# Shading concepts and layering techniques to master direct anterior composite restorations: an update

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## In brief

- Provides an overview of the various layering techniques at hand for direct composite restorations in the smile frame.
- Demonstrates the clinical rationale for using any of the listed layering techniques.
- Demonstrates the specific advantages of the natural layering and polychromatic concepts to optimise aesthetic results.

Creating perfect direct composite restorations has been for long time a strict challenge due to many materials' limitations impacting either shade integration or surface quality, and possibly colour stability. Next to technological drawbacks, a certain complexity and lack of predictability in clinical application was inherent to the technique and made it elitist for a long time. Shading and layering concepts then progressively evolved from a simplistic, non histo-anatomical, bilaminar technique to a multi-layering approach (3 to 4 or more layers), following the Vita Classic™ system. One of the most achieved concepts is polychromatic layering which makes use of a variable number of layers (basically VITA™ or non-VITA™ opacious dentin, chromatic enamel and translucent/opalescent enamel), driven by the natural tooth optical composition. In parallel with this evolution, a simplified, non-VITA shading system was developed with a reduced number of layers (basically dentin & enamel layer, plus effect shades if required) known as the natural layering concept, aiming to the same optimal esthetic integration and natural colour reproduction/emulation. The latest improvements appear all driven by the same view of improved reliability and clinical simplification.

## Introduction

Contrarily to a widespread belief, several modern composites are equal to or better than some porcelain systems, featuring enhanced optical properties and aesthetics; it is today up to the operator, acting as an artist and scientist, to exploit the full potential of direct bonding and correlate them with natural tooth tissues to create better function and aesthetics without any bio-mechanical impairment, which may prove elusive with indirect ceramic restorations. Essential to the successful use of composites for direct free-hand dentistry, knowledge of tooth anatomy, colour and materials' optical and physical properties enables dentists to achieve high-end and long lasting aesthetics, promoting tissue conservation and constraining treatment costs.

Layering of composite restorations for aesthetic purposes, started with the development of light-curing technology and the launch of comprehensive, optically structured composite systems such as the Herculite XR (1985) (Kerr, Orange-CA, USA) offering various material opacities and shades, integrating for the first time in 1991 VITA shades into a direct restorative system (Herculite XRV, Kerr). Then, the interest for such products, fueled by the increasing demand of patients for a better aesthetic integration of their direct restorations, triggered a rapid increase in product offerings and the development of several alternative shading and layering concepts. Nowadays, various options are available implying different levels of clinical complexity and reliability; again, the successful application of aesthetic composite systems depends on the operator's understanding and knowledge of their intrinsic properties and his or her ability to master related clinical protocols. Overall, composite systems can be classified according to the number of layers usually applied together with their specific optical parameters;[1–3] it includes mono-layer systems, bi-laminar systems (aiming or not to emulate natural tooth anatomy and colour) and tri-layer systems showing a few variations (ie.: opaque dentins – dentins – enamels or dentins – chromatic enamels – incisal shades). Next to hue and opacity, opalescence and fluorescence properties, as well as filler technology, will impact the final aesthetic integration, underlining, once again, the need for a proper understanding and integration of this material's various properties. This is key to a successful use of composite in the smile frame.[4–7]

This article aims to review current shading concepts and layering techniques and will provide indications and clinical protocols of the most prevalent and successful options. Detailed clinical guidelines will be suggested to obtain reliable and optimal colour and overall aesthetic integration.

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**Table 1 Historical perspective on the various layering concepts applied to direct anterior composite restorations**

