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Editor

Esthetic Oral Rehabilitation with Veneers

A Guide to Treatment Preparation
and Clinical Concepts

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Update to Preparation Design and Clinical Concepts Using the LeSage Veneer Classification System

1

Brian P. LeSage

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1.1 Introduction

Porcelain veneers had long been considered to be only an esthetic solution. However, their range of indications has been steadily increasing, making ceramic veneers a highly viable alternative to classic, far more invasive forms of restorative treatment. Today, veneers can be used to handle esthetics (discolored teeth, fractured and worn teeth, diastemas, dental defects, etc.) and to restore the biomechanics of the dentition, as well as many other indications.

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Historically, preparations for ceramic veneers have varied from extremely aggressive to a minimal reduction or a lack of preparation. The concept of no-preparation or minimal-preparation veneers is nearly 40 years old, but for decades there was no classification system categorizing the extent of preparation for different veneer treatments [1]. This lack of clear-cut guidelines for technical procedures and for case selection led to confusion and misunderstandings. The author proposed such a classification system in 2013, and in this chapter, the LeSage veneer classification system is expanded on and explained, and examples for implementing the system are presented. The author's veneer classification system published in 2013 is based on an assessment of the amount of enamel available and the amount of dentin exposed. This system benefits dentists, lab technicians, and patients, by assisting in diagnosis of various clinical scenarios and guiding conservative veneer preparation and placement [1].

Today, we are moving toward minimally invasive dentistry with the philosophy that less is more. Treating esthetic demands with noninvasive or minimally invasive techniques can preserve the natural tissues [2]. Less tooth reduction means better adhesion and clinical longevity. It is no longer acceptable to over-prepare teeth for convenience or lack of understanding of alternative treatments. In recent years, laboratory techniques have evolved to produce ultrathin ceramic veneers, which has increased the popularity of “no-prep” veneers [3]. This so-called “no-prep” approach has been described for more than 10 years in the literature [4–6] and ideologically reiterates the methodologies of when veneers were first introduced as conservative, additive restorative procedures for which slight or no preparations were required [7, 8]. When properly selected and managed, “no-prep” veneers can have biologically healthy and optically beautiful margins and emergence profiles, all supporting the biomimetic dental philosophy of tooth preservation and less amputation of tooth structure [9] (Figs. 1.1 and 1.2).

However, these days, it is no longer acceptable to limit veneer descriptions to no-prep or conventional all-ceramic designs. Explained in this chapter are two additional, distinct classifications that should aid dentists, lab technicians, and patients in their ability to provide better communication, consent, diagnosis, treatment planning, material selection, education, and tooth structure preservation.

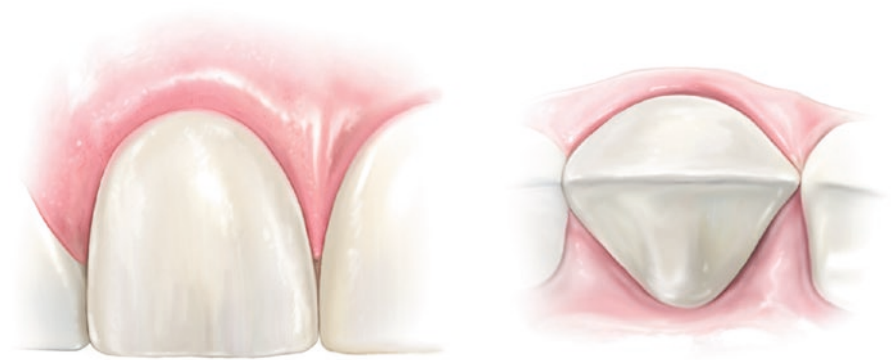


Fig. 1.1 Normal tooth contours from facial and occlusal views

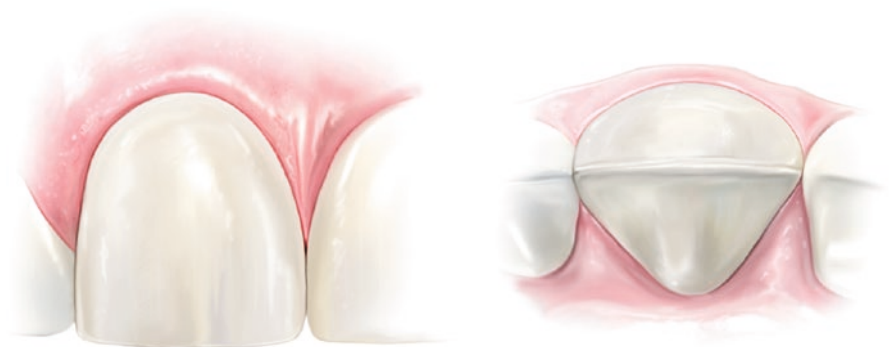


Fig. 1.2 “No-prep” veneer shown when indicated. In many clinical scenarios, adding volume will move line angles to the interproximal zone and make the tooth appear wider

It is important to consider veneers as part of the multidisciplinary field of restorative dentistry. In addition to the LeSage veneer classification system, this chapter also includes tips for ensuring the long-term success of veneers and patient satisfaction. These include the usage of prototypes, digital smile design, a try in one veneer technique, as well as proper preparation and adhesion protocol. Ultimately, clinician experience is the most important tool for determining appropriate treatment plans to address clinical concerns and patients’ esthetic demands [1, 10].

1.2 Orthodontics as an Interdisciplinary Approach

There are a variety of treatments and solutions that can be applied to move, straighten, and ultimately align your teeth. One of our goals is to limit the amount of tooth structure removal when placing veneers. Often, we can employ a minimally invasive interdisciplinary ortho-restorative treatment plan. Frequently, far less tooth structure is lost if orthodontic treatments are used to fix tooth alignment prior to placing veneers. Orthodontic treatment is a noninvasive modality for achieving desired results and/or ensuring teeth are properly positioned for long-term predictable function and esthetics.

For example, prominent gaps may require orthodontic treatment before the placement of veneers. Without orthodontic treatment, closing the gaps with veneers will result in creating the look of abnormally large teeth. Moderate to severe crowding may also require orthodontic treatment to align the teeth. If veneer treatment is carried out without orthodontic treatment, the rotated teeth will need to be heavily ground down to accommodate the veneers, weakening the teeth in the process and in some cases exposing the nerve. Similarly, a patient who presents with a narrow arch form may require orthodontics before the placement of veneers. The author uses Invisalign® approximately 50% of the time as a pre-prosthetic modality to prevent preparing beyond the dentinoenamel junction in the teeth. Providing esthetics, while accommodating for anterior guidance and eliminating working and nonworking interferences, is a key component of long-term orthodontic occlusal stability.

Interdisciplinary modalities may also include the following: perio-plastics, tooth bleaching, direct composite restorations, and porcelain veneers, which are options providing predictability and longevity in carefully selected esthetic cases [1, 11].

1.3 Prototypes, Digital Smile Design, and a Try in One Veneer Technique

Veneers have to be esthetically pleasing. There are multiple opportunities within the veneer placement process that we affirm, and reaffirm, the veneers are pleasing to the patient before solidifying the final treatment outcome. The patient likely has specific expectations, and there should be a test drive with provisional restorations to ensure proper esthetics and function prior to fabrication of the final veneers [12].

It is common to create mock-ups, or temporary trial veneers, by taking impressions or by using CAD/CAM technology to make a mock-up digitally. The author prefers to make prototypes, which can be used for a significant amount of time, simulating the final outcome, allowing the patient to test esthetics, phonetics, and function. Bis-acryl resin temporary materials have become the material of choice for *esthetically driven* veneer prototypes due to excellent mechanical and optical properties, marginal adaptation, polishability, and favorable add-on properties [13].

Similarly, a digital smile design (DSD) can be used to increase the emotional commitment and consequently the rate of acceptance of your dental treatments through an emotional mock-up [14]. The DSD is a digital planning tool for esthetic dentistry, in which the evaluation of the esthetic relationship among the teeth, gingiva, smile, and face is obtained through lines and digital drawings that are inserted on the facial and intraoral photographs of the patient [15–18]. A bis-acryl temporary material is dispensed into the putty matrix to fill the facial surface. The filled matrix is inserted into the patient's mouth, the matrix is removed, and excess material is removed. It is common to then take photos or a short video of the patient for them to see the transformation. This full-face picture of them will increase satisfaction and emotional commitment to the final treatment plan.

While DSD presents some advantages, the author regards prototypes as an objective and efficient tool in treatment planning communication. They can be used to confirm the treatment plan before and/or after the final preparation, thereby evaluating the final restorations within the limitations of biological and functional considerations [5, 19].

