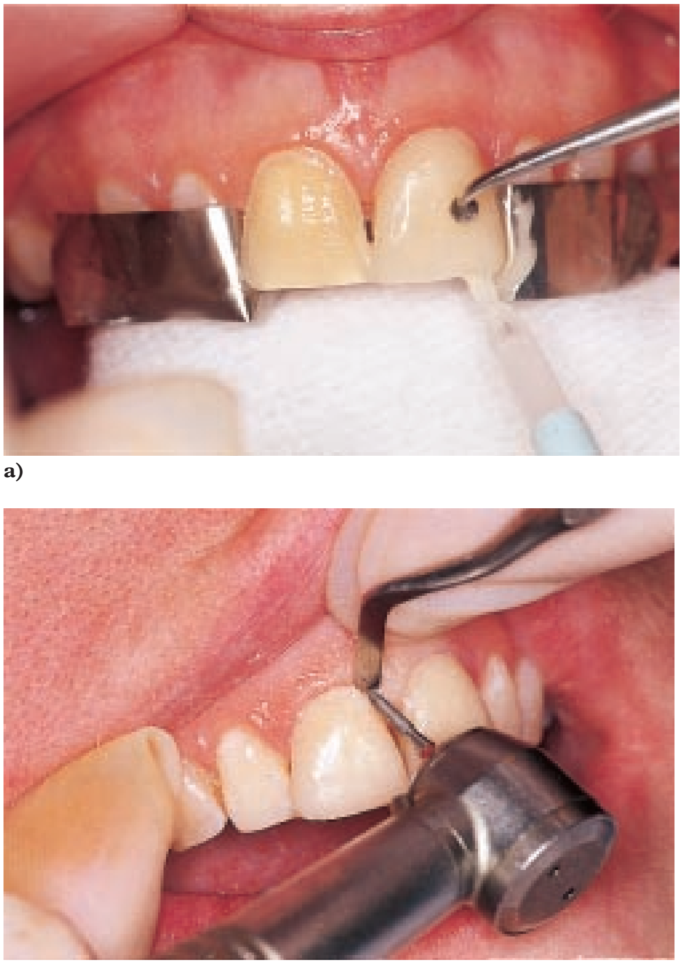
This is rarely indicated for minimal veneer preparations and, when required for a single veneer, can be accomplished with light-cured composite resin build-up. The tooth preparation is coated with a layer of water-soluble separator (glycerin), light-cured composite restorative is applied and excess removed from interproximal spaces before curing. After light curing, the hardened material may be removed for shaping and polishing. It may be cemented to the tooth surface with a layer of composite after the preparation has been spot-etched centrally (Fig. 10.26).

Fig. 10.26 Spot-etching of UR1 prior to temporary coverage for porcelain laminate veneer.

Pairs of veneer preparations may be made at the chairside or in the laboratory on a quick-setting plaster cast poured from an impression. Multiple temporary veneers may be made at the chairside with the aid of a transparent vacuum-formed plastic mould prepared from a model in the laboratory. A light- or chemically cured provisional composite resin may be used to make the provisional veneers. After trimming and adjustment, the veneers may need to be relined to improve marginal fit. These temporary prostheses are generally not separated but are cemented in one piece. A eugenol-free temporary cement or zinc phosphate may be used for this purpose or a resin-based temporary cement (Temp Bond Clear, Kerr). When there is incisal coverage or the veneer has had to be extended interproximally or converted to a partial cover dentine-bonded crown (reverse three-quarter), there is a greater need for a provisional restoration to satisfy patients' aesthetic demands and to reduce the risk of tooth sensitivity.

Laboratory aspects

Porcelain veneers may be fabricated on platinum foil matrices, or using refractory dies. With both techniques the fit surface of the fired porcelain veneer is grit-blasted with 50 micron Al_2O_3. The veneer fit surface is then etched with a hydrofluoric acid etch gel and a silane solution is applied to it. It is important, if possible, to get most of the desired final shade from the porcelain restoration itself rather than the luting cement.



a)

b)

Fig. 10.27 Try-in (a) and cementation (b) of porcelain laminate veneer.