| Time | Basic layering approach | Shading concept | Composite type | Typical brand |
|---|---|---|---|---|
| 1979–1984 | Mono–laminar | Non-VITA basic shading | Microfilled | Durafill (kulzer); Isosit (Vivadent); Silux (3M) |
| 1985 | Bi-laminar | Body + incisal shades | Micro-hybrid | Herculite XR (Kerr) |
| | | Non-Vita shading | | |
| 1991 | Tri-laminar | Dentins + chromatic enamels + Incisals | Micro-hybrid | Herculite XRV (Kerr) |
| | | Vita Shading | | |
| 1997 | Bi/multi-laminar* | Dentins + value and effect Enamels | Micro-hybrid | Enamel HFO (Micerium) |
| | | Vita Shading | | |
| 1999 | Tri-laminar | Opaque dentins + body shades + translucent enamels | Micro-hybrid | Esthet-X (Dentsply) |
| | | Vita shading | | |
| 2000/2006/2013 | Bi-laminar | Universal dentins + mutli-tint and translucency enamels | Micro-hybrid | Miris & Miris2 (Coltenewhaledent) |
| | Natural layering shading | Non-Vita shading | | Inspiro (Edelweiss DR) |
| 2002/2011 | Polychromatic | Dentins + body shades + chromatic enamels + incisals | Spherical | Filtek Supreme/Filtek Supreme XTE (3M-ESPE) |
| | | Vita shading | | Estelite Omega (Tokuyama) |
| 2003/2010 | Bi/multi laminar* | Universal dentins + value & effect enamels | Micro-hybrid | Enamel HFO Plus/Enamel Hri (Micerium) |
| | | Non-Vita shading | | |
| 2014 | Histo-anatomical layering[13] (penta-laminar) | Deep dentin and superficial dentin shades + dentin-enamel junction liner + deep & superficial enamels | NA | NA |

*Multiple layers/shades or dentin and enamels recommended

## Development of layering concepts and composite systems

Overall, layering concepts evolved from a primitive approach to emulate natural dental anatomy and optical properties to superior and reliable protocols to perfectly match tooth colour and its many dimensions. Actually, 'colour' integration as perceived by the patients implies a correct hue, opacity, opalescence and fluorescence in regard to optical determinants and also surface gloss and light reflection (mainly related to micro-anatomy restoration). An optimal result in terms of aesthetic integration is feasible today, although it will rarely be achieved without proper material choice and appropriate layering approaches and applications, which are largely product specific. This is why understanding and mastering the various layering concepts at hand is essential to clinical success with direct bonding.

We normally classify composite systems in relationship to the number of recommended layers (1, 2, 3 or more, when cavity/decay's size involves dentin replacement or when more elaborate colour characteristics are evident) and as well as some selected optical properties, which allow for finer differentiation among brands. Next to the number of layers to be applied, composite systems evolved from a non-Vita shading approach with only a few generic shades (ie universal opaque, yellow opaque, light, yellow, dark yellow, grey with eventually one or two incisal/translucent shades)(typical brands: Durafill, Kulzer; Silux, 3M or Herculite XR, SDS Kerr) to Vita based shading, starting in the early nineties (typical brands: Herculite XRV, SDS Kerr; Estelite Omega, Tokuyama) until eventually, new non-Vita composites were developed, following the natural layering concept (NLC) (typical brands: Miris, Miris2/Coltenewhaledent; inspiro, EdelweissDR).

In parallel, filler technology also evolved considerably, aiming to offer the practitioner universal materials which could be used for both posterior restorations, owing to their excellent mechanical properties and wear resistance, and anterior, aesthetic rehabilitations, thanks to appropriate shade options, excellent surface quality and gloss retention. This goal was only partially achieved with micro-hybrid technology (typical brands: Herculite XR/XRV, Kerr; Tetric, Ivoclar; Miris, Coltenewhaledent) and it remained a major development objective for all manufacturers until new filler technologies finally arrived to the market (mere spherical: ie Filtek Supreme, 3M or Estelite Omega/Sigma and Asteria, Tokuyama; partially spherical: ie Empress direct, Ivoclar or homogenous nano-hybrid: ie Inspiro, EdelweissDR). Some practitioners still combine hybrid and microfilled composite to take advantage of both technologies (ie Renamel, Cosmedent).

