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Direct Anterior Composites: A Practical Guide

Abstract: For more than 40 years dentists worldwide have been using directly placed resin-bonded composite to restore damaged anterior teeth. While such techniques are invariably more conservative of tooth tissue than indirect procedures, operative techniques using direct composite can be challenging and are considered technique sensitive. Clinicians require both technical *and* artistic skill to provide composite restorations that restore function and aesthetics to blend seamlessly with the residual dentition. This paper provides an update on the aesthetic considerations involved in the restoration of anterior teeth with directly placed composite and outlines the contemporary materials, equipment and techniques that are available to optimize every clinical stage.

Clinical Relevance: Successful restoration of anterior teeth with direct composite is an integral component of contemporary clinical practice.

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In 1973, *Dental Update* published a prize-winning paper detailing a new application for resin composite in the restoration of a fractured central incisor of a ten year-old patient.[1] While the procedure was considered a provisional method of long-term stabilization prior to a definitive indirect restoration, it was noted that the technique offered a number of benefits:[1]

- The procedure maximized preservation of natural tooth tissue;
- Minimal preparation (confined to enamel) provided a large area for retention via the acid-etch technique;
- The patient's appearance was immediately improved via a 'very good and simple means of restoring aesthetics';
- The technique allowed the endodontic status to be monitored over a number of years and left all other future restorative options open.

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Following the work of such early innovators, the last four decades have seen remarkable technological advances in the fields of aesthetic and, more recently, minimally invasive dentistry. The dental literature now even contains entire textbooks devoted to the aesthetic restoration of anterior teeth using direct composite.[2,3]

Operative techniques and materials with enhanced optical properties have been refined to such a highly sophisticated level that they present a first line approach,[4] delivering predictable and reliable restorations[5] of aesthetic and functional excellence,[6] rivalling the best ceramics[7] (Figure 1). The great popularity of composite resin restorations also results from their acceptable longevity at relatively low financial cost.[8]

While anterior composite restorations are ubiquitous, advanced multiple-layering techniques using a range of shades, opacities and translucencies remain the domain of relatively few practitioners.[2] Dentists commonly report that such techniques are time-consuming or complicated and do not offer predictability in terms of aesthetics.[2] Therefore, when aesthetic demands are high, many practitioners still resort to more destructive indirect procedures, relying on their technicians to employ well-established ceramic techniques to mimic the complex optical properties of natural teeth.

With the objective of reducing this tendency, this paper aims to provide:

- An overview of aesthetic factors to consider when restoring anterior teeth with direct composite;
- An update of the latest equipment,

Figure 1. (a, b) Direct composite restoration of two fractured incisors.

- Caries management
- Fracture repair
- Management of non-carious tooth tissue loss
- Aesthetic improvement by modifying colour/shape/length/alignment, etc
- Diastema closure
- Trial, temporary, long-term provisional or core restorations
- Repair of indirect restorations
- Replacement of missing teeth, eg using fibre-reinforced composite resin-bonded bridges

Table 1. Indications for restoring anterior teeth using direct composite.

- Post-operative sensitivity
- Marginal discoloration
- Restoration fracture
- Restoration de-bond
- Wear of opposing teeth
- Iatrogenic damage
- Pulpal injury
- Restoration removal results in an increase in cavity size

Table 2. Potential complications of aesthetic restorative procedures.

materials and techniques that will enable predictable aesthetic restoration of teeth in commonly occurring clinical situations (Table 1).

Advantages of anterior composites

Minimally invasive

The main advantage of direct adhesive procedures is that they require minimal (or no) tooth preparation to enhance resistance and retention form[6] (Figure 2). Multiple studies confirm that these conservative techniques offer a number of benefits compared to indirect restorations, including:[9]

- Significantly fewer endodontic complications;[10]
- More favourable mode of failure;
- Re-intervention is easier as restorations are more reversible and amenable to repair;
- Occlusal scheme can be assessed and corrected immediately;
- Reduced risk of wear to opposing teeth.

a

b

Figure 2. (a, b) Cosmetic diastema closure using direct composite, with no tooth preparation.

a

b

Figure 3. (a, b) Direct composite renovation using finishing and polishing techniques to remove marginal excess/stain.

Aesthetics

It is a well-established fact that the appearance of a patient's teeth is an important psychological factor influencing his/her attractiveness and self-confidence.[3,11] Techniques that enable the immediate restoration of aesthetics in a single appointment, requiring no provisional restorations and at a lower financial cost, are popular with patients.[5,8,12]

These versatile procedures are also professionally satisfying, as dentists are entirely in control of an aesthetic, biologically respectful technique, without the risk of communication errors that are common with indirect procedures.[12] In common with the pioneering dentists of 40 years ago, practitioners using these minimally invasive techniques preserve all future treatment options.

Disadvantages of anterior composites

Biological

Although direct techniques generally maximize tooth tissue preservation, it must be stressed that, as with any restorative procedure, an irreversible cycle of restoration replacement and repair begins with every operative intervention. The risk/benefit ratio must be considered at the outset and the patient informed of the potential short- and long-term complications that may ensue (Table 2) and his/her ongoing maintenance requirements.

Longevity

Regardless of material, the average survival statistics for direct restorations are far from encouraging.[12,13] However, the figures for indirect restorations are also poor, averaging approximately ten years before restorations require total replacement[13,14] and, when failure occurs, complications are often catastrophic for the tooth. With an optimum technique, it should be possible to provide direct composite restorations that exceed the average lifespan of indirect restorations and, in addition, retain the option of being able to increase their *functional survival* using conservative renovation techniques such as:

- Re-polishing to regain surface lustre that is commonly lost from direct composite over time;
- Refurbishing restorations to remove marginal stain (Figure 3);

Figure 4. Direct composite restoration of four carious incisors **(a–c)** and at review **(d)** demonstrating restitution of interdental papillae.[21]

- Re-sealing restorations;
- Localized repair.

Technique sensitivity

The main determinant of success in any direct adhesive procedure is based upon the operator's skill in optimizing assessment, diagnosis, treatment planning/sequencing and execution and all operative stages.[15] When providing restorations in the aesthetic zone, these demands must extend to detailed anatomical knowledge and artistic skill. Therefore it is essential to have comprehensive understanding with regard to:

- The optical properties of natural teeth;[16]
- Tooth proportions and their relationships to each other and to the surrounding soft tissues;
- Selection of appropriate restorative materials that match adjacent residual tooth tissue.

Figure 5. Study of *ideal* maxillary anterior teeth: **(a)** informs direct composite shaping procedures (**b, c).**

The following summary of the fundamental principles of aesthetics in dentistry aims to provide the basis on which to design and carry out aesthetic direct restorations involving the maxillary anterior teeth.

Key factors influencing the aesthetic properties of anterior maxillary teeth

A complex range of interrelated factors combine to determine the overall aesthetic properties of each individual patient's smile. Principles of 'smile design' are well-documented and the dental literature contains a number of excellent publications which provide guidelines for restoring the aesthetics of anterior teeth.[17,18,19] It should be emphasized that these guidelines are not designed to form dogmatic rules to which *all* restorative procedures must adhere.