The author now introduces into the literature the practice of the “try in one” (TIO) veneer technique. At the delivery appointment, one central incisor prototype is cut out and the definitive veneer is tried in. This single veneer should fit to place confirming the midline and the length of the definitive restorations (Fig. 1.3). Thus, the author's TIO technique confirms fit, length, contacts, and color. Trying in one veneer provides a reference point to prove that the length, shape, and shade are appropriate prior to cementing all the final restorations. This TIO technique is a useful process for reassuring the patient that all their esthetic parameters and expectations have been met and holding the dentist and ceramist accountable.

Fig. 1.3 (a, b) “TIO technique” (a) Close-up of patient’s approved esthetically driven bis-acrylic prototypes demonstrating uniformity with variety (b) Definitive veneer #8 placed within existing prototypes to confirm length, width, and midline and hold all team members accountable



All of these processes build trust between the patient and dentist. They allow the patient to request changes throughout the process, so that they feel in control and satisfied with the final outcome.

1.4 Veneer Preparation

Expected veneer longevity depends on tooth preparation, which should ideally be confined to enamel and minimally involve proximal contact areas and functional considerations, such as occlusion [20]. It is also necessary to maintain the cervical enamel margin and incorporate the incisal edge to increase fracture resistance and enable proper placement [20]. To increase functional and esthetic properties of these restorations, proximal extensions should be created just beyond contact areas [20]. The clinical success of porcelain veneers depends upon many factors. Although dental and gingival structures play important roles in optical response and withstanding masticatory forces, dentists must consider and recreate many anatomical components while providing functional integrity [20].

One critical step in the preparation technique is the achievement of sufficient ceramic thickness [13]. While conducting their studies, researchers Shillingburg and Grace found that as patients age, the enamel thickness on the facial surfaces of anterior teeth decreases [21–23]. On the cervicofacial surface of the central incisor, 1 mm above the cemento-enamel junction, enamel thickness ranges from 0.17 mm to 0.52 mm, with a mean thickness of 0.31 mm [21–23]. The thickness on the mid-facial surface, 5 mm from the cemento-enamel junction, ranges from 0.45 mm to 0.93 mm, with a mean thickness of 0.75 mm [21–23]. The author used these tooth structure parameters as a framework for the LeSage veneer classification system and the author’s preferred Class I or Class II veneer preparation techniques. The

guidance provided in the LeSage classification system, informed by enamel thickness, allows for conservation of tooth structure and predictable minimally invasive veneer preparations.

The typical veneer preparation model is technique-sensitive and incorporates guidelines for achieving functional and esthetic results. When reducing the labial and proximal surfaces, there must be no less than 0.3–0.5 mm of room, and it should be uniform whenever possible [21, 24–29]. When going from thick to thin—as in a large Class IV incisal fracture or large Class III composite removal—a smooth transition must be incorporated. Extending the preparation interproximally to the mid-point of the papilla, parallel to the crown’s original form, is necessary to improve adhesion, conceal the margin, allow an accurate impression, and increase the overall veneer strength [21, 26, 29]. The decision to reduce the incisal edge should be based on whether there is a need to increase the tooth length and the labiolingual width of the incisal edge [21, 26, 29]. Since line angles are involved, rounded corners and edges must be established.

Veneers with an incisal butt margin usually demonstrate fracture loads similar to those of unprepared teeth [21, 30]. In these cases, the incisal edge may be reduced by up to 2 mm [21, 28, 31]. However, the preparation’s facial margin should ideally be chamfered and in enamel [21, 26, 28, 29, 32]. The interproximal and gingival margins of porcelain veneer restorations also must end in enamel at or above the free gingival margin or barely within the gingival sulcus when possible [21, 26, 29].

Techniques exist that allow for consistent tooth surface reduction while minimizing it [12, 33, 34]. Because traditional veneering approaches can lead to significant dentin exposure, strategies should be taken to limit preparations to the enamel [12, 13, 34]. Using an additive diagnostic procedure and silicone indexes avoids unnecessary dentin exposure, improves biomechanics and esthetics, and allows more predictable bonding [13].

Gürel et al. recently showed a 98.7% success rate of porcelain laminate veneers when the preparation depth is kept within the limits of enamel [35]. For misaligned teeth, a transparent silicon index can be used to prepare esthetic pre-evaluative temporaries to be used as a guideline to prepare the tooth structure. They resemble the exact final contours of the final outcome, such as the incisal edge position and the facial contours of the teeth; we can start by preparing the teeth 0.5 mm through the mock-up as if we were dealing with a simple case in which the teeth are aligned properly [36]. Once teeth are prepped according to their limitations, adhesion protocols can commence.

1.5 Proper Adhesion

The enamel bond is beyond reproach and is the strongest, least invasive, most conservative, and most predictable bond available. Enamel bonding mimics the dento-enamel junction or the natural bond between enamel and dentin [37]. The same cannot be said about bonding to the dentin. However, even bonding to dentin is favored over nonadhesive approaches [38]. The “gold standard” remains total-etch three-step systems or three-step etch and rinse [38–40].

There remain many issues to consider before bonding to dentin [21]. For example, adhesion more often fails at the dentin–cement interface [21, 41]. Also, micro-leakage typically occurs between the dentin and cement, leaving underlying dentin unprotected [21, 41]. Studies show that the bond strength of resin cements to dentin is much lower than bonds to enamel, which is why maintaining an enamel periphery is essential [21, 41–45].

The ideal scenario is to keep the bond completely in enamel. Of utmost importance and when properly prepared, enamel substrates provide the most predictable surface to bond porcelain [1, 46–49]. The micro-retentive adhesion of porcelain to enamel has been well-documented for more than 20 years [1, 30, 46]. In a longitudinal study with a 12-year follow-up, ceramic veneers cemented on enamel showed significantly higher clinical longevity than those cemented on dentin, with success rates of 98.7% and 68.1%, respectively [50].

Unaffected by lingual preparation design, porcelain veneers adhesively bonded to enamel demonstrate the greatest long-term success rates, making no-preparation veneers the treatment of choice when indicated [1, 46–49]. When dentin is involved, an enamel periphery is preferable for predictability [1, 30, 46]. When less than 50% of enamel periphery and less than 50% enamel remain, discussion with the patient about limitations and predictability of the outcome is necessary [1, 10, 46]. Given these conditions—50% or more enamel on the tooth is required and 50% or more of the bonded substrate is on the enamel—70% or more of the margin must be enamel. The condition or integrity of the substrate to which veneers will be bonded is also important for success [51–53].

Veneer cementation is fundamental; it should be done with extreme care. It is important to remember that, unlike conventional crowns, which use dual-cured resin cements, ceramic laminates should use a purely light-cured luting agent to prevent the color shifts that can occur due to chemical changes in the curing process [54]. Absolute isolation during cementation procedures is essential for bond maintenance, which ultimately protects the internal surface of the restoration and is necessary for longevity [52, 53].

1.6 Classifications of Veneer Preparations

Referred to as no, minimal, or conventional preparation, veneer classifications—or lack thereof—create a large gray zone of misunderstanding and miscommunication with patients and within the dental profession. Left unanswered, questions regarding tooth structure removal, finish lines and margins, and other aspects can cause confusion in practice.

Flaws and inaccuracies in previously proposed preparation guidelines make those guidelines irrelevant [55]. To dissolve uncertainty, this veneer classification system was proposed to aid with diagnosis, treatment planning, patient education, consent and understanding, and communication among dental team members, and to provide viable solutions to public requests for elective procedures.

Defined as the way something is categorized, labeled, organized, distinguished, arranged, or sorted, classification adds clarity. Dentistry has distinguished Class I through Class V classifications in operative dentistry; there are inlays, onlays (3/4 and 7/8), and full-coverage crowns in prosthodontics. Classifications exist for furcations in periodontics; lip lines; bone quality; LeFort's CL-I, CL-II, and CL-III in orthodontics; removable prosthesis cantilevers; and bone/crest levels. In 1974, Talim and Gohil classified tooth cracks and fractures in endodontics, and Misch classified implant prostheses for patients; in 2009, McLaren classified ceramics [52]. Since classification systems have infiltrated so many aspects of life, veneers should be no different.

In the absence of widely advocated porcelain veneer tooth preparation guidelines, Tables 1.1 and 1.2 show the basis for the LeSage veneer classification system. The system was introduced to clarify the aforementioned gray zone between classic conventional veneer preparation and no- or minimal-preparation veneers. This metric provides an accurate measurement system for quantifying tooth structure removal on a case-by-case basis [56]. Studies show that when a conservative approach is taken and significant tooth structure remains, dentists can provide patients with a better prognosis for the restored teeth [56].