Many concepts were then developed and applied to direct free-hand anterior restorations using light-curing composite resins (Table 1); they are presented below, according to the number of layers recommended for deep cavities/decays (involving dentin). The original monolaminar/shading approach used with the chemically-curing composite resins and the first generation of light-curing microfilled systems (typical brands: Durafill, Kulzer; Isosit, Vivadent; Silux, 3M) will not be discussed here as most are not present anymore on the market. As well, a mono-layer/single shading concept (ie Ceram.X mono or Ceram.X universal, Dentsply) is not considered appropriate for restorations in the demanding smile area; a single composite layer would actually be sub-optimal in regard to both polymerisation stress management, as well as restoration optical integration. The only indication would be for small cavities

(Class III) with no extension toward the facial surface or small class V restoration, which is not the scope of this review.

## Bilaminar 'non histo-anatomical'

It comprised one set of body masses, usually following the Vita Classic shading system, offering different hues (A to D) in varying chroma levels (1 to 4, according to the shade group). Body shades exhibited an intermediate opacity (between natural dentin and enamel values); a few 'opaque' and 'incisal' masses (referring to manufacturer material designation) usually completed the overall system (typical brands: Herculite XR, SDS Kerr or Renamel microfill or hybrid, Cosmedent). This concept was based on a monolaminar chromatic build-up of the restoration with one incisal/translucent shade on the surface to emulate translucency and possibly opalescence as well. Most of those composite systems were making use of the porcelain VITA shade guide.

While being a simple layering approach, the restoration aesthetic quality was overall restrained by an oversimplified, non histo-anatomical shading approach.

## Bilaminar 'natural layering shading'

The use of a natural tooth as a model has been a logical evolution of direct restorative materials, leading to an improved shading and layering concept logically named after nature's original model and source of inspiration. It indeed resulted from a thorough study of true natural dentin and enamel optical properties, recognising the variations in tissue quality related to tooth age and functional maturing.[8] Related findings have logically drawn the lines of this new concept[2,9,10] (Fig. 1).

Spectrophotometric measurements (tristimulus L*a*b* colour and opacity values) of natural teeth belonging to various VITA shade groups led to the conclusion that the use of distinct dentine colours for a direct composite restorative system could be avoided, providing that enamels would offer not only different value/opacity levels, but also different tints. Likewise, limited natural dentin opacity within a given chroma level variation did not support the use of different dentin opacities (i.e.: translucent, regular or opaque dentins).

Then a new concept was born, allowing the emulation of practically all usual VITA shades by using a proper combination of universal dentin shades of a single opacity level and presenting a wide chroma range that extends beyond Vita Classic shades and multi-tint/multi-translucency enamels (typical brands named after their development period: Miris and Miris2 [Coltenewhaledent], Ceram-X duo [Dentsply], Enamel HFO Plus [Micerium], and inspiro, EdelweissDR.).

### Specific characteristics of NLS dentins and enamels

In summary, in a NLS composite system, the specific material optical properties for dentin are a single hue, a single opacity and an extended chroma range. For enamel, three specific enamel types are needed to mimic young enamel: white tint and reduced translucency; adult enamel: neutral tint and intermediary translucency; and for elderly enamel: yellow tint and higher translucency, maintaining a natural opalescence among the three aforementioned basic enamel types.

### Effect shades

For teeth with richer colour composition (strong opalescent halo, noticeable dentin mamelons, enamel opacities, etc), special effect shades produced in a flowable consistency are available in some NLS systems to unleash aesthetic boundaries (typical brand: Miris/Miris 2, Coltenewhaledent or inspiro, EdelweissDR). As an alternative to flowable effect shades, other composite systems provide 'effect enamels' in a restorative consistency (typical brands: Enamel HFO Plus and Enamel Hri, Micerium).

## Other bilaminar NLS systems

Following the principle of NLS, other systems are also commercially available, with, however, a noticable distinction in the number of dentin hues as well as the range of enamel shades. One such system (Vit-l-escence, Utradent) uses A and B hues of a wide chroma range for dentin shades, which propose to cover the natural dentin chromatic scope, and two categories of translucency/opacity (Trans and Pearl) with several tints/hues for the enamels. By virtue of selecting an enamel shade of correct opacity/tint, the chroma and value of the underlying dentin is modulated to achieve the final intended colour. Effect enamels for internal bluish opalescence and extrinsic higher value characterisation are also comprised within the available shades of the system. The concept behind this technique allows for a true and natural replication of both dentin and enamel chromatic variations and may prove very effective in the hands-on work of knowledgeable operators; shade selection being the greatest clinical challenge.