Extra-oral and soft tissue aesthetic factors

The facial and periodontal tissues are key ingredients in dental aesthetics.[20] Useful guidelines for the relationships between teeth and these structures are as follows:[17,18,19]

1. Tooth shape;
2. Surface texture;
3. Colour.

Table 3. Principal factors affecting dental aesthetics, in order of importance.

- The *smile line* (*aka* incisal line) is the imaginary line joining the upper incisal edges and canine tips and should generally follow the curve of the lower lip on smiling;[17,18,19]
- Ideally, on smiling the entire labial surface of the central incisors should be revealed and approximately 0–2 mm of marginal gingivae;[17,18]
- Restorations should be designed to allow interdental papillae to fill each interdental embrasure[3,21] (Figure 4);
- The upper central incisor midline should be vertical and perpendicular to the interpupillary line;
- Ideally, the midline should correspond to the facial midline, but deviation up to 4 mm is not usually detectable;[3,22]
- Resting incisal display (often referred to as the 'M' position) should average approximately 1–2 mm in young males and 3–4 mm in young females;[23]
- When making an 'F' sound, the tips of the central incisors should touch the lower lip at, or just behind, the wet/dry border.[17,18]

Dental aesthetic factors

When providing anterior restorations, it is useful to refer to widely recognized guidelines describing the key factors that influence the overall dental appearance.[17,18,19,24] Tooth shape is generally considered to be the most important determinant of successful aesthetic integration.[3,6] Furthermore, a restoration with the correct shape and surface texture is likely to integrate with the residual dentition successfully, even when small colour disparities exist[2,3] (Table 3).

Tooth shape

This relates not only to the outline form of individual teeth, but also to their relative proportions and relationships to each other. Useful restoration guidelines include[17,18,19] (Figure 5):

- Central incisors should dominate the

Figure 6. The optical properties of natural teeth and aesthetic restorations are highly influenced by primary, secondary and tertiary surface texture.

patient's smile and be symmetrical to each other;
- The ratio of width/length dimensions of a central incisor should ideally be 75–80%;[3]
- Incisal edges of central (and lateral) incisors should be generally parallel to the patient's interpupillary line;
- Distal incisal line angles should be more rounded than their mesial counterparts and incisal embrasures should increase in depth, moving distally from the midline;
- While the majority of lateral incisors are asymmetrical, their incisal edges should be approximately 0.5–1.0 mm shorter than those of the central incisors (and canines) and their maximum width approximately ²/₃ that of the central incisor;
- The frontal smile should show only the mesial ½ of canine teeth and the long axis of all the anterior teeth should ideally be slightly mesioangular.[6]

Surface texture

Following shape, restoration surface texture is the next most important factor influencing successful intergration[3] and requires a detailed understanding of the equivalent anatomical features in natural teeth.[2,3]

The labial surface texture of young, unworn teeth is highly reflective and results in an attractive bright appearance (Figure 6).[3] Surface texture features may be divided into three groups.

Primary surface texture

When incident light strikes the labial surface of an anterior tooth the majority is reflected back to the observer.

Figure 7. **(a, b)** To simulate the optical properties of natural teeth, direct composite restoration of Class V cavities generally requires only a thin translucent *enamel* layer overlying more chromatic *dentine* layers.

This reflective area, which has various names (reflective face/zone; apparent face; silhouette form), is bordered by curved surfaces which deflect light giving a darker outline. The junctions of these zones, widely referred to as *transition lines*, are key features in restorative dentistry.[2,3,16] Accurate positioning of transition lines in direct (and indirect) restorations is critical if restorations are to blend seamlessly with the residual dentition.[6,16,19]

Secondary surface texture

This is referred to as *macrotexture* and includes:
- *Developmental lobes* (usually three) on the labial surface;
- *Developmental grooves* of varying length dividing the lobes longitudinally;
- A *cervical bulge* in the gingival third;
- *Mamelons* (often present on the tips of unworn incisors in young patients).

Tertiary surface texture

This is referred to as *microtexture* and includes:
- Accessory ridges/grooves;
- *Perikymata* – very small surface striations caused during the formation of enamel prisms (Figure 6);
- *Imbrication lines* – subtle, broken, crescent-shaped ridges on the cervical bulge, running parallel to the amelo-cemental junction.

Tooth colour

While tooth colour is not considered to be the prime factor determining successful restoration integration, it is still a vital component and is certainly the most complicated parameter. The dental literature contains numerous articles devoted entirely to the subject.[25] The following outline describes aspects of tooth colour relevant to direct anterior restorative techniques.

Basic tooth colour theory

Dentistry is amongst a number of disciplines that have adopted the famous Munsell system[26] which describes colour in terms of three basic properties: hue, chroma and value.
- **Hue:** This is the name of the colour and refers to the portion of the spectrum (wavelength of light) reflected by teeth back to an observer. Natural tooth colour has been described as 'a true colour mosaic in the yellow/white colour range'.[27]
- **Chroma:** This describes the saturation of colour within the tooth: for example, canine teeth are usually more chromatic than their mesial and distal neighbours as they have a greater thickness of dentine showing through the relatively translucent enamel.[3]
- **Value:** This is considered to be the most important factor in shade matching[2,3] and refers to the brightness of the tooth/restorative material. High value teeth appear bright as interpreted by the rods in

Figure 8. Tooth section demonstrating enamel thickness in a natural central incisor and incisal opalescence.

- Composition
- Structure
- Thickness
- Transparency
- Translucency/opacity
- Opalescence
- Fluorescence
- Cracks and fissures
- Characterizations
- Intensive colours

Table 4. Factors influencing the optical properties of enamel.

- Incisal 'halo' effect
- Intensive white spots, clouds or bands
- Chromatic spots or bands, eg amber, brown, white
- Dentine lobes of varying colour

Table 5. Colour characterizations in natural anterior teeth.

the retina.[25] Hue and chroma are detected by cones[25]and small variations in them will be imperceptible if the tooth/restoration value blends.[2,3]

Before selecting materials designed to mimic natural teeth it is essential to understand how the optical properties of the various tooth layers influence overall colour.[6,12,24]

Enamel, dentine, pulp and the amelo-dentinal junction (ADJ) all possess different optical properties, which are determined by their composition, structure and relative thicknesses. These tissues are constantly evolving via dynamic interaction with the extrinsic and intrinsic environments via numerous exchange processes.[27] Numerous natural colour changes occur throughout life.

Dentine

In terms of colour, dentine may be considered the most important layer.[28] It provides most of the tooth's hue which falls in the yellow/red portion of the spectrum. In natural teeth, light passes through the translucent enamel and is reflected from the yellowish, relatively opaque dentine, which is approximately 20% less translucent than enamel[4] (Figure 7).

Dentine colour varies from patient to patient and from tooth to tooth and changes throughout life.[27,28] These variations are influenced by its composition, which is mainly mineral hydroxyapatite crystals (70%) supplemented by organic material (20%) and water (10%).

The organic component is partly responsible for making dentine more opaque than enamel.[28] Opacity is further increased by its tubular structure which deflects some of the light rays entering the tooth.[28]

The dentine 'core' contour is as complex as enamel surface texture and comprises *dentine lobes* (usually three) divided by grooves labially and incisally. In unworn teeth, dentine terminates in the incisal third, short of the incisal edge.