The LeSage veneer classification system divides preparation and veneering into reduction (referred to as space requirement, working thickness, or material room), volume of enamel remaining, and percentage of dentin exposed. Notably, classifications I, II—both of which incorporate addition veneers—and III require 70% to 100% enamel periphery.

Table 1.1 Basis for the LeSage veneer classification system (dentin exposed)

Reduction	Facial	Dentin exposed
CL-I No-prep or practically prep-less	Detectable with magnification, with or without gingival finish lines	0 ^a
CL-II Modified prep-less or minimally invasive	Up to 0.5 mm	10–20% ^a
CL-III Conservative design	0.5–1 mm	20–50% ^a
CL-IV Conventional all-ceramic design	1+ mm	50%

^aEnamel periphery of at least 70%

Table 1.2 Basis for the LeSage veneer classification system (enamel remaining)

Reduction	Facial	Enamel remaining
CL-I No-prep or practically prep-less	Detectable with magnification, with or without gingival finish lines	95–100%
CL-II Modified prep-less or minimally invasive	Up to 0.5 mm	80–95%
CL-III Conservative design	0.5–1 mm	50–80%
CL-IV Conventional all-ceramic design	1+ mm	<50%

1.6.1 CL-I

CL-I is the purest form of *no-preparation* or *practically prep-less* veneers but can include a discreet finish line or only a loupe-detectable margin (Fig. 1.4). The term *addition veneers* frequently describes this preparation design today. In this classification, 95–100% of enamel volume remains after preparation, and no dentin is exposed. Ideal whenever possible, preparation must be completely and only in enamel.

This preparation type can be easily achieved using a bis-acrylic preparation guide created from a putty or silicone matrix of the diagnostic wax-up, which can be applied to the teeth [55]. Depth cuts of 0.5 mm for CL-I are placed into the incisal and facial aspects of the bis-acrylic preparation guide, which should result in the depth-cutting bur not touching the tooth, and the clinician should consider removing the aprismatic enamel and placing a practically undetectable finish line to aid ceramists in determining margin placement. These depth-cutting grooves minimize potential for over-preparation.

Many times considered the best option because of their tooth structure preservation qualities, prep-less veneers have limitations, including esthetic outcomes. Calamia found that veneers placed with no preparation resulted in periodontal problems as a result of over-contoured teeth that changed the emergence profile [1, 46, 57]. It was concluded, however, that the veneer treatment modality would function long term [1, 46, 49]. To correct the emergence issue, a 0.5-mm reduction restored by 0.5 mm of porcelain provided nearly the original tooth profile with the veneer in place [1, 46]. Additionally, it was discovered that wrapping the incisal edge enhances strength and that preparations limited to the facial surface only were not as strong as those with a wrapped incisal edge [1, 31, 46]. This latter veneer preparation type is described below as CL-II.

Some indications for no-prep veneers include peg laterals, genetic anomalies producing smaller teeth, short and worn teeth, orthodontics leading to a narrow arch, and patients with larger lips. Disadvantages may include limited shade alteration capability, difficulty developing the correct axial inclination, proportional errors, and trouble forming the proper gingival symmetry [1, 46, 58].



Fig. 1.4 Illustration demonstrating LeSage Class I veneer preparations requiring little to no tooth structure removal. Facial reduction allowing for 95–100% of the enamel remaining and no dentin should be exposed

1.6.2 CL-II

CL-II deals with *minimally invasive* or *modified prep-less* veneers (Fig. 1.5). Addition veneers also may fall in this classification. This category should exhibit 80–95% volume of remaining enamel, 10–20% exposed dentin, and up to 0.5 mm of reduction. Ideally, CL-II veneers would have complete enamel periphery but may involve a small zone on the gingival margin consisting of dentin to clearly establish the restoration margins [59]. Additionally, 5–15% of dentin may be exposed on any facial surface (i.e., mesial, distal, or gingival), depending on veneer rotation. To complete a CL-II preparation, a bis-acrylic preparation guide, as previously described, can be used. An example of a CL-II prep will be discussed in the following section.

1.6.3 CL-III

CL-III is a *conservative preparation* classification (Fig. 1.6) and described as 60–80% enamel volume remaining, 20–40% dentin exposed, and 0.5–1 mm of



Fig. 1.5 Illustration demonstrating LeSage Class II veneer preparations requiring a modified design. Facial reduction should be less than 0.5 mm, 80–95% of the enamel should remain, and 10–20% of the dentin can be exposed. (Brown in illustration is exposed dentin)



Fig. 1.6 Illustration demonstrating LeSage Class III veneer preparation design requiring some “conservative” reduction. Facial reduction is 0.5–1 mm, the enamel remaining should be 50–80%, and dentin exposure is maximized at 50%

reduction. With more room for restorative material, the gingival margin will typically involve more dentin [59]. However, greater than 70–80% of the finish line must still be in enamel.

1.6.4 CL-IV

CL-IV is a *full veneer* or *conventional all-ceramic* design (Fig. 1.7) and is best described as approximately 50% of enamel volume remaining, greater than 40% of exposed dentin, and 1 mm or more of reduction. The peripheral margin may consist of only 50–70% enamel. Although this veneer preparation type has become an almost universally accepted technique for placing full veneers, functional and esthetic limitations remain—including lower fracture loads and decreased marginal integrity that ultimately lead to restorative failure [60, 61]. Preparation design and fatigue influence the marginal accuracy of veneers bonded to maxillary central incisors, with significantly higher marginal gap formations developing in complete veneer preparations [60, 61]. Therefore, all limits of restorative options should be considered before undertaking this procedure. A case study of a CL-IV prep will be discussed in the following section.

Any given patient could exhibit any combination of classifications due to acidic erosion, genetics, restorative material requirements, occlusion, or tooth- and arch-size discrepancies. As in periodontics, one tooth can be a CL-I furcation and a CL-III in the same dentition, and each has differing treatment approaches, prognosis, and varying care. Again, this veneer classification system was designed to help clarify professional communication and allow patients to better understand how much tooth structure will need to be removed. Such information will enable better informed consent, with patients making the choices they see fit.

When preparations fall outside these parameters, a crown should be *considered* for predictability and longevity.

It is well established that when a tooth has greater than 50% of enamel missing, moderate sclerotic dentin, and greater than 3 mm of unsupported porcelain, a crown must be considered. Magne found that 65% of a tooth's integrity comes from the



Fig. 1.7 Illustrations demonstrating LeSage Class IV veneer preparations, considering conventional preparations. Facial reduction is typically greater than 1 mm, with less than 50% of enamel remaining and greater than 50% of dentin exposed

cingulum and approximately 27% from lingual marginal ridges [62, 63]. These anatomical landmarks must be preserved at all costs [64]. No significant differences in crown flexure were found between natural and veneered incisors when the cingulum is preserved [64].

However, clinical decisions must be based on the dentist's clinical experience, scientific data, evidence-based literature, the clinical scenario, the patient's desires (i.e., time and money considerations), and full consent based on knowledge of advantages, disadvantages, risks, benefits, and prognosis. These factors are significant in treatment selection. CL-I veneer preparation with its 100% enamel substrate is more predictable than CL-IV with its significant dentin exposure.

1.7 Case Studies

1.7.1 Case I Demonstrating the LeSage CL-II Veneer Preparation Design

Patient is a 62-year-old male who wanted a better color to his teeth and to show more teeth by adding length and width to his smile. The pre-op images show the dark color, deficient vestibular reveal, chipped incisal edges, and damage to his dentition due to parafunctional habits (Figs. 1.8 and 1.9). The goal was to create a pleasing smile with minimal tooth reduction, while maintaining good health.