## Trilaminar approach

This comprises dentins and chromatic enamels shades, following the VITA shading system (with different hues: A to D, in varying chroma: 1 to 4, according to the shade group), completed by one or several incisal/translucent shades. Dentin masses exhibit opacity close or higher than natural dentin, while enamels are showing an intermediate opacity, in-between natural dentin and enamel. The practical application of this concept usually implies a polychromatic build-up of the restoration,

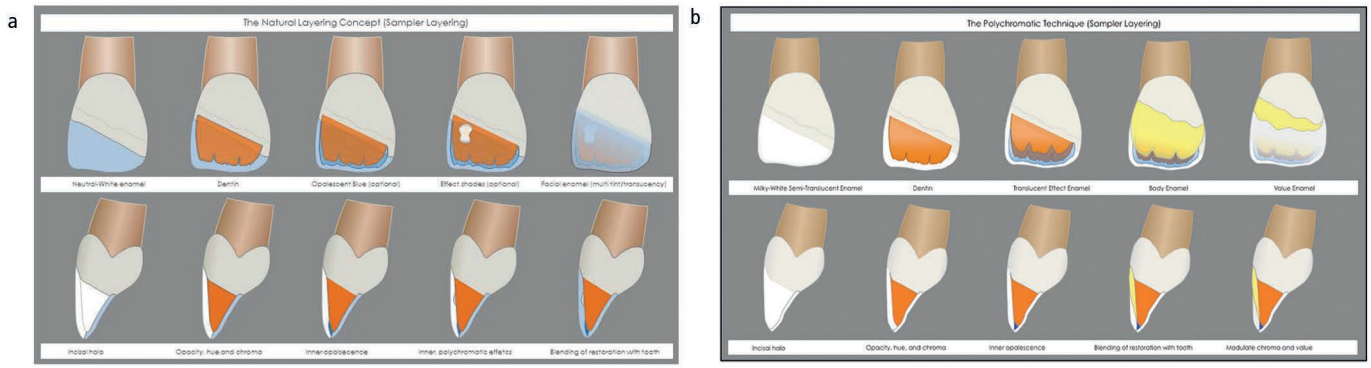



**Fig. 1 a and b) Layering samplers for the polychromatic technique and the natural layering concept**

Fig. 2 Smile showing pre-operative condition of defective Class IV restorations on upper central and lateral incisors

Fig. 3 Close-up intra-oral view reveals an unaesthetic arrangement of form and colour

Fig. 4 A putty matrix was fabricated intra-orally based on a mock-up to capture the new incisal edge position of the central incisors

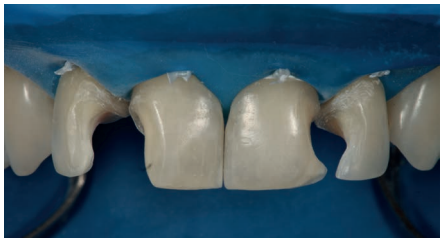


Fig. 5 After removal of the defective composite restorations, the dentition presents large and deep cavities requiring incremental layering

Fig. 6 After the adhesive protocol was performed, a thin layer of a milky-white semi-translucent enamel (Estelite Omega MW) was used to create a lingual shell

Fig. 7 A dentin shade (Estelite Omega DA3) of slightly higher chroma was applied following the histo-anatomical boundaries of the natural dentin

Fig. 8 A thin layer of translucent effect enamel (Estelite Omega Trans) was applied in-between the mamelons and proximally to convey natural opalescence

Fig. 9 Body enamel (Estelite Omega EA2) and value enamel (Estelite Omega MW) were applied sequentially to achieve a natural optical blending effect

Fig. 10 The lateral incisors were restored in a similar fashion

Fig. 11 The finished and polished restorations depict a harmonious morphological arrangement and an aesthetic integration between optical and colour parameters

Fig. 12 Preoperative view showing a defective Class IV restoration of an upper left central incisor

with the use of different opacities and chroma levels from the cavity depth to the restoration surface. As the different masses do not match the true optical properties of natural tissues, nature's model can't be strictly followed, mandating a longer learning curve (typical brand: Herculite XRV or Point4, Kerr). Such a composite system and layering is still popular, although progressively replaced by new simpler and more reliable ones.