Amelo-dentinal junction

The interface between enamel and dentine plays an important role in light transmission. It has a high mineral content and may be considered to have properties similar to a fibre-optic cable.[28]

Enamel

Enamel is 95% mineral (5% water and organic components) resulting in largely translucent optical properties.[27] The overall appearance of enamel depends on a complex interaction of factors[2,3,29] (Table 4).

Translucency

For successful restoration integration, accurate replication of translucency is considered to be almost as important as value.[29] The translucency of natural enamel (and restorative material) is strongly influenced by its thickness[27,29] (Figure 8).

Cervical enamel is thin (average 0.2–0.3mm in young teeth)[27]and highly translucent, allowing the more chromatic dentine to show through and creating a considerably more opaque appearance.[28] Moving incisally enamel thickness increases and it becomes less translucent. In the incisal third, enamel is thickest (average 1.5mm)[27] and may possess a localized bluish, opalescent effect[27] (Figure 8).

Opalescence

When very fine hydroxyapatite crystals are illuminated by light in the visible range of the spectrum, short wavelength light is scattered.[27] Reflected light results in a blue/grey/violet appearance, often extending to the proximal surfaces and transmitted light results in amber/reddish/orange effects. While these iridescent phenomena may occur across the entire labial surface, it is more evident in the incisal third, where there is no interference from dentine.[2,28]

Fluorescence

Dental hard tissues (particularly enamel and the ADJ) also fluoresce when struck by invisible/short wave ultraviolet light, reflecting it back as visible, bluish longer wavelengths.[16] Therefore, for successful integration, dental materials should possess fluorescent properties.

Characterization

Localized mineralization differences, of varying aetiologies, are common in tooth structure and may result in unusual colourations. Detailed classifications[16,30] provide useful guidance when copying these features in composite resin (Table 5). Central incisors generally

- *HFO/HRI* (Micerium, Avegno, Italy)
- *Vit~l~escense* (Ultradent, UT, USA)
- *Clearfil Majesty ES-2 Classic* (Kuraray, Japan)
- *Miris 2 /Synergy D6* (Coltène Whaledent, Switzerland)
- *Renamel Microfill/Nano* (Cosmedent, IL, USA)
- *Venus diamond/ Durafill VS* (Heraeus Kulzer, IN, USA)
- *Esthet-X HD /Ceram X duo* (Dentsply, York, PA, USA)
- *Filtek Supreme Ultra* (3M ESPE, St Paul, MN, USA)
- *IPS Empress Direct/ Tetric Evoceram* (Ivoclar, Liechtenstein)
- *Gradia/Genial* (GC, Japan)
- *GrandiSO/ Amaris* (Voco, Cuxhaven, Germany)
- *Herculite Ultra/ XRV* (Kerr, Bioggio, Switzerland)

Table 6. Examples of polychromatic composite resin materials designed to be applied in layers

have more elaborate incisal characterization than lateral incisors.[6]

Cracks and fissures

Naturally occurring fissures (enamel lamellae) and cracks resulting from functional forces fill with air and water, effectively dividing the enamel surface into portions with differing optical properties.[28] These features also allow the passage of stains which may extend to the dentine layer and may be simulated using pigmented composite resins.

Pulp

Even the naturally dark red colour of pulpal tissue has an influence on tooth colour and can result in a pinkish appearance, which reduces as pulp volume decreases with age.[28]

Effect of age on tooth colour[2,27,28]

Young enamel is thick, with lower mineral content, creating high value tooth colour. With age, mineral content increases and enamel thins due to natural wear. This results in an increase in enamel translucency, which may be pronounced or even transparent, allowing the dentine colour to show through.

Young dentine is very opaque. With age, dentine become less opaque but has more colour saturation as highly mineralized secondary dentine is laid down. Tertiary dentine, which has varying structure and composition, will also influence tooth chroma.

The ADJ translucency increases with age and it can sometimes become completely transparent.

Extrinsic and intrinsic stains can have a potent effect on tooth colour over time and this may be partially or completely reversed by tooth whitening procedures.

When restorative procedures aimed at improving tooth colour are planned, it is often recommended to carry out whitening procedures first, reducing the need to mask darker colours with opaque materials. Following tooth whitening, it is not recommended to carry out adhesive restorative procedures for at least two weeks, to avoid the negative effects of oxygen inhibition and to allow colour stabilization.[31]

Clinical stages for restoring anterior teeth using direct composite

Having studied the anatomical and optical properties of natural tooth tissue, it should now be possible to select appropriate materials, equipment and techniques judiciously for the accurate, predictable, aesthetic restoration of anterior teeth using direct composite.

Material selection

As with any restorative procedure, a thorough understanding of materials science enables selection of composite resins suitable for each clinical situation and optimizes the restoration of function and aesthetics.

A wide range of composites is available for the restoration of anterior teeth, all with subtly different formulations, which can be confusing.[8] Prior to purchase, practitioners are recommended to study, test and select materials based on their fundamental physical properties rather than focusing on their marketing literature. Filler content determines a material's mechanical properties and influences volumetric shrinkage. As with posterior composites, hybrid materials are commonly used, as their combination of large and small filler particles provides the strength necessary to withstand functional forces.[15]

Filler particle composition and filler/resin refractive index mismatch are among the most important variables in determining the optical properties of individual materials.[32]

Where high functional forces are not anticipated, resins containing low average filler particle size (microfills) may be selected for their superior polishability properties.

All procedures using direct resin placement are considered technique sensitive.[15] Therefore, for successful, predictable restorations, materials must be selected that possess the handling characteristics favoured by individual practitioners.[12,15]

For clinical situations, where aesthetic demands are high, the majority of manufacturers supply materials in multiple shades. These are designed to be placed using stratification techniques similar to those used by dental ceramists[6] (Table 6).

While the *perfect* composite with optical properties *identical* to those of enamel and dentine does not exist,[2,33] the dental literature now contains a growing number of ground-breaking publications detailing the seemingly limitless capabilities of direct composite for the precise restoration of damaged teeth, in a comprehensive range of clinical situations.[2–4,6,8,12,16,24,29,30,32,34–37]

Shade-taking

Analogous to natural tooth tissue, the appearance of dental restorations is influenced by shape, surface texture, translucency/opacity, value, chroma and hue, with each property combining to affect the final outcome.

While shape and surface texture are still considered of greatest importance, predictable shade matching is an essential requirement for all practitioners and a number of techniques are available to facilitate this process.

Shade guides

While shade guides are included with most composite systems, unfortunately they are generally considered to be inaccurate and unsuitable for

Figure 9. Enamel and dentine shade tabs fabricated from composite.