A full mouth series of X-rays showed minor tooth decay indicating replacement of an existing crown and several simple composites prior to analyzing his dentition for

Fig. 1.8 Full-face pre-op of patient before orthodontic care and all-ceramic restorations on maxillary and mandibular teeth in the esthetic zone

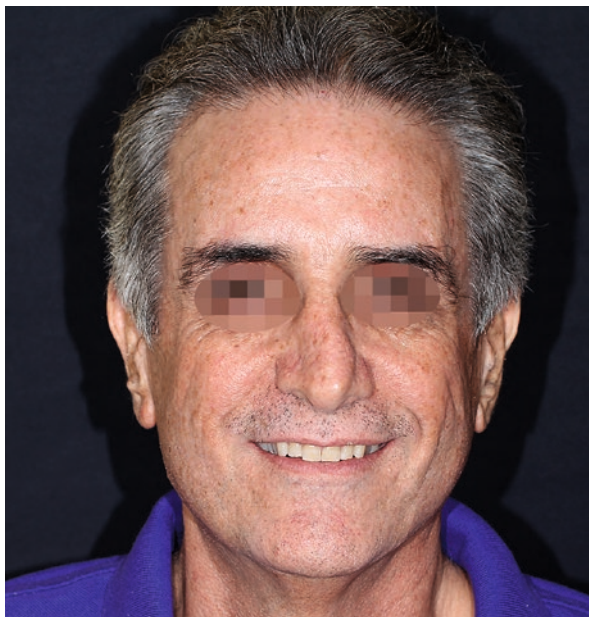


Fig. 1.9 Smile view pre-op showing patient's chief complaint, "I would like a better color to my teeth and want to show more teeth when I smile"



Fig. 1.10 Retracted view pre-op showing damage to lower teeth with exposed dentin and dark, aged color to dentition



veneers. A diagnostic workup was performed with facebow transfer and centric relation mounted study models on a semi-adjustable articulator (SAM-3, Great Lakes, Tonawanda, NY) and diagnostic photographs. It revealed the need for orthodontic treatment to widen the arch and reposition the maxillary and mandibular teeth into more ideal anterior relationship to create a more protective occlusal scheme and not prepare past the dento-enamel junction. The incisal edges in both arches had exposed dentin which needed to be covered for long-term stability (Fig. 1.10).

After approximately a 1-year course of Invisalign (Figs. 1.11 and 1.12), a new series of diagnostic models were mounted on the SAM-3 articulator, diagnostic photos retaken, and a diagnostic wax-up completed (Fig. 1.13). Minor occlusal equilibration to eliminate any CO-MIP slide and gain immediate anterior disclusion was performed prior to starting the smile makeover.

Luxatemp (DMG, Ridgefield Park, NJ) bis-acryl, using the preparation guide introduced by Drs. Magne and Gürel, was applied to the teeth using a putty matrix fabricated from the diagnostic mock-up (Fig. 1.14) [13, 36]. Depth-cutting grooves of 0.5 mm were placed in the bis-acrylic material minimizing the depth and thus also minimizing the amount of enamel removal on each tooth (Figs. 1.15 and 1.16).

Fig. 1.11 Full face of patient after Invisalign treatment. Notice fuller buccal corridor

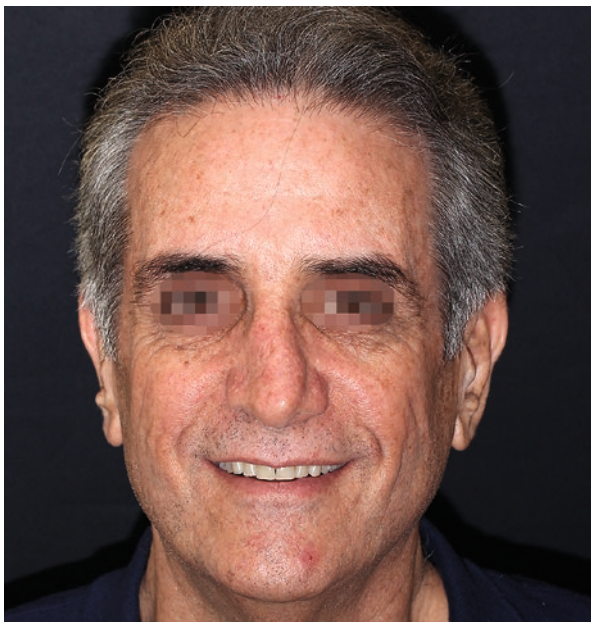


Fig. 1.12 Retracted frontal view showing wider arch and better alignment of teeth after Invisalign



Fig. 1.13 Wax-up of maxillary teeth #4–13 on articulator working out esthetics and function



Fig. 1.14 Custom preparatory guide placing bis-acrylic on teeth to be restored



Fig. 1.15 0.5 mm grooves placed into bis-acrylic. On patient's right the bis-acrylic has been removed, and visible is the less than 0.5 mm groove remaining to guide a minimal preparation of the final restorations. Note the incisal edges of the teeth #6–8 and the facial of tooth #7 were not even touched with the depth-cutting bur guides

Fig. 1.16 Preparation of teeth #4–8 showing minimal dentin exposure—LeSage Class II veneer preparation design. Minor troughing visible after electrosurgery unit as a means for retraction



This modified prep-less veneer preparation technique will almost guarantee the authors preferred LeSage veneer CL-II preparation design: maintaining the preparation in 95% enamel and a 0.1 mm interproximal separation of the prepared teeth at its narrowest point (Fig. 1.17). To aid with shade communication including the ceramist, properly exposed images with the appropriate shade tabs are taken (Fig. 1.18).

An easy and effective way for patient visualization of their new smile design and final outcome is in fabricating prototypes, also known as temporaries or provisionals. These prototypes are created to the specifications of the anticipated definitive restorations, used to test and verify that the desired esthetic and functional outcomes are met.

Fig. 1.17 Minimal preparation to teeth #4–13, confined primarily in enamel



Fig. 1.18 Shade tab photo taken prior to dehydration of dentition. This is one of the multiple images taken to communicate chroma and value of the teeth and final restorations to the ceramist



Fig. 1.19 Prototypes immediately finished and polished in the mouth



Prototypes were fabricated using the “shrink wrap” technique; bis-acrylic was placed in the putty matrix and allowed to self-cure set in the mouth. This allows the prototypes to shrink and lock between the teeth and onto the teeth (Fig. 1.19). Prototypes are worn until the patient expresses complete satisfaction with their smile makeover (Figs. 1.20 and 1.21). Patient’s approval of the prototypes is essential prior to the ceramist fabricating the veneers.

The Geller model poured from a PVS impression shows the removable dies and the stone papilla form and gingival tissues (Fig. 1.22). An incisal putty matrix from the model of the approved prototype aids the ceramist in fabricating predictable definitive restorations. Shown are the definitive feldspathic restorations on the Geller model (Fig. 1.23) and a mirror (Fig. 1.24).

The first step at the delivery appointment is the TIO technique; one central incisor prototype is cut out and the definitive veneer is tried in. This single

Fig. 1.20 Smile view showing prototypes/temporaries to trial esthetics and function



Fig. 1.21 Full face with prototypes trialing midline, smile line, incisal edge position, arrangement, and composition



Fig. 1.22 Geller models showing removable dyes and stone papilla. Putty matrix from approved prototype to aid ceramist with length, midline, and incisal edge effects



Fig. 1.23 Definitive restorations on Geller model



Fig. 1.24 Minimal thickness veneers showing polychromaticity



veneer should fit to place confirming the midline and the length of the definitive restorations. Once fit and esthetics are confirmed by the clinician and approved by the patient in the authors' TIO technique, the remaining prototypes are removed. The tooth preparations were cleaned and all final veneers were tried in for approval by the patient. Once approved, the cementation process began.

Following the proper adhesion protocol is essential to the long-term success of the restoration. With proper isolation, the preparations were cleaned, etched, rinsed, and partially dried. The strong adhesion of porcelain to enamel is one of the primary reasons that no-prep (LeSage CL-I) and minimally prep veneers (LeSage CL-II) are the treatment option of choice when indicated. The primer was then applied and agitated for 30 s, air-dried, and light cured. Resin adhesive was placed on tooth and light-cured resin cement on the intaglio surface of the veneer. Bonding the definitive feldspathic restorations to an enamel substrate allows for the most predictable bond strengths, which directly correlate to clinical longevity [65]. The veneers were seated, light pressure was applied, and excess cement was wiped from the margins. The shade of the veneer and thickness of the porcelain material help to guide the curing time.

Fig. 1.31 Remove veneers on teeth #8 and 9 and refine preparations. Typical LeSage Class IV veneer preparation design as seen in most re-treatment cases



Fig. 1.32 Smile view with prototypes. Notice gingival health, pleasing translucency, and outline form



Fig. 1.33 Retracted view of prototypes. Gingival embrasure properly contoured to allow for gingival ingrowth



Fig. 1.34 Definitive all-ceramic restorations showing natural harmony and balance to patient's smile





Fig. 2.21 (continued)

Correction of Excessive Overjet

Knowing the etiology of an overjet is essential for appropriate treatment. The practitioner will determine whether the root cause of this condition is of skeletal or dental origin and what division of the class II malocclusion (Figs. 2.22, 2.23, and 2.24). A better approach is to consider whether a class II molar relationship exists. In such instance, a patient will present with crowding, cl II molars, and without increased overjet. Failing to recognize the skeletal cl II pattern that underlies the malocclusion in cases without severe overjet is crucial. In such cases, the mere alignment of anterior teeth in a class II division 2 malocclusion will expose a severe overjet (Fig. 2.25).