## Trilaminar 'modified'

This concept actually relies on the application of two basic masses which more closely replicate the optical properties of natural tissues and then allow for a spatial arrangement nearer to the natural tooth structure. Dentin/body shades are available in different hues (Vita A to D shades) with varying chroma and two opacity levels; at least one being near to natural dentin. Enamel shades were developed according to the concept of the 'natural layering'[9] which implies the use of three different basic translucent enamel shades (white, neutral and ivory-grey) and some additional tint/translucency variations to expand the system's options: clear enamel (CE), white enamel (WE), yellow enamel (YE), amber enamel (AE), grey enamel (GE) and extra-light (XL); a typical brand is Esthet-x (Dentsply). This latter system, however, demands the application of additional opaque dentin shades for deep cavities to control/increase the restoration value.

This approach certainly represents an advance of the basic trilaminar layering approach, although it requires some good clinical judgement to select the appropriate number of layers, while it also lacks the option or internal characterisation using effect shades.


Fig. 13 Shade selection is performed in two steps using separate dentin and enamel samples which can be combined together (F14) enabling a precise visual perception of the final outcome resulting from the selected dentin-enamel combination

Fig. 14 A small amount of flowable composite is placed on the incisal edge to level-up both teeth (inspiro flow, EDelweissDR)

## Polychromatic

This layering technique proposes the use of an assembly of working modes into one that is not strictly dependent on a specific commercial brand of composite resin. The concept, coined polychromatic layering (Fahl, *et al.*, 1995)[4], categorises and terms the shades artificial dentin and artificial enamel. The dentin shades can be either VITA based or non-VITA based. The enamel shades are subclassified into: a) body enamel; b) value enamel; c) translucent effect enamel; and d) milky-white semi-translucent enamel (Fig. 1). Although there is currently only one system that carries precisely this shading designation (Estelite Omega, Tokuyma), the shade terminology actually represents the type of optical characteristics that should be replicated with each layer of the restoration and may probably be termed differently within the various systems available. The actual number of layers in a given restoration will then be determined by the polychromaticity intended. For instance, in fairly monochromatic teeth with little or no incisal translucency or mamelon expression, two or three shades may suffice; for the more polychromatic dentition, with accentuated incisal characterisations, five or even more shades may be indicated.[3, 11]

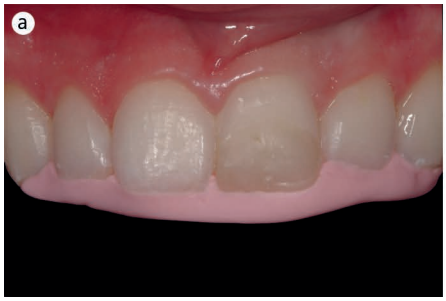



Fig. 15 An index is prepared for the lingual anatomy with a hand-mixed condensation putty

## Specific characteristics of polychromatic dentins and enamels

### *Dentin shades*

The dentin shades can be selected from within any restorative system that presents an average hue-chroma level (usually A shades of varying chroma), and a degree of opacity closest to natural dentin. As the opacity may vary among systems, selecting the ones that are most suitable is pivotal for proper colour/opacity rendering. Non-VITA (for example, inspiro, EdelweissDR; Miris and Miris2, Coltenewhaledent; Ceram-X duo, Dentsply; Enamel HFO Plus, Micerium) and VITA (for example, Vit-l-escence, Utradent; IPS Empress Direct, Ivoclar Vivadent; Venus Pearl, Hereaus; Estelite Omega, Tokuyma) dentin shades are suitable for layering. As not every system presents with a wide enough chroma range to cover the young to mature dentition, creating an assembly of dentin shades from different brands might be necessary.