Figure 10. Pre-operative digital photographs enable colour mapping **(a)** and may be manipulated with suitable software to accentuate incisal characterizations **(b).**

Figure 11. **(a, b)** A silicone template made from a prototype restoration (or wax-up) simplifies placement of the palatal composite increment.

precise colour matching for a number of reasons:[2–4,8,12,35,38]

- The majority of shade guides are not fabricated from the restorative material that they represent;
- Shade guides are generally less translucent than natural teeth and restorative materials;[3]
- Most shade tabs are of standard thickness;
- Incongruous composite shade classifications are brand (and batch) dependent;
- Composite nomenclature can be confusing,[2] for example, *dentine*, *body* and *opaque* shades may be synonymous;
- There is poor correlation between composite shades and those used for dental ceramics;
- Composite resins frequently undergo a significant shade change during polymerization;[39]
- Set composite resin material absorbs water post-operatively and this may result in unpredictable colour changes.[40]

Various techniques have been described that aim to overcome the limitations of commercially available shade guides and include:

- Placing a sample of the material(s) on the tooth surface (or a suitable adjacent tooth).[7] Ideally, use the same quantity required for the restoration and the test sample should be light-cured to account for polymerization shade shift;[2,3,15]
- Chairside construction of customized shade guides made from genuine materials, which may be layered in various thicknesses;[2,3,4,12]
- Practise prototypes copying anticipated proportions of definitive restorations;[3,6]
- Purchase of materials with innovative two component shade guides, eg *Miris 2* (Coltène Whaledent);
- Purchase of systems containing shade guides fabricated from composite, eg *CeramX duo* (Dentsply) (Figure 9).

Shade-taking technique

Various technique tips have been identified to improve precision when selecting shades for direct (and indirect) restorations, including:

- Shade should be taken immediately at the start of restorative procedures before dehydration has occurred (see below);
- Study cavity configuration and anticipate optical requirements of the final restoration, eg cavities extending from labial to palatal surfaces must transmit light in the same way as the adjacent tooth tissue;
- Assess (or measure) the cavity with regard to the relative quantities of missing enamel and dentine;[3]
- Note any discolorations that will require masking with opaque material;[4,12]
- Where both enamel and dentine are exposed, take the shade of both (Figure 9);
- When assessing control teeth, use the middle third to record the basic shade;[3]
- Take shade quickly. (After five seconds staring at a tooth or shade guide subtle colours blend);[28]
- Look away at a complementary (opposite) colour, eg blue to re-sensitize the eyes to the yellow/orange/red spectrum;[2,3,16,28]
- Use different lighting sources to avoid metamerism, where coloured objects appear the same under one light source and different under another;[27]
- Use a colour-corrected light source (International daylight standard 5,500K) to select hue and chroma;[2,27]
- Use less bright light to select value (5,500K is considered too bright for this).[27]

Colour mapping

As enamel loses water rapidly, shade selection should be carried out as early as possible and before isolation.[3] Dehydration blocks the passage of visible light and this decrease in refractive index

a

b

c

d

Figure 12. **(a–d)** Fractured tooth fragments may be adhesively reattached to deliver unsurpassable aesthetic results, at negligible biological cost.

causes enamel (and dentine) to become lighter and more opaque, in less than three minutes.[2]

Maximum dehydration is reported to occur 30–45 minutes after isolation[2] and complete rehydration may not occur for 24–48 hours.[2] Dehydration also masks the internal colour

Figure 13. Rubber dam optimizes moisture control and may be stabilized with floss ligatures.

characteristics.[3]

For these reasons, experienced practitioners refer to a pre-operative photograph or diagram of well-hydrated teeth to guide their placement sequences. This is commonly referred to as a *colour map*.[6,12,16,30]

A good photograph used with an appropriate shade guide is reported to be the most precise method of colour communication.[16] Digital images may be underexposed or manipulated with software to reveal characteristic internal features, particularly occurring in the incisal third[16] (Figure 10).

Occlusal record

As with all restorative procedures, functional integration is as important as that required for aesthetic blending. Restoration of guiding palatal surfaces using direct techniques presents challenges, but can be simplified by using a template constructed from a prototype restoration or a pre-operative wax-up[3,6,7,34] (Figure 11).

The initial palatal composite increment may be applied to a template made of conventional silicone putty or specialized transparent material before or after insertion into the mouth. Once light-cured, the palatal *shell* immediately establishes the three dimensional form of the whole restoration.[12]

Cavity preparation

In certain clinical situations, tooth preparation may be avoided completely, eg fracture repair (Figure 12) or diastema closure (Figure 2).

Where preparation is necessary, it should be minimized and confined to the enamel to optimize adhesion and reduce the risk of marginal staining.

Natural cavity undercuts or pulp chambers/root canals of endodontically treated teeth may also be used to enhance retention.[34] Particle air abrasion may be employed to clean cavities and increase the surface area available for micro-mechanical and chemical retention.[4] In certain clinical situations, it may be necessary to bevel enamel margins to assist retention and to mask the transition between tooth structure and the restorative material.

Opinion varies on the size and form (eg scalloping[7]) of enamel bevels or whether discs, ultrasonic tips or rubber points should also be used to remove fragile enamel from preparation margins.[3]

Isolation

While use of a rubber dam is far from commonplace,[41] it is generally considered to be the optimum method of moisture control for adhesive restorative procedures[2,15] (Figure 13).

Following isolation with a rubber dam, stabilizing cord, wedges or floss ligatures may be used to optimize the seal and prevent the dam partially obscuring adjacent teeth which are being used to guide restoration shape.

Another useful isolation technique for Class III, IV and V restorations involves the use of gingival retraction cord, which may be soaked in an astringent product.[34]

Matrix technique

There is a variety of matrices designed for anterior composites restorations involving proximal surfaces. They are made from a number of translucent polyester materials, commonly referred to by the brand name *Mylar*. They are available in a number of shapes including: full contour crown forms, strips and specially designed sectional matrices designed to facilitate restoration of the complex curvature of anterior teeth.[3] Matrices should be secured with suitable wedges to minimize cervical excess, provide

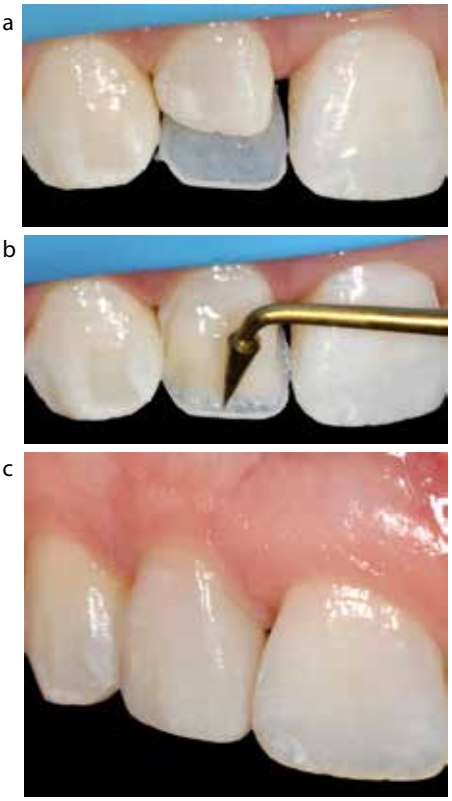

Figure 14. (a–c) The relative thicknesses of *enamel* and *dentine* composite layers is critical to success with stratification techniques.

tooth separation and soft tissue control and stabilize the rubber dam.[3,15] Thin metal sectional matrices designed for posterior composites may also be used or 'dead soft' foil wrapped around adjacent teeth.

A popular technique employs plumber's tape (Polytetrafluoroethylene (PTFE) tape). This inexpensive, inert, non-sticky material is usually wrapped around adjacent teeth to protect them from etch, adhesive, and excess composite. PTFE tape is of negligible thickness promoting tight contact formation[34] and it does not interfere with adaptation of silicone templates.