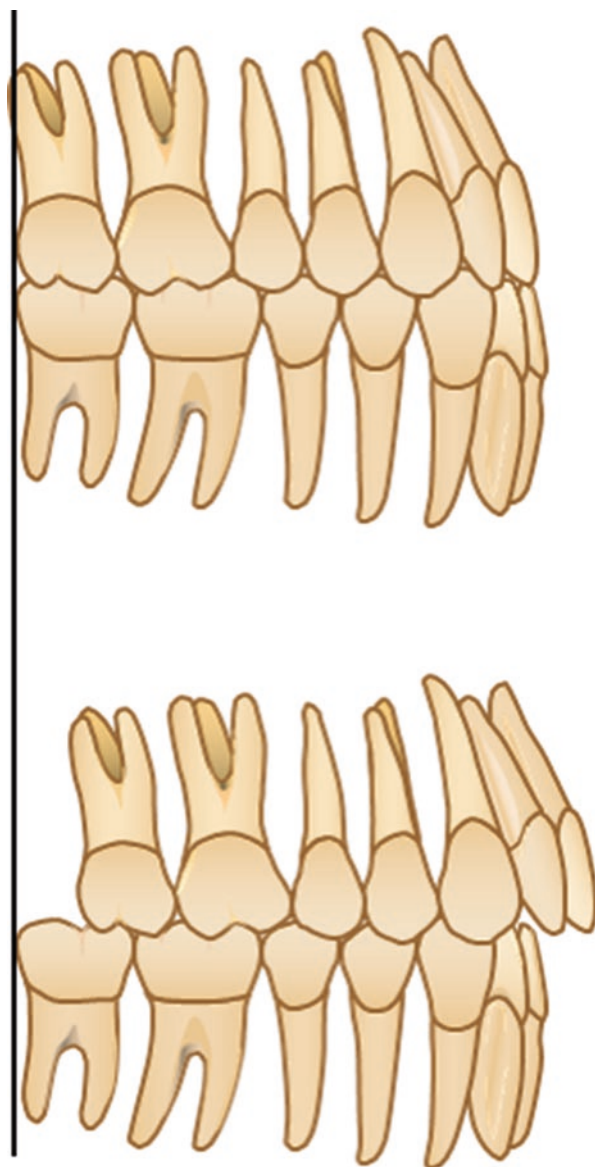
In any case, the treatment plan should consider the ideal position of the maxillary incisors, determine how complex the required dental movements are, and decide whether they would require comprehensive treatment. Considering that a simple approximation indicates that 2 mm of space must be created to retract the incisal edges by about 1 mm, usually 1 mm per side to maintain midline alignment, an astute practitioner will decide whether a combination of IPR and proclination of the lower incisors would achieve esthetic placement of the teeth and facilitate placement of well-proportioned anterior teeth.

2.6 Skeletal Analysis

2.6.1 Cephalometric Analysis

Orthodontists frequently use cephalometric radiographs to diagnose the skeletal pattern by assessing the position of the maxilla and the mandible in relation to the

Fig. 2.22 Note the increased overjet resulting from displacing the maxillary arch to a class II relationship



cranial base and in relation to each other. Cephalometric radiographs are also used to evaluate the angular inclination and the position of the incisors. There are many reported analyses that use different references. For example, Steiner's analysis uses the nasion to A point (Na-A) line as a reference to measure the incisal angulation of the maxillary incisors and to determine the anterior-posterior position (Fig. 2.26). The Na-A line forms an angle by intersecting with the maxillary incisor long axis,

approach for cases that require restorations and crown lengthening is to perform the surgical procedure 3–6 months prior to the final impressions, the main reason being possible postoperative position changes of the gingival margins [14]. By following this method, very predictable results can be achieved to correct not only the excessive gingival display but also the overall look of the smile [48] (Fig. 3.22a–o).



Fig. 3.22 (a) Initial situation. Patient complains about the amount of gingival display and wants to achieve a more natural looking smile. (b) Image calibrated using a digital ruler following the DSD concept. (c) Smile design with calibrated measurements. (d) Digital preview of the desired outcome. (e) Calibrated digital measurements transferred from the digital design to the cast. (f) Final wax-up based on the digital design. It will allow us to fabricate silicon indexes for preparation, temporization, and surgical guidance. (g) Intraoral view of the initial situation. Notice the bulkiness of the prefabricated veneers and the overeruption of the anterior segment. (h) Old veneer removal to create enough space for the surgical guide. (i) Mock-up used a surgical stent for gingivectomy. (j) Mock-up removal for soft tissue collar remotion. (k) Bleeding controlled and provisional veneers inserted. Spot-etch technique with Luxatemp and Luxaflow B1 (DMG, Hamburg, Germany) was used for that purpose. (l) Full-thickness flap elevated for bone contouring. Notice that bone has been positioned 3 mm away from the prosthetic margin, creating space for the deno-gingival complex avoiding the violation of the biologic width. (m) Vertical mattress suture with polypropylene 5/0. Two months after final preparation and final impressions were taken. (n) Intraoral view of the case 1 year after insertion of the veneers. (o) Final situation with correction of the gummy smile showing stability of the results 1 year after

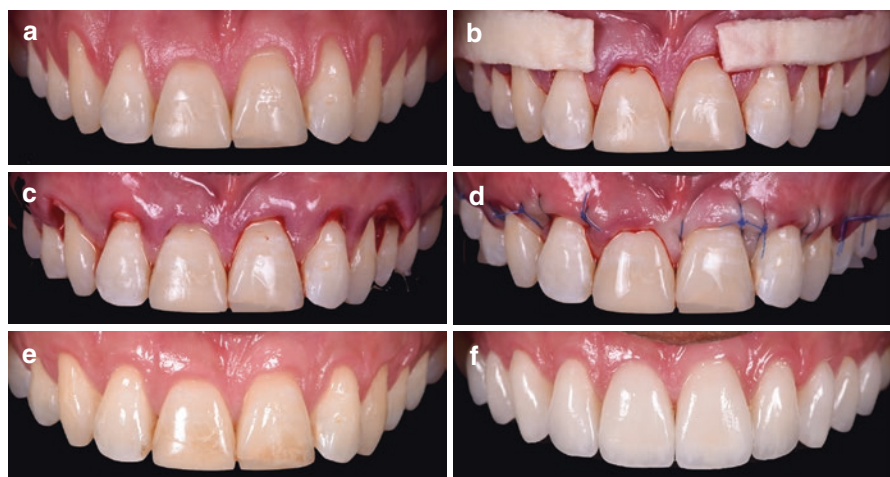


Fig. 3.25 (a) Initial situation with multiple recessions. (b) The thickness of the tissue was considered insufficient for long-term stability. Due to the size of the defect, it was decided to use a graft substitute, in this case acellular dermal matrix (ADM) (Alloderm Tissue Matrix, Biohorizons, Birmingham AL, USA). (c) A tunnel approach was chosen for this case, due to the correct amount of interproximal tissue and minimal invasiveness of this technique, improving the healing of the surgery. (d) Suspensory suture technique for coronal advancement of the tissue with polypropylene 5/0. (e) Surgical outcome 3 months after surgery (ready for the restorative phase). (f) Final result 3 months after restorative treatment with feldspathic veneers. Notice that gingivectomy was performed on #8 and 9 to harmonize the gingival margin position after the root coverage procedure

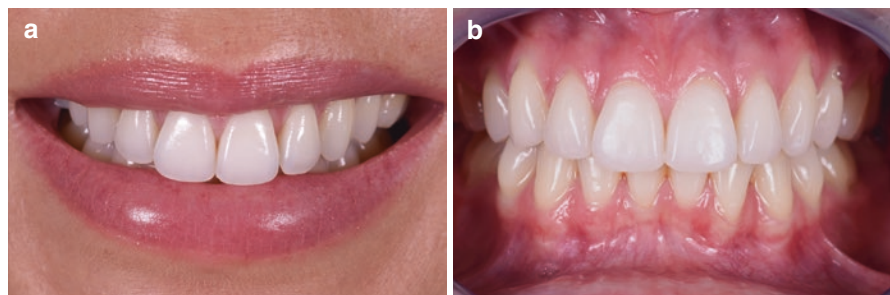


Fig. 3.26 (a) Initial situation. Patient complains about misalignment of her teeth and gingival recessions. She had orthodontic treatment before and refuses that option. (b) Intraoral view. Notice the thin biotype of the patient. (c) Restorative phase performed before the surgery. The esthetic concerns of the patient have been addressed. The position of the restorative margins will guide the surgeon during the advancement and reposition of the flap. (d) Notice that the restorative margins have been positioned based on the ideal esthetics for this case, leaving radicular surfaces exposed. (e) Surgical initial situation. (f) Incision design for a tunnel approach with coronal advancement and no releasing incisions. Notice the ADM already positioned inside the pouch. (g) Coronal advancement of the tissue and suspensory suture with polypropylene 5/0. (h) 1 year after surgery