### *Enamel shades*

Again, the enamel shades can be from any commercially available system provided the ideal physical and optical properties are present.

Body enamels are VITA based and their application is usually indicated as a final chromatic layer at the transition between tooth structure and restoration, most frequently at the cervical and middle thirds due to the amplified perception of surface hue and chroma in those areas. The degree of opacity of the area being restored will determine the selection of body enamels of lower (for example, Estelite Omega, Tokuyma, Filtek Supreme XT Enamel, 3M ESPE; IPS Empress Direct, Ivoclar Vivadent) or higher opacity (for example, Filtek Supreme XT Body, 3M ESPE; Renamel Microfill, Cosmedent). In the polychromatic layering, body enamels are to be applied at the correct thickness, which may vary according to the system, and are crucial in determining the final hue, chroma and value of the areas where they are applied.

Value enamels are non-VITA based and closely follow the role of the enamels as they are indicated in the natural layering shading technique, including modulating the chroma and value of the underlying substrate. Most VITA based systems will provide a few achromatic shades of varied tints and opacities that are suitable for this purpose. Although they may cover the entire facial aspect of a restoration, as in the case of a direct veneer, in the polychromatic layering technique a value enamel is most frequently applied over the incisal surface, and feathered over the middle third of the facial surface to allow the perception of underlying characterisations, such as dentin mamelons, bluish opalescence, craze lines and white spots.

Translucent effect enamels are non-VITA shades used internally inbetween and around dentin mamelons to impart a bluish opalescence and can be found in many systems (for example, Vit-l-escence IrB, Ultradent; IPS Empress Direct Trans Opal, Ivoclar Vivadent; inspiro; Enamel HFO Plus OBN, Micerium; Estelite Omega Trans, Tokuyma).

Milky-white semi-translucent enamels are non-VITA shades that are used to establish a lingual shell and create whitish-amber incisal halos. Similarly to value enamels, they find representation in many commercial brands.

Fig. 16 A medium value and translucency enamel (inspiro white) is placed into the index

Fig. 17 This enamel palatal shell is about 0.5 mm thick

Fig. 18 Dentin (inspiro bodyi2) is applied against the palatal shell and dentin mamelons shaped to emulate natural dentin core morphology

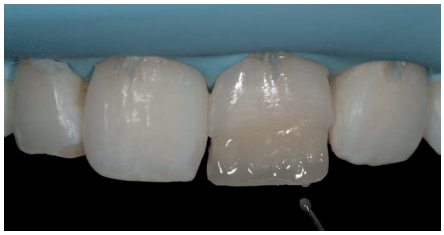


Fig. 19 A small amount of opalescent blue effect shade (inspiro effect azur) is deposited atop the dentin edge and mamelons to enhance the marked incisal blue halo of the natural teeth

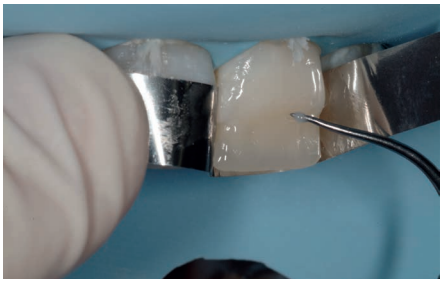


Fig. 20 A few spots of white effect shade (inspiro effect ice) complete the internal characterisation

Fig. 21 The facial volume is finalised with a last layer of whitish enamel (inspiro white)