Etching

Before etching, cavities must be thoroughly washed, dried and inspected for any debris. Starting with enamel, etchant is applied to the entire cavity and just beyond the margins. Excessive etchant should not extend beyond this area, to prevent excess composite adhering and being difficult to remove without iatrogenic damage to underlying enamel. When application to the dentine is complete, it is left for 15 seconds and then rinsed off thoroughly.

With total etch systems, enamel can be dried to a 'frosty' appearance but dentine desiccation should be avoided. This also promotes adhesion to dentine and reduces the risk of post-operative sensitivity.[12,15] Unprepared enamel should be etched for longer (30–60 seconds)[42] to optimize adhesion to the acid-resistant aprismatic surface layer of enamel.

Bonding

As successful adhesion is a fundamental requirement for long-lasting restorations. Fastidious attention must be given to manufacturers' protocols.[15]

Self-etching adhesives are not recommended when restoring cavities that lack sufficient resistance and retention form (eg Class IV), as they contain weaker acids that will not sufficiently penetrate enamel to a depth that maximizes resin-tag formation.[43]

Before light-curing, all cavity surfaces should appear glossy/shiny.[15]

Placement techniques

A wide range of placement protocols have been proposed for anterior resin composites. With multiple cavities the general recommendation is to restore the central incisors first, one at a time, following the aesthetic principles previously described.[34] Once complete, restoration of lateral incisors and then canines is carried out.[6]

Proficient operators tend to *slightly* overbuild restorations before reducing them to correct contour. This avoids the need for time-consuming additions, which may also lead to visible layers/voids between increments.[3]

All composites shrink during polymerization and create stresses, with the potential to cause a range of well-documented complications.[15]

Fortunately, the wide, open configuration of many anterior cavities allows restorative material particles to flow during their polymerization reaction. This relaxes stresses and often permits placement of larger increments than those recommended for cavities with a less favourable *configuration factor*.

Composite increments may be injected from compules or applied using a variety of instruments. Practitioners are recommended to master placement techniques with a select range of instruments designed for the purpose.[2,15] Composite may be warmed using specialized (or improvised) heaters to enhance adaptation to the cavity and between increments.[16] The common practice of lubricating instruments with adhesive agents should be avoided as they contain solvents that may dilute composite resin materials and have negative effects on their physical, optical and surface staining properties.[44]

Solvent-free modelling liquids, eg *Biscover* (Ultradent), *Enaseal* (Micerium), are also available, but their use is not universally recommended,[2,3] other than to recover the oxygen inhibited layer following corrections to subsurface increments using rotary instruments.[2]

Layering techniques

Despite technological advances in contemporary composite systems, the majority of practitioners use monochromatic materials for anterior composites.[2] Such techniques are ideally suited for small cavities but they may deliver sub-optimal aesthetic outcomes in more aesthetically important areas.

Although placement of successive increments helps to minimize the effects of polymerization shrinkage stress, aesthetic layering techniques are considered problematic[3] and less predictable than those which use a single material.

Errors in layering techniques result in restorations which appear too translucent or opaque.

The thickness relationship of opaque *dentine* composites and translucent *enamels* is the key to successful layering techniques.[2,29] The overall outcome is determined by the propagation of light as it passes through these layers to create an illusion of depth, equivalent to that seen in natural teeth [6,32,36] (Figure 14).

Unfortunately, a 'utopian' material, engineered to replace enamel and dentine in their exact dimensions, does not exist.[2] To avoid restorations having an excessively translucent, grey-looking

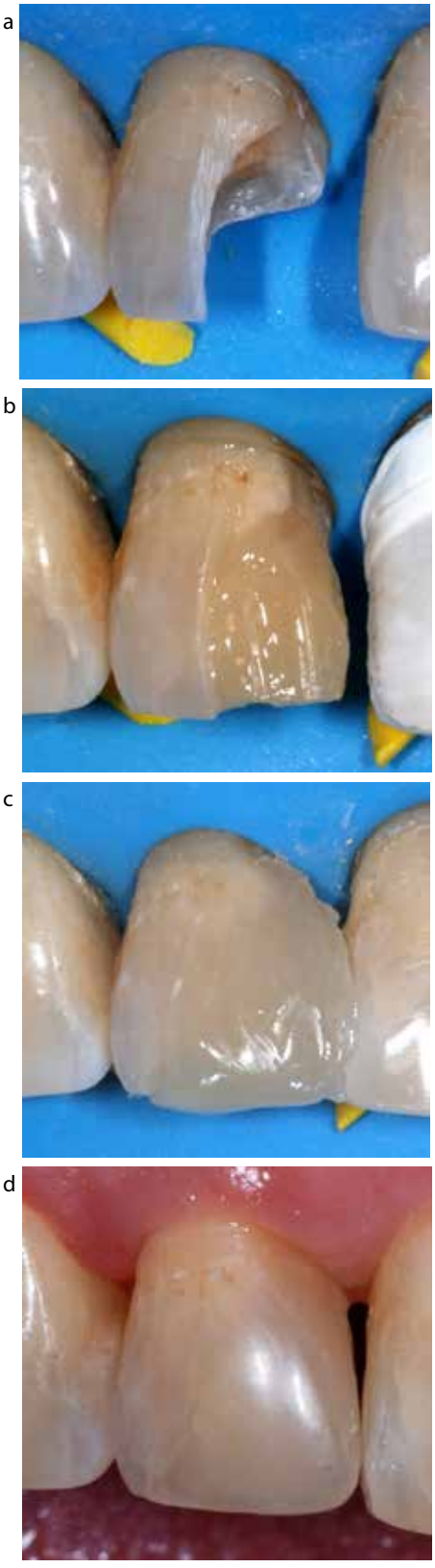

Figure 15. Dual-shade layering technique: **(a)** cavity preparation; **(b)** *dentine* layer; **(c)** *enamel* layer; **(d)** completed restoration.

appearance, it is widely recommended to apply *enamel* composite layers in thicknesses *no greater than half* that of the total enamel thickness.[2]

A wide range of composite stratification techniques, of varying complexity, have been described.[2] To ensure predictable, aesthetically pleasing results, layering concepts should be simple, standardized and reproducible.[3]

The following basic dual-shade and more complicated multi-layered (polychromatic) placement sequences are presented as methodical guidelines for all clinicians wishing to create more natural looking direct anterior composite restorations.

Dual-shade layering technique

Inexperienced practitioners are recommended to develop confidence in layering techniques by beginning with two material shades, as this simplified technique is reported to deliver an acceptable colour match in a large number of clinical situations.[2]

Following etching and adhesive application, an opaque *dentine* material is applied, shaped and light-cured (Figure 15a, b). Most *dentine* restorative materials (and 80% of natural dentine) are in the shade group A and selection of the correct chroma is a key to success.[2] Palatal, proximal and labial *enamel* increments are then layered, freehand over the opacious central core at approximately half the thickness of residual enamel (Figure 15c, d).

Polychromatic layering technique

When aesthetic demands are high, the widely accepted stratification technique proposed by Lorenzo Vanini is recommended.[16] As each clinical situation presents different aesthetic challenges, study of detailed atlases[2,3] describing the comprehensive range of layering options is highly recommended. The fundamental principle of polychromatic layering technique is to use different composite shades to replicate the layers seen in natural teeth,[32,37] as demonstrated in Figure 16, which is now described in stages.