Fig. 4.11 Pre-op photos of our patient



Fig. 4.12 Acquired smile shows some display but obviously an esthetic liability





Figs. 4.23–4.25 Final restoration post-cementation

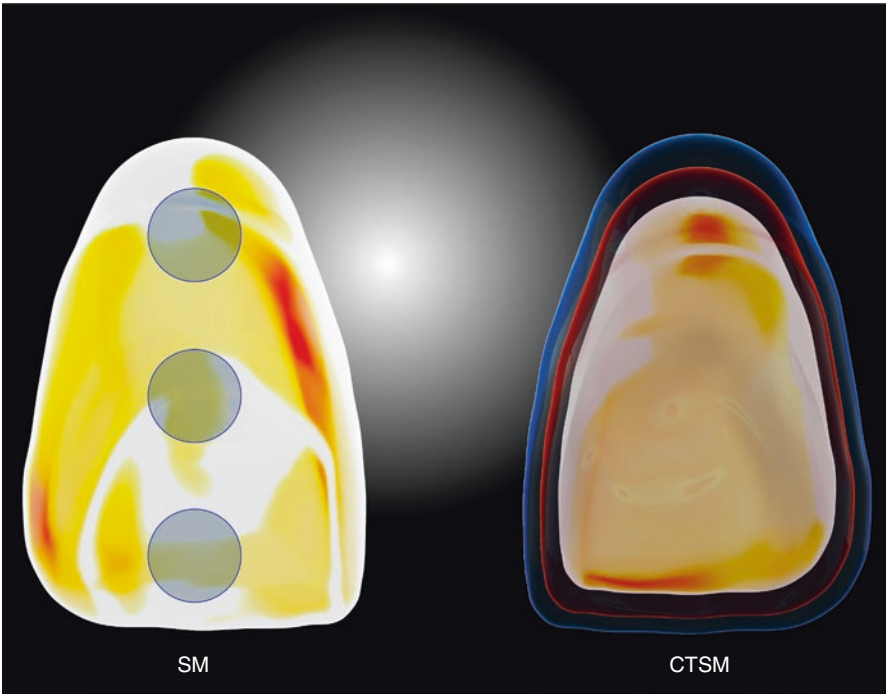


Fig. 5.23 Instrumental shade evaluation is either spot measurement (SM) at several regions, e.g. cervical, middle and incisal, or complete tooth surface measurement (CTSM)

Table 5.1 Dental colour-measuring devices

Device	Technology	Measuring area ^a	Manufacturer
ShadeEye-NCC	Colorimeter	SM	Shofu, Japan
Digital Shade Guide DSG 4 Plus	Colorimeter	SM	A Rieth, Schorndorf, Germany
ShadeVision	Colorimeter	CTSM	X-Rite, Grandville, MI
ShadeScan	Colorimeter	CTSM	Cynoprod, Montreal, Canada
Easysshade V	Spectrophotometer	SM	VITA Zahnfabrik, Bad Säckingen, Germany
ShadePilot	Spectrophotometer	CTSM	DeguDent, Hanau, Germany
Crystaleye	Imaging spectrophotometer	CTSM	Olympus, Tokyo, Japan
SpectroShade Micro	Imaging spectrophotometer	CTSM	MHT, Verona, Italy

^aSM spot measurement, CTSM complete tooth surface measurement

Imaging spectrophotometers take advantage of both direct shade measurements and digital images to analyse the entire surface of the tooth. A paper comparing three colour-measuring devices, ShadeVision, Easysshade and SpectroShade, concluded that SpectroShade produced the most reliable and consistently repeatable

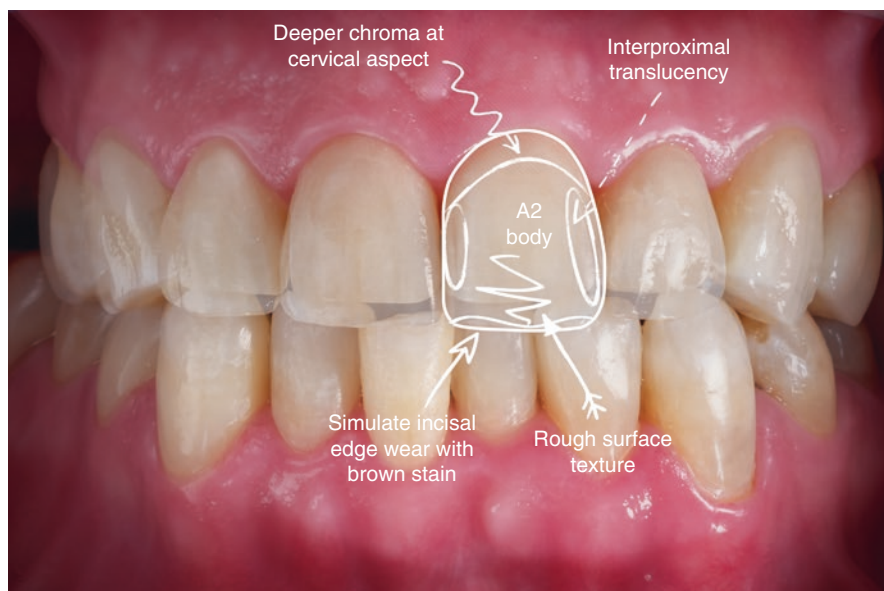


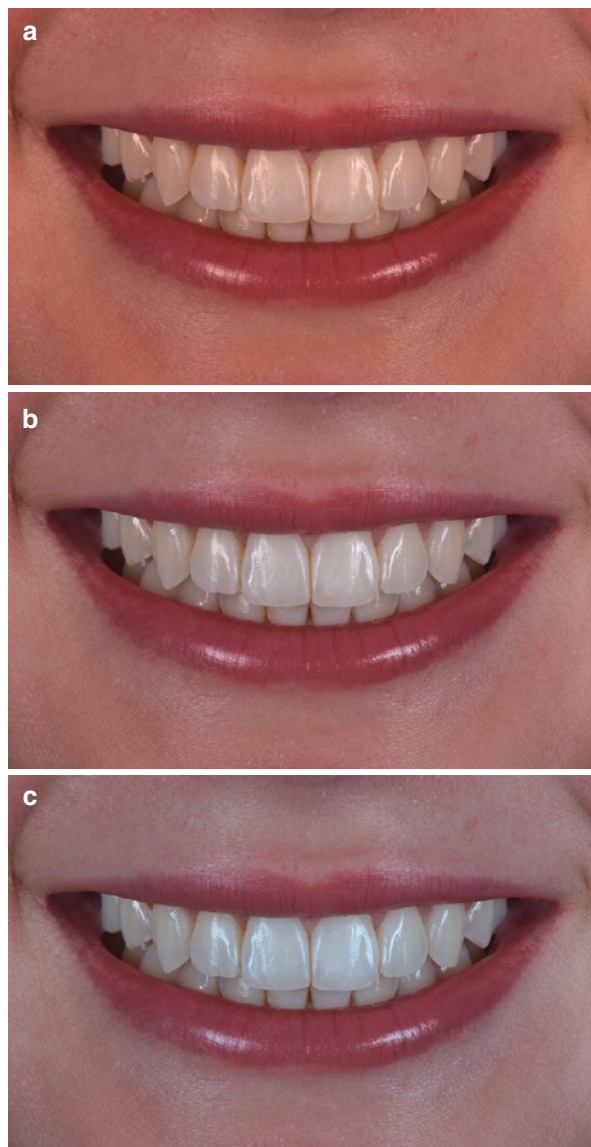
Fig. 5.32 Annotations are useful for providing a prescription for shade distribution and characterisations

Fig. 5.33 Post-operative aesthetic result of PLVs for the maxillary anterior sextant



For complex shade nuances or intricate characterisations that require mimicking in an artificial restoration, the dental laboratory can fabricate bespoke porcelain shade tabs based on photographic and visual/instrumental shade assessment. The tailor-made tabs can then be assessed adjacent to the tooth being matched, photographed and further analysed or adjusted until desired. This method requires a skilled ceramist, perseverance and considerable expenditure [105]. Finally, photographic shade evaluation is also useful for confirming that the outcome of treatment is as anticipated and is an indisputable record for dento-legal documentation (Figs. 5.33 and 5.34).