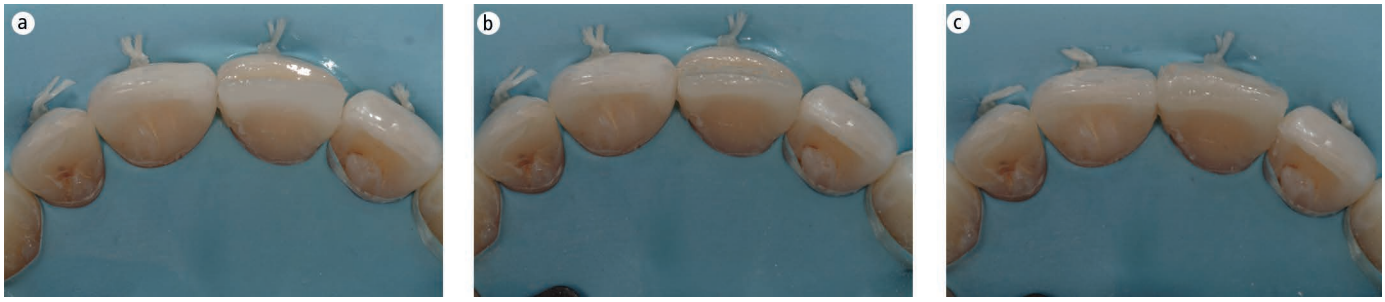



Fig. 22 Incisal views (palatal shell – dentin core – facial enamel) show the 3D control of layer thickness and volume; this perspective is crucial to control the layering technique and then also the colour outcome

The polychromatic approach demands a thorough mastery of the four-dimensionality of colour on the part of the clinician in order to be able to apply the technique effectively. One of the challenges posed by it is that it requires the clinicians being sufficiently knowledgeable to gather the most suitable shades from within the broad spectrum of commercially available brands or utilising one single system with efficacy. On the one hand, the technique enjoys wide acceptance as it may appeal to those who are accustomed to working with VITA-based systems.[3,11]

## Pentalaminar-histo-anatomical layering

Following recent work by Bazos and Magne[12,13] and the Bioemulation group, revisiting the dentin-enamel 'complex', an expanded layering approach was presented (pentalaminar) which aims to emulate specific dentin and enamel areas which can be seen on natural teeth sections, when using an appropriate sample preparation. It is then suggested to consider two different composites layers to mimic primary/secondary and mantel dentin on one hand and two more layers to mimic deep and superficial enamel on the other hand – both dentin and enamel masses being separated by a fifth layer as the dentin-enamel junction. This later concept (mimicking the dentin-enamel junction) was formerly suggested by Vanini and others.[6,7,14] Such approach will logically require a very precise control of layer thickness, eventually limiting a universal use.

So far, this technique is primarily conceptual but supports the importance of observing and emulating natural tooth structure and anatomy.

## Clinical application

Figures 2 to 11 illustrate the clinical application and step-by-step for the polychromatic approach while the natural layering concept is being described and presented in Figures 12 to 25. The flow-chart presented in Figure 25 summarises the treatment sequence for optimal shade integration using any of the aforementioned layering concepts; it outlines the need to proceed with shade selection using, as a reference, clean, moist teeth for optimal results. For demanding aesthetic cases, the final shade match shall be systematically re-assessed after 24 hours or more, to visualise and assess the restoration optical integration with surrounding tissues and neighbouring teeth.