Palatal *enamel* layer

A palatal 'shell' of translucent *enamel* composite is light-cured in place. In this example, using a silicone template made from a pre-operative wax-up (Figure 16a, b, c).

***Dentine* layer**

To avoid a monochromatic appearance, *dentine* lobes are restored using progressively chromatic increments[2,3,16] (three in this example) (Figure 16d, e, f). The *dentine* build-up should stop short of the incisal edge and should be shaped into lobes, leaving room for the incorporation of materials designed to replicate the appropriate optical properties of the incisal third.[2,3,16]

Special features

These are very case specific. In natural teeth, they are generally optical properties of enamel, but materials aiming to mimic these features are ideally placed *before* the final *enamel* layer[2] (Figure 16g).

'Painting' these features on the surface layer often appears artificial, because it lacks the quality of depth and may wear off. When the translucent *enamel* material is subsequently applied and polished these features show through, producing very natural appearances, such as the incisal 'halo effect'.[6,16]

Materials designed to replicate special features may be divided into opalescents, characterizations and intensives[16,30] and are usually applied in that order.

Opalescents

Opalescent materials are placed in spaces left between the *dentine* lobes and, if required, extended into mesial and distal proximal spaces.[2,3,6,16]

Opalescent composite transmits light more efficiently and is designed to reproduce the iridescent optical properties commonly seen in the incisal third.[2] The degree of opalescence is judged by the amount of blue that the material shows under direct light and amber features seen under transmitted light. Composites specifically designed to recreate opalescent effects include Trans Opal (*Empress Direct*; Ivoclar), OBN (*Enamel Plus HFO*, Micerium)

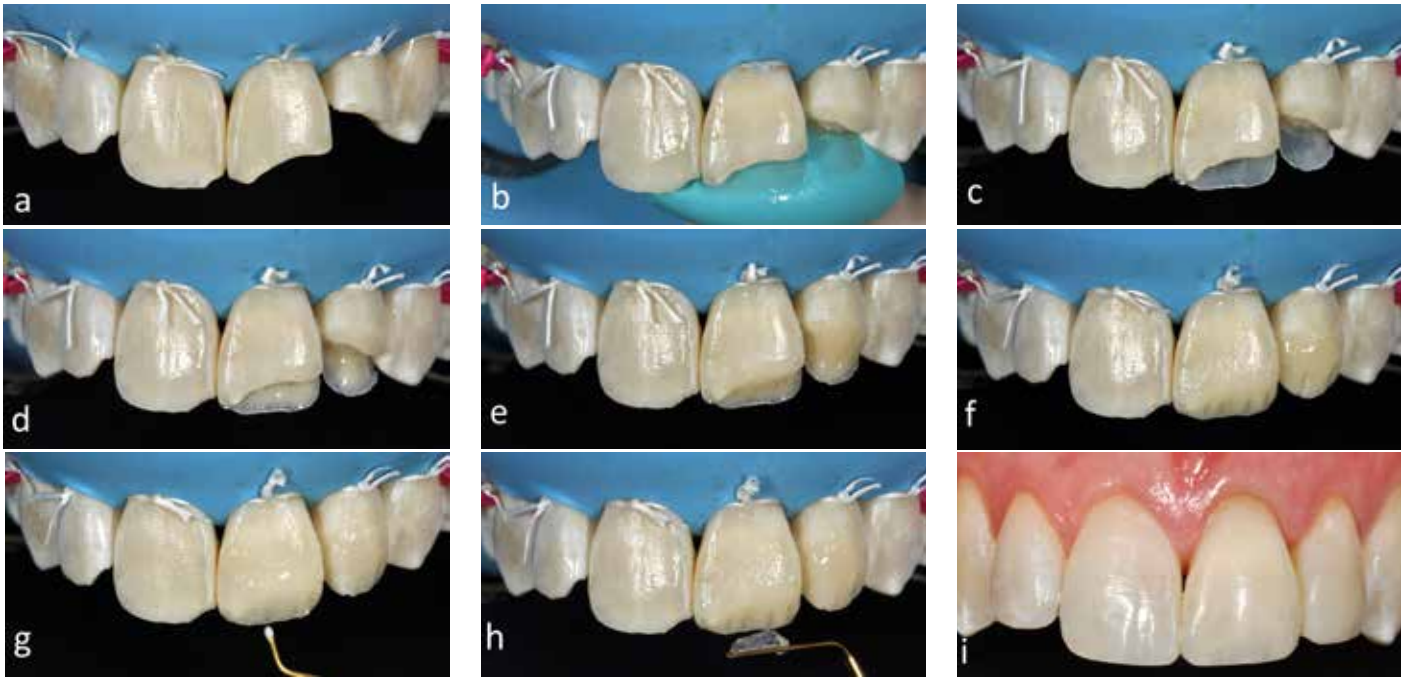

Figure 16. (a–i) Use of different composite shades to replicate the layers seen in natural teeth.

and Effect Blue (*Miris 2*, Coltène Whaledent).

Two generalized groups of material may be used to create opalescent effects: tinted flowable materials or artificially achromatic enamel (AAE) composite,[12] which is inherently pigmented and not keyed to the Vita shade system.[6] Either material may be used to impart various degrees of translucency and subtle hues, ranging through grey, blue, violet, amber, to milky white.

Characterizations and intensives[16,30]

Experienced clinicians are capable of precisely reproducing a diverse range of *characterizations*, including those listed in Table 5.[2,3,16,30]

Intensives are used to recreate white spots or patches in teeth found with hypoplastic and hypomineralization defects. White features vary in opacity extent and lack opalescence. A range of tinted conventional and flowable materials may be applied using suitable instruments or brushes (Figure 17) or mixed to copy unusual colourations.[2] It is recommended to use them sparingly to avoid obviously unnatural appearances[12] and to refer to an adjacent tooth or a pre-operative colour map.

Labial *enamel* layer

The final layer generally comprises an *enamel* or *incisal* material with smaller average filler particle size with translucent (and often opalescent) optical properties that modify those of the underlying layers (Figure 16h).

It is advisable to minimize the time spent manipulating superficial increments to reduce the risk of incorporating air bubbles, which may affect the optical properties and/or be revealed during finishing and polishing procedures.[2] The final layer may be slightly overbuilt and then finished and polished to the correct incisal edge thickness. It is recommended that the total *enamel* thickness should be a maximum of half of the thickness of the natural enamel that it replaces (or maximum thickness of 0.5mm)[3] to prevent restorations being too translucent, too low in value and not life-like.[2,6]

Light-curing

While various alternative light-curing regimes have been proposed, general recommendations include: regular equipment checks using appropriate light intensity meters; light-curing for a suitable duration (usually at least 60 seconds) from all angles; keeping the light tip as close to the material as possible and avoidance of premature polymerization by ambient light.[16] A layer of translucent material, such as glycerine, may be placed over the final increment.[34] This minimizes contact with oxygen which inhibits surface polymerization.

Figure 17. Tinted flowable composite may be applied using suitable instruments to create natural incisal effects.