Fig. 6.10 (a) A warmer color temperature making the teeth appear yellower than reality. (b) A photo demonstrating the appropriate color temperature. (c) A cooler photo temperature makes the teeth appear bluer than reality



Consider the example of a full smile photo. A photo taken from slightly below (Fig. 6.11a) will give the perception of a reverse smile, i.e., the canine tips positioned lower than the edges of the maxillary centrals. A photo taken from slightly above (Fig. 6.11b) will result in an exaggerated smile curve, where the canines would appear deficient in length relative to the centrals. Positioning the camera at exactly 90° to the smile (Fig. 6.11c) results in an accurate portrayal. Any sort of treatment planning, and especially digital



Fig. 6.30 Expanded view of the VITA 3D linear shade guide (VITA North America, Yorba Linda, CA), showing the separation of tabs into value and chroma groups

Fig. 6.31 Proper orientation of the shade tabs to the teeth and proper angulation of the camera lens to the tabs and teeth



6.4.3 Example Case

This patient presented to the author's private practice with a chief complaint of an existing crown on #9 that did not match the surrounding natural dentition (Fig. 6.32). A thorough and complete examination was completed, including the entire set of diagnostic photos detailed in the previous section. These initial records guided the fabrication of the wax-up. After an intraoral evaluation of the wax-up on the second visit, the treatment plan was accepted, and the preparation appointment was scheduled. The sequence of this appointment would be as follows: desired shade photos, anesthesia, removal of the existing crown, gingivectomy, refinement of the preparation, preparation photos, impression, provisionalization, and photos of the provisionals. Note that the *very* first step is photographing the tooth we are matching; it has been shown that local anesthesia, which reduces blood supply to the tooth, could affect the perceived shade of a tooth (making it falsely higher in value) [10]. In addition, it is well known that desiccation occurs when the patient has their mouth open and teeth isolated for an extended period of time [11]. This too would make the tooth/teeth in question appear falsely higher in value. Thus, we begin with

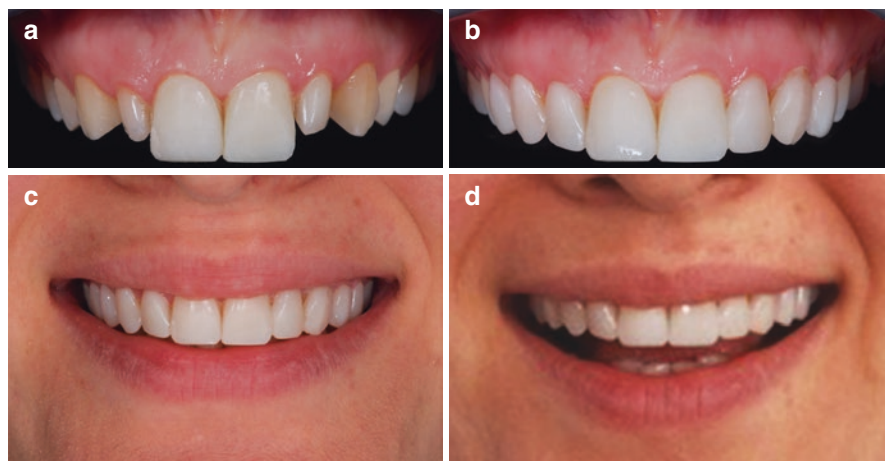


Fig. 9.4 Either a direct mock-up or a wax-up should be placed into the patient's mouth in order to visualize the final design before even the case is treatment planned. (a) Direct mock-up should first start by placing the composite over the two centrals, defining the incisal edge position, (b) and gradually continued over the laterals, canines and premolars, (c) and evaluated with the lips and (d) the face

There are different ways to make the mock-up. It can be directly created in the patients' mouth or indirectly either through a wax-up or by digital ways.

The direct mock-up is the fastest way of starting the communication with the patient. A composite can be placed on the teeth with free hand carving without the need of any bonding material over the existing teeth. Ideally, the first step to execute the direct mock-up should be to start morphing the composite on the two maxillary centrals. Technically, it will be the ideal if the final incisal edge position of the centrals is decided just after the composites on two centrals are placed, before further adding the composites on the remaining teeth (Fig. 9.4a–d).

This step is extremely important, since the design of a smile and the following treatment planning would purely be based on the incisal edge location of the two maxillary central incisors. And this should be done by sitting the patient upright on the dental chair and when the dentist and the patient are standing face to face to each other. There will be a lot of factors that will be influential on the decision making of this procedure, such as the relationship of the centrals primarily to the upper lip line, then the lower lip line, their proportions, age and sex of the patient. Upon this decision, then the mock-up can be done on the rest of the teeth.

9.3 The Aesthetic Pre-evaluative Temporaries (APT)

Once this preliminary design on the direct mock-up is approved by the dentist and the patient, the case can now be sent to the laboratory, for a wax-up. When the wax-up is sent back to the dental office, a silicone impression is made from the wax-up. This silicone impression is filled with a flowable resin and placed in the mouth before the patient is anaesthetized, and the teeth are prepped. This is named as the aesthetic pre-evaluative temporaries (APT) (Fig. 9.5a–d).

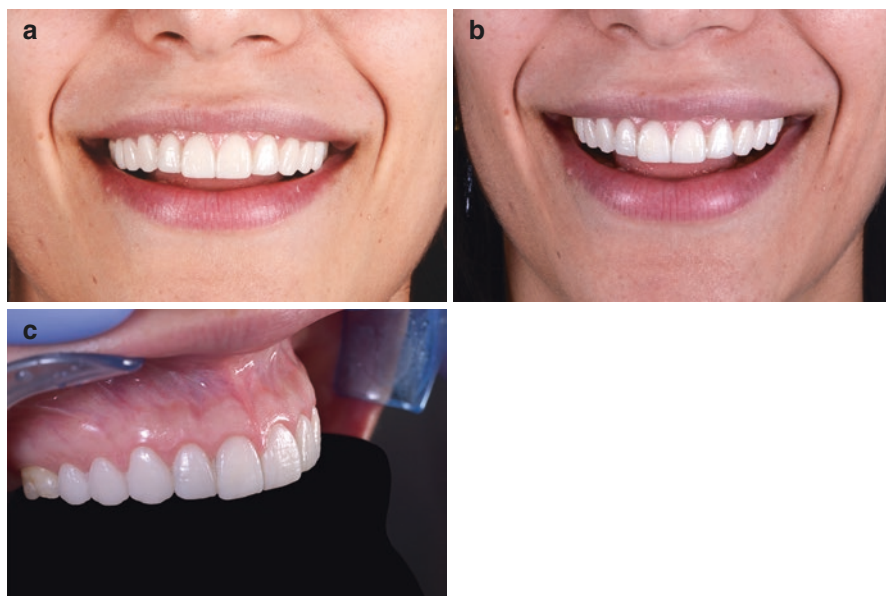


Fig. 9.21 (a–c) The visualization of the APT in the mouth and its relation to the facial appearance. REBEL design according to the facial perception and personality of the patient, the design is created with the rectangular shape of the individual tooth shapes, straight tooth axis, dominant centrals and flat to triangular incisal silhouette

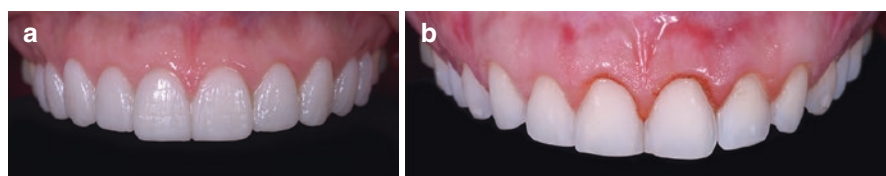


Fig. 9.22 (a, b) After the approval of the aesthetic outcome of the APT (from the REBEL 3D digital wax-up), the dentist can start preparing the teeth through the APT for the most aesthetic and minimally invasive preparations (note the minor soft tissue touch-up correction on the centrals, to define the zenith points)

9.23 Tooth Preparation Through the APT

Once the final design is approved by the dentist and the patient, the dentist can anaesthetize the patient and start preparing the teeth through the APT (Fig. 9.22a, b).

9.24 Finalizing the Case

As soon as the teeth are prepared, it is then the choice of the dentist to further continue the case digitally by making an intra-oral digital scan or continue with the conventional analog way.