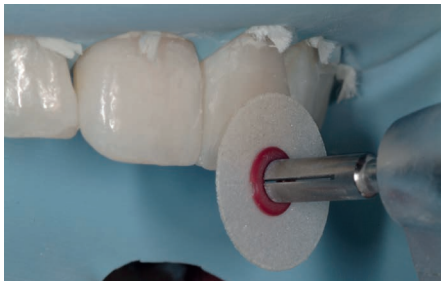


Fig. 23 Finishing of the restoration; discs are used to create the macro-anatomy

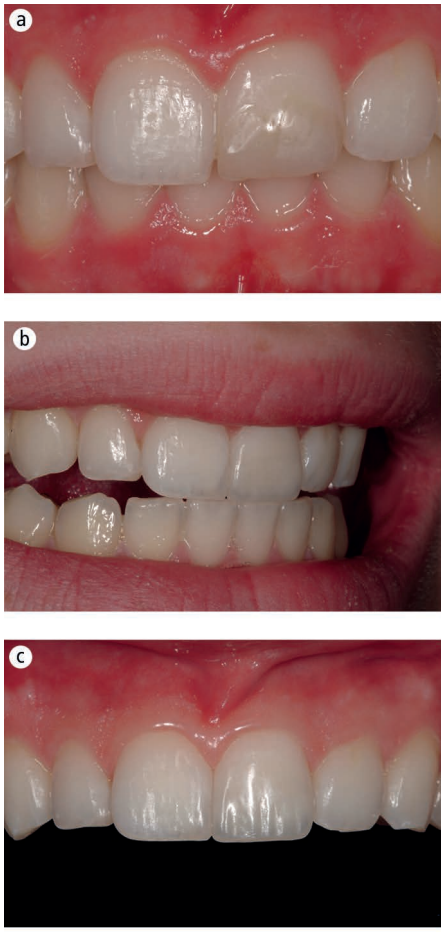
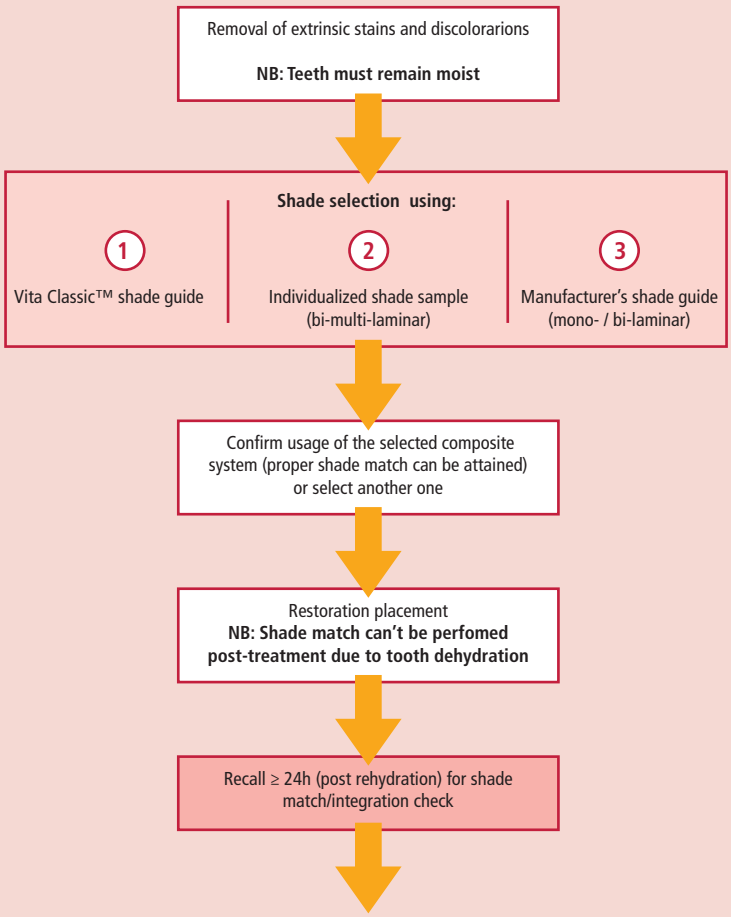



Fig. 24 Natural layering concept (NLC)

Fig. 25 Flow-chart illustrating the timing for shade selection and post-operative colour match pre- and post-restoration placement




## Discussion/conclusion

Layering techniques evolved from a basic, oversimplified shading approach (one or two layers, non histo-anatomical) when light-curing technology was introduced to dentistry, to more effective but complex layering techniques (three layers or more, still non histo-anatomical). For years, a perfect aesthetic outcome was linked to a long, demanding learning curve. Lately, new improved shading/layering concepts were developed which rely on a better understanding and knowledge of tooth histo-anatomy and light interaction with natural tissues. Although manufacturers still follow different colour concepts (VITA or non-VITA) and suggest a variable number of layers, predictability of the aesthetic outcome has clearly improved. One more common approach and trend is to analyse, first, tooth optical composition and apply the minimum number of layers required to emulate optimal restoration integration with surrounding natural tissues. Simplicity and predictability are undoubtedly the new driving forces to continuously improve the quality of direct composite restorations.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