Shaping

Shape is the most important factor in the final appearance of an aesthetic restoration.[2] It is therefore essential that the primary anatomical features of natural teeth are meticulously reinstated using appropriate burs, discs and finishing strips (Figure 18). Initial shaping may be carried out using red-stripe (30–40 µm) composite finishing burs. When shaping a single central incisor, the adjacent tooth should be studied to re-establish symmetry by making the reflective face of both teeth equal.[3]

Repositioning of transition lines can change the appearance of poorly shaped teeth, making them appear aesthetically pleasing even though their outline remains the same.[3]

Functional surfaces should be designed and contoured so that both the restoration and tooth can tolerate the anticipated occlusal forces.[6] In patients with parafunction, more fracture resistant, large particle, hybrid composite is recommended, which may be veneered with a more aesthetic/polishable microfill or small particle nano-hybrid material.

The correct shape must be established *before* refinements are made; if this is not done the finishing and polishing process will tend to magnify any errors.

Finishing and polishing techniques

Finishing and polishing are well-researched procedures[45,46] and play an essential role in the way that light interacts with the restoration.[2] The natural secondary and tertiary surface texture features may all be simulated in direct restorations, using a variety of equipment (Figure 19), including:[6]

- Finer diamond or tungsten carbide composite finishing burs (yellow/white/purple stripe) to refine shape and correct marginal plaque retention factors;
- Medium finishing discs to smooth the restoration and refine line angles/transition lines;
- Fine polishing discs to create the attractive surface lustre seen in natural enamel;
- Silicone rubber points and cups to introduce secondary anatomical features such as developmental grooves (Figure 19b);
- Abrasive finishing strips to remove proximal excess and refine emergence profiles;
- Sharp instruments, eg scalpels or scalers to remove unbonded excess;
- Tungsten carbide or coarse diamonds (used at 'stallout' speed[7]) to create a 'perikymata effect' that increases the restoration's value (Figure 19c);
- Goat's hair/chamois/felt wheels and brushes to develop a high shine after all other stages have been completed (Figure 19d, e).
- Specialized polishing pastes of varying particle size, eg Aluminium oxide.

A methodical approach is required to complete each finishing and polishing procedure before moving on to the next. Great care should be taken to

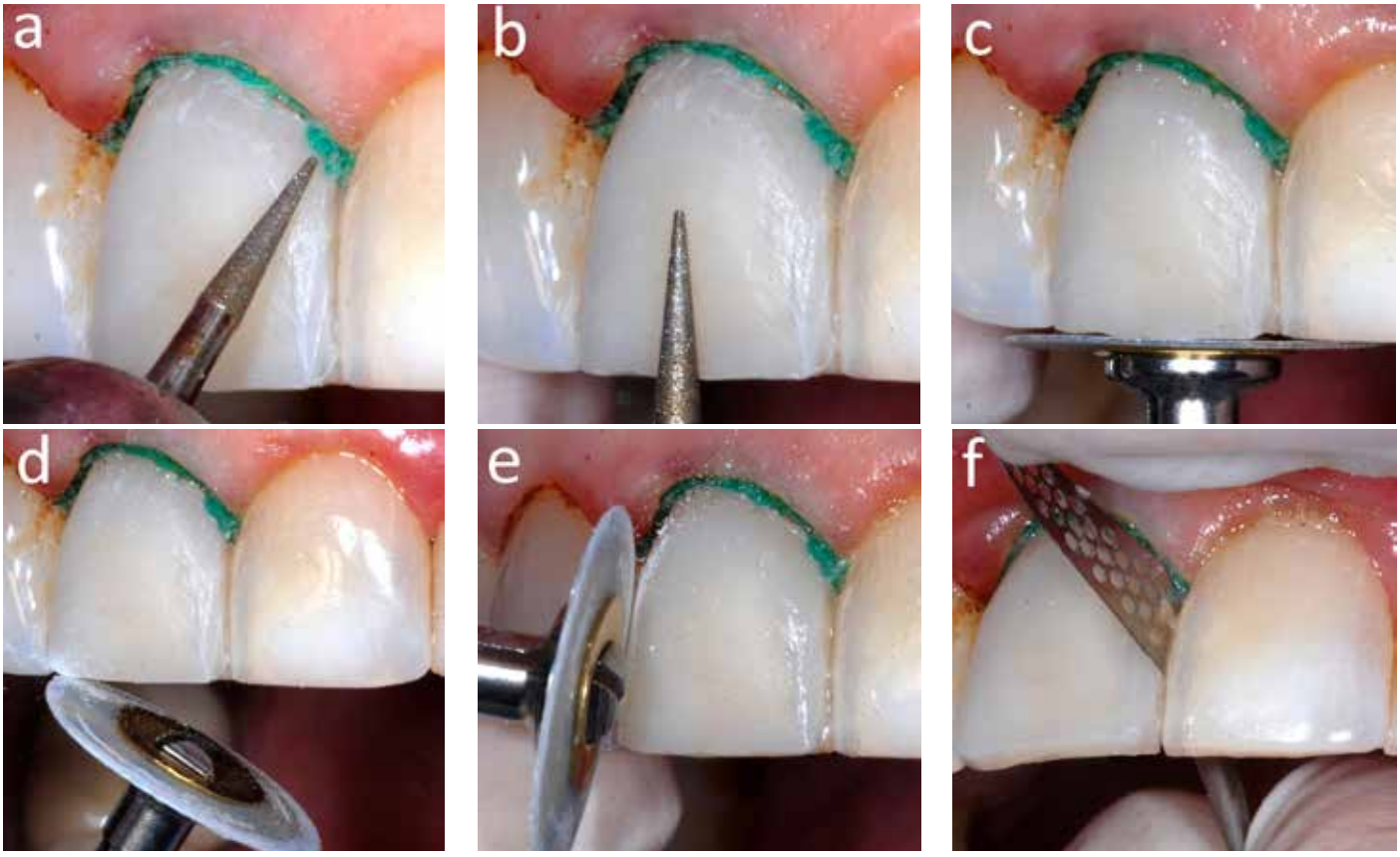

Figure 18. *Shaping procedure stages*: **(a)** cervical bulge/transition lines; **(b)** labial face; **(c)** incisal edge; **(d)** incisal line angles; **(e)** refine transition lines; **(f)** emergence profile.