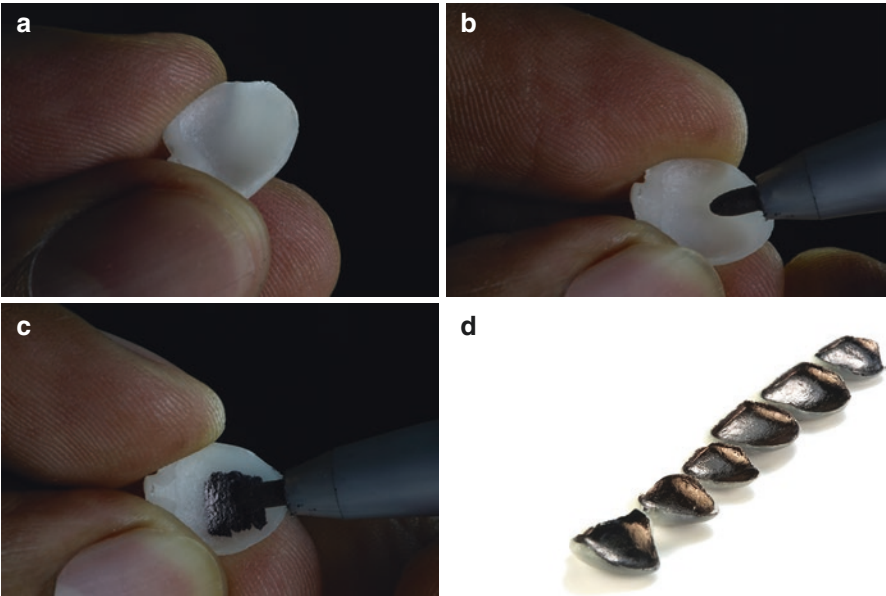


Fig. 10.10 (a–d) With the permanent markers the restorations are painted on the inside

Fig. 10.11a Permanent markers



Fig. 10.17a Full face photograph



Fig. 10.17b Resting lip position



Fig. 10.17c Final photo
of the smile



Fig. 10.17d Right lateral
view of smile



Fig. 10.17e Left lateral
view of smile



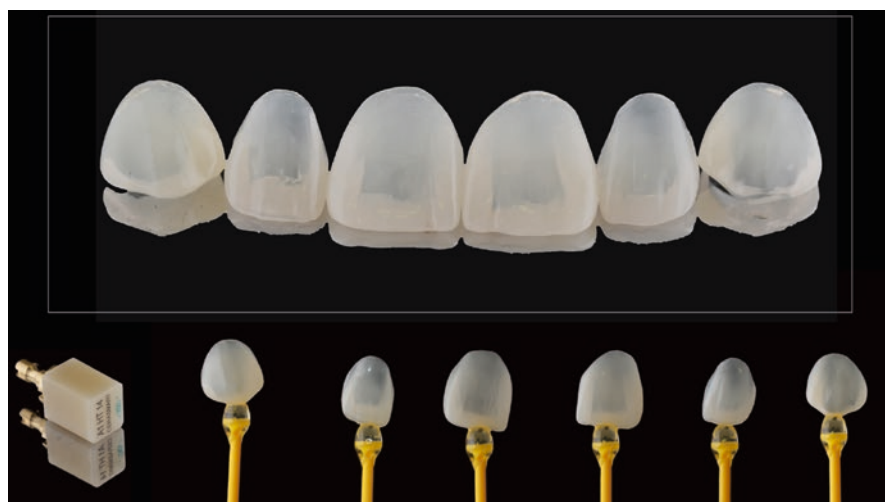


Fig. 11.48 The six additive CAD/CAM milled veneers realized with a resin matrix ceramic material (Cerasmart GC): a chair-side path assisted by the technician was chosen. We are ready for the luting step

Fig. 11.49 The “abutments” (i.e., the natural untouched “small” teeth) ready for the luting step



Fig. 11.50 Since the a-prismatic enamel (no bur was used) is still present, it is mandatory to sandblast it for 5 s. with an aluminum oxide 50 μm powder before its etching. The rubber dam is used on every single tooth and kept in place with the fingers to avoid any possible marginal tissue damage

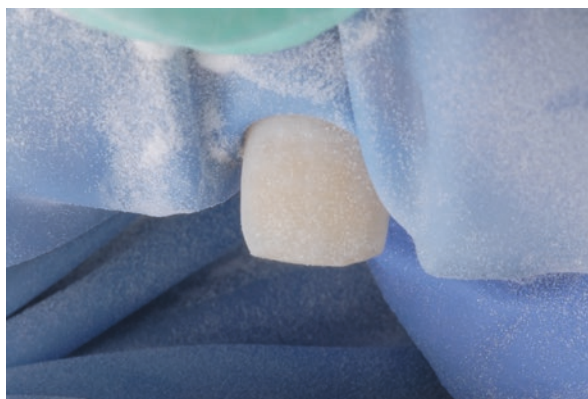


Fig. 11.64 One more clinical case. The frontal view of a young patient at the end of the orthodontic treatment (upper lateral agenesis); the two upper cuspids are positioned in place of the laterals and the two upper premolars in place of the cuspids



Fig. 11.65 The wax-up (guided by the DSD) impression made by a stiff silicon material to be placed in the mouth as mold for the mock-up resin



Fig. 11.66 (a, b) The wide smile with the printed mock-up



Fig. 11.69 (continued)

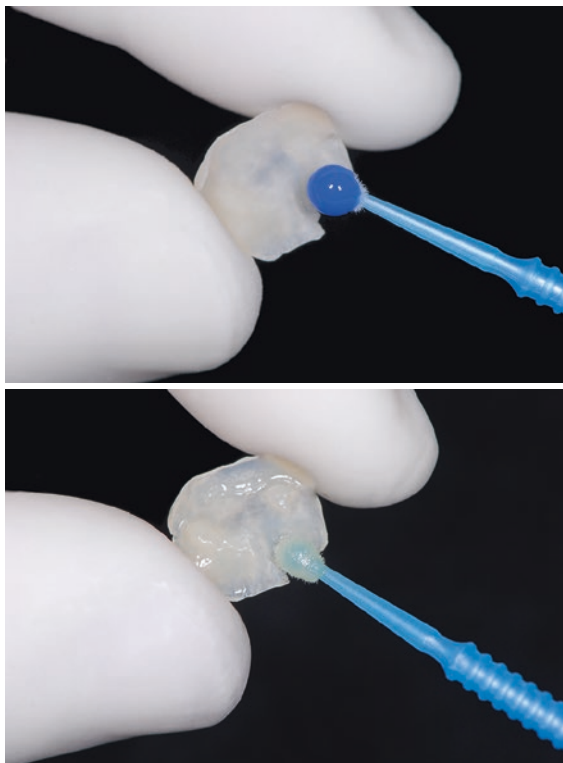
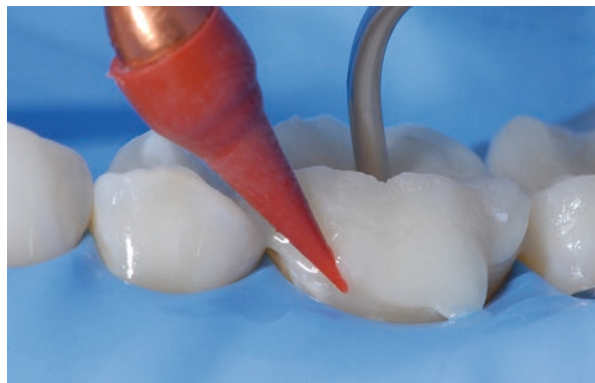


Fig. 11.72 (a, b) The smile surrounded by the lip frame: before (left) and after (right)

Fig. 11.73 The 1-year follow-up



In some cases, the restorations are entirely additive, and, obviously, all the previous steps and the considerations about the tooth preparation become unnecessary and vain in order to only add a new “skin” to the present untouched enamel! (Figs. 11.21, 11.22, 11.23, 11.24, 11.25, 11.26, 11.27, 11.28, 11.29, 11.30, 11.31, 11.32, 11.33, 11.34, 11.35, 11.36, 11.37, 11.38, 11.39, 11.40, 11.41, 11.42, 11.43, 11.44, 11.45, 11.46, 11.47, 11.48, 11.49, 11.50, 11.51, 11.52, 11.53, 11.64, 11.65, 11.66, 11.67, 11.68, 11.69, 11.70, 11.71, 11.72, and 11.73)

Figs. 12.25–12.27 (continued)**Fig. 12.28** Excess cement removal with rubber tips and brushes

Figs. 12.41–12.45 (continued)



Figs. 12.46 and 12.47 Excess cement removal with rubber tips and fine brushes



Fig. 12.48
Photopolymerization from palatal, incisal and labial surfaces