Try-in

Clean prepared teeth with a pumice/water slurry, rinse and dry. If necessary, clean interproximally with finishing strips. Care is needed to avoid trauma to the gingival margin and bleeding. The tooth is isolated (cotton wool rolls, suction) and airway protection (gauze or throat pack) is placed.

The individual veneers are checked for fit and contour. (If multiple, try in together). *Do not* seat veneers forcefully but adjust as required with diamond burs (veneers are fragile at this stage and final minor adjustments are best left until after bonding). If porcelain margins are exposed, silane and bond resin have to be reapplied in the laboratory before proceeding (Fig. 10.27).

Choose the correct shade of composite luting cements (use the shade of veneer itself as a guide). Use water or glycerin if required for initial aesthetic try-in (an air gap will adversely affect the shade evaluation). Only if essential, use a trial mix of luting composite applied to the veneer fit surface (having wetted the tooth surface with water) for shade assessment. Switch off the operating light beforehand! Wipe out excess resin with cotton wool and place the veneer in an appropriate solvent (ethyl alcohol) to remove remaining unpolymerised luting cement.

Cementation

Obtain strict moisture control with cotton wool rolls, saliva ejectors and sponges etc. Gingival retraction cord may also be required. Adjacent teeth are protected with soft metal matrix (Dead soft matrix material, Den Mat) or mylar strips folded over uninvolved contacts to secure in place or use wedges.

Acid etch with phosphoric acid gel for 30 seconds, rinse for 20 seconds, and dry until a frosted appearance is evident. (If areas of exposed dentine are present, use an enamel/dentine bonding system in accordance with the manufacturer's instructions.)

Apply unfilled bond resin and blow thin. Do not light cure! It is essential that excess bond resin is not allowed to pool in interdental or cervical areas where it may prevent complete veneer seating.

Place the chosen shade of composite resin luting cement as a thin layer over the veneer fit surface (avoid incorporating air bubbles) and seat the veneer onto the tooth with slow continuous pressure until fully in place. Remove gross excess cement from the margins with a probe (or a brush tip dipped in unfilled resin). Run Superfloss interproximally in a labial to palatal direction to remove interproximal excess. If the veneer is correctly seated, 'tack' it into place with a 10–20 second period of light irradiation incisally. Remove more excess resin taking care not to drag out cement from under the margins. Complete light curing by overlapping light guide tip applications (60 seconds each) in incisal, labial and proximal areas.

Cement adjacent veneers one at a time (always check for correct seating beforehand!).

Finishing

Gross excess cement can be removed with hand instruments such as scalers and composite finishing burs. Remove residual excess from the margins with water-cooled composite finishing burs which may also be used for fine trimming of porcelain margins. The gingiva is protected by retraction with the blade of a 'flat plastic' hand instrument and the proximal area is finished with com-

a)

b)

Fig. 10.28 Final finishing of veneers.

posite finishing strips. Finally, a check is made with floss for smooth passage (Fig. 10.27).

The final polish of margins is undertaken with impregnated polishing discs and cups (Enhance-Dentsply), polishing pastes (Prisma-Gloss/Dentsply) and/or composite polishing discs (Soflex 3M). Fig. 10.28). A final check is made on the occlusion and the PLV is adjusted to remove premature contacts in all excursions.

Review and maintenance

The patient is reviewed 1 week later to ensure that all excess resin cement has been removed and that correct plaque control procedures are being employed. The marginal integrity is checked for signs of marginal leakage, colour, aesthetic acceptability and gingival health at regular recall. The occlusion is inspected for interferences and adjusted if required. It is known that properly executed porcelain veneers rarely fail due to bond failure. However, a mouth guard should be provided for contact sports players to avoid damage.

SUMMARY

Complex restorations are clinically rewarding but they do require careful treatment planning to ensure their longevity in the mouth. This aspect of restorative dentistry ensures that the patient has a functional restoration which is mechanically sound but also biologically compatible.