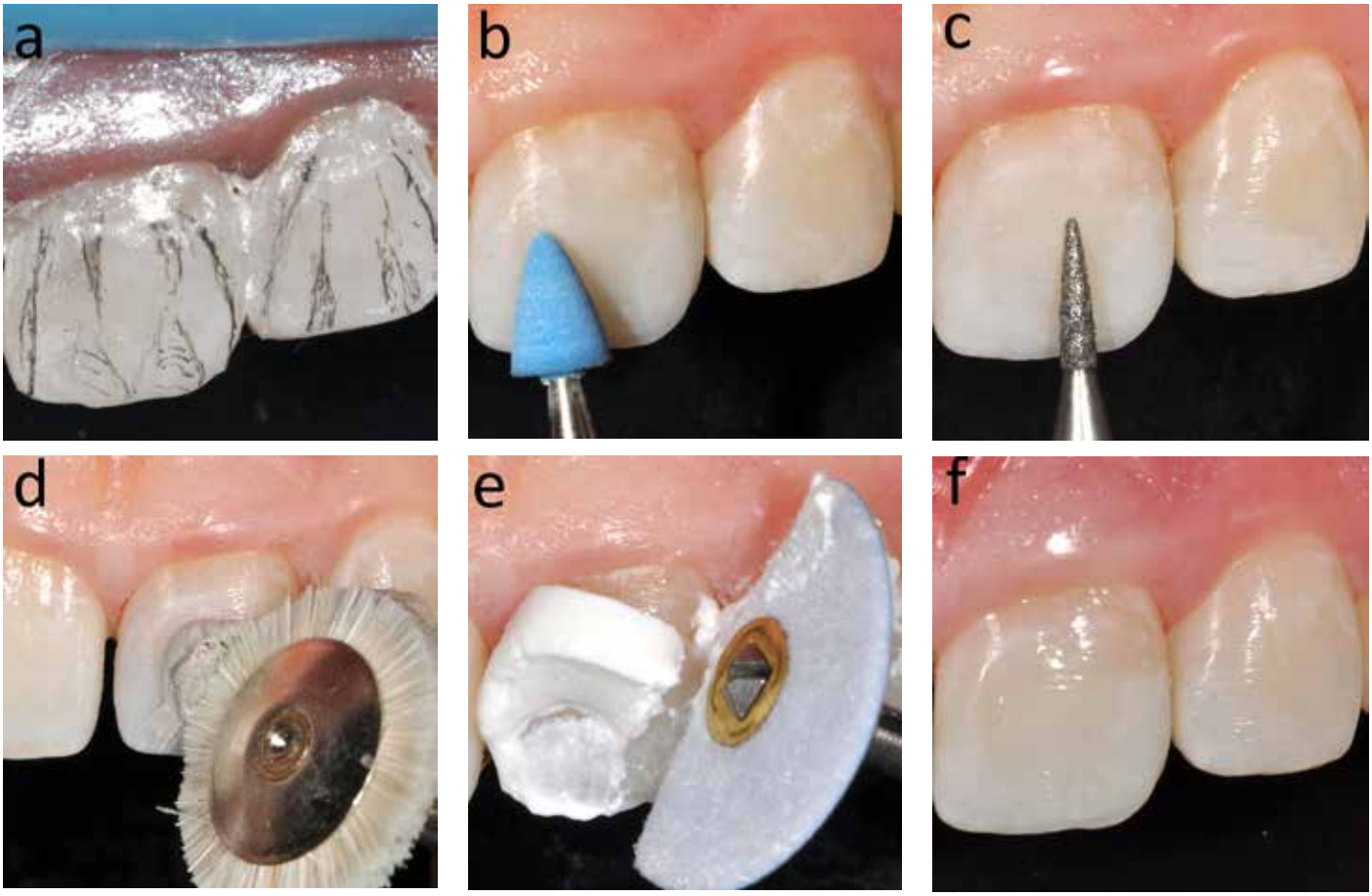

Figure 19. *Finishing and polishing stages*: **(a)** highlight surface texture features using silver powder and pencil marks (optional); **(b)** contour developmental grooves with a silicone point; **(c)** introduce *perikymata* with a coarse diamond bur; **(d)** polish with goat's hair brush and polishing paste; **(e)** buff with felt disc and fine polishing paste; **(f)** restoration complete.

avoid iatrogenic damage to tooth surfaces and adjacent periodontal tissues. Copious water spray and a light touch should be used as rotary finishing equipment can generate significant heat. This may damage hard and soft dental tissues, restorative material, and adhesive interfaces or destroy finishing burs designed for multiple uses.[2,15]

Restorations should never be painted with adhesive agents containing solvents. Although this will deliver a short-lived shine, surface degradation will rapidly encourage stain formation. The time taken to shape, finish and polish anterior composite restorations accurately will deliver reliable, aesthetic, long-lasting restorations equivalent to those made from ceramic.

Review

Composite resin materials absorb water which is attracted to the filler particles altering the optical properties of the restoration.[40] For this reason, fine finishing and polishing procedures may be postponed to a second appointment when shade stabilization has occurred. Clinicians will also be able to reflect on the functional and aesthetic outcome and carry out any necessary adjustments.

As with all direct and indirect procedures, patients must be informed at the outset of the importance of restoration maintenance and the need for regular reviews to allow assessment and renovation or repair in the longer term.

Conclusion

Successful anterior composites are satisfying for both patients and clinicians. The time taken to study dental aesthetics and practise and refine operative techniques[2] (Figure 20) will be rewarded on a daily basis. Direct adhesive procedures have almost limitless potential to restore function and aesthetics, while preserving healthy tooth tissue and, as such, anterior composites are at the very forefront of contemporary minimally invasive aesthetic dentistry.

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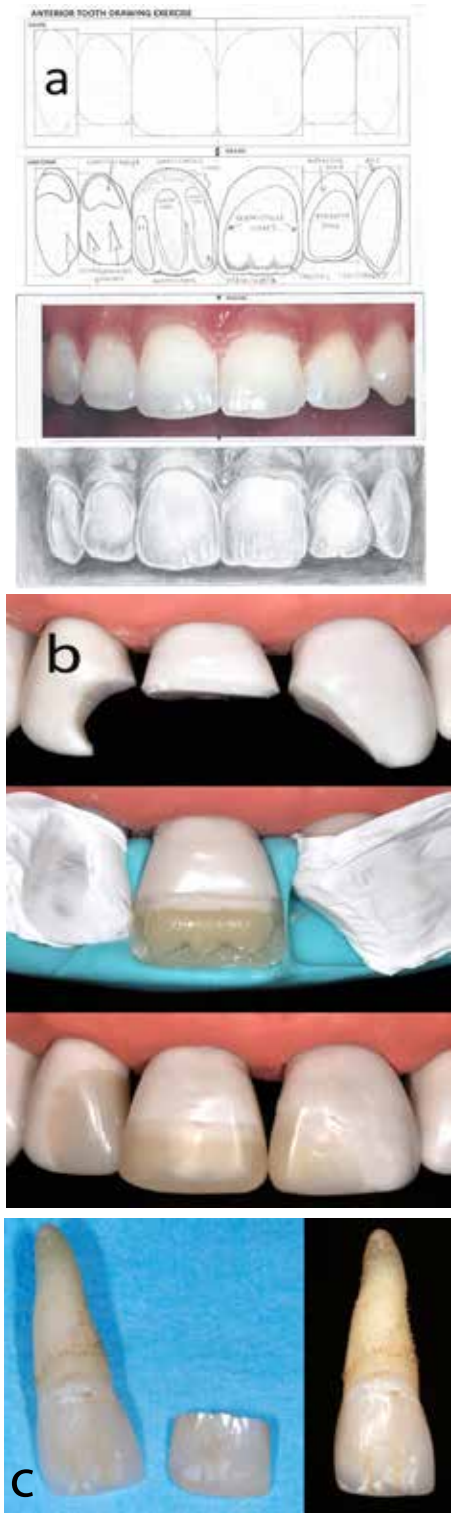

Figure 20. Undergraduate training exercises completed by students at the University of Birmingham School of Dentistry. **(a)** Diagrams aimed at teaching tooth shape, proportion, relationships and surface texture. **(b)** Simulated direct anterior composite procedures. **(c)** Natural tooth sectioning and replication exercise.

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