Ceramic Laminate Veneers: clinical procedures with a multidisciplinary approach

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Ceramic laminate veneers: clinical procedures with a multidisciplinary approach

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Abstract

Complex cases with high esthetic needs represent a challenge for clinicians. A multidisciplinary approach is vital to achieve the planned result. New technological devices are needed to facilitate the collaboration between the clinical team members and to develop a fluent and effective diagnostic and therapeutic pathway. This article describes a well-defined protocol for the treatment of complex esthetic cases with the use of ceramic laminate veneers. The protocol involves different branches of dentistry: periodontal therapy, mucogingival surgery, restorative dentistry, orthodontics, and prosthodontics. Each step of the protocol should be executed in a very strict order: intra- and extraoral esthetic analysis of the patient, with photographs; digital previsualization by means of Digital Smile Design (DSD); clinical previsualization by means of a mock-up; orthodontic, mucogingival, and endodontic treatments, if needed; minimally invasive tooth preparation, driven by a mock-up and silicone indices; manufacture of ceramic laminate veneers; try-in and adhesive cementation. In this article, this protocol is illustrated by a clinical case report in which all the above-mentioned steps were carried out. The finalization was obtained by means of state-of-the-art adhesive techniques and ceramic laminate veneers. The correct use of modern materials, in combination with rigorous adhesive procedures, allows for a minimally invasive and highly esthetic treatment, with adequate function and a perfect integration that is in harmony with the patient's face.

(Int J Esthet Dent 2017;12:2–24)

Introduction

Modern restorative dentistry is essentially based on adhesion. This allows it to comply with three vital parameters: esthetics, function, and sound tissue preservation. The correct use of composite and ceramic materials with rigorous adhesive procedures allows for a minimally or even noninvasive (ie, additive) approach that is innovative, highly esthetic, and predictable in terms of both result and long-term prognosis.

Modern dentistry should be in keeping with biomimetics or bioemulation concepts:[1,2] Restorations should reproduce the physiologic behavior of the natural tooth as far as possible, with biologic, biomechanic, functional, and esthetic integration.[3] Different treatment options may be considered when esthetic adhesive restorations in the anterior region are required: direct composite restorations, composite or ceramic laminate veneers, and metal-free crowns (lithium disilicate, zirconia, alumina). The choice between direct and indirect techniques should be based on several criteria: tooth vitality preservation, minimum loss of sound tissue, a minimally invasive approach toward the gingival complex, esthetic demands, patient age, financial cost, and total treatment time. Further parameters are: the number and extent of involved teeth, type of function, antagonist teeth situation, feasibility of functional and anatomical recovery of the restored tooth, and biomechanical resistance of the restored tooth.

Direct techniques provide the maximum preservation of residual sound tissue. They are indicated in the following conditions: white spots (treated by means of enamel mega abrasion), class V cavities, class III and IV cavities (small, medium or large), and minor modification of color or shape.

Indirect techniques, on the other hand, provide remarkable advantages:

- Maximum esthetic result due to the high dimensional stability and color stability of ceramics.
- Optimal control of tooth dimension, shape, contact points, layering, finishing, and polishing.
- Try-in and esthetic evaluation on the hydrated tooth prior to the start of cementation procedures.

Indirect techniques are indicated when treating multiple complex restorations, endodontically treated teeth with a major loss of sound tissue, complete crown fracture, major shape modifications, dental crowding, very young uncooperative patients, and patients with high esthetic demands.

Among indirect techniques, ceramic laminate veneers represent a well-documented, effective, and predictable treatment option.[4,5] An indirect technique may be considered the first treatment choice when an adequate amount of residual sound tissue exists. The classification by Magne and Belser[6] (Table 1) describes three main indications:

- Type I: teeth where bleaching was ineffective.
- Type II: major morphologic modifications.
- Type III: extensive restorations in adult patients.

Innovative preparation designs for porcelain laminate veneers are much less invasive than conventional complete-cov-

Table 1 Classification of the indications for ceramic laminate veneers by Magne and Belser[6]

TYPE I WHITENING RESISTANT TEETH
Type I A: Grade II and IV discoloration from tetracycline
Type I B: Lack of response to external or internal bleaching
TYPE II IMPORTANT MORPHOLOGICAL CHANGES
Type II A: Conoid-shaped teeth
Type II B: Closing diastemas and interdental triangles
Type II C: Increasing length and incisal prominence
TYPE III EXTENSIVE RESTORATIONS (ADULTS)
Type III A: Extensive coronal fractures
Type III B: Extensive loss of enamel due to erosion and wear
Type III C: Acquired and generalized malformations

erage crown preparations. Edelhoff and Sorensen[7] quantified, with a gravimetric analysis, the amount of tooth structure removed during these preparations: Porcelain laminate veneers required approximately one-quarter to one-half the amount of tooth reduction of conventional complete-coverage crowns.

Achieving optimal and predictable results with the use of veneers cannot be taken for granted. Success comes from correct planning and accuracy in performing every single step of the treatment.

Many adult patients present with a combination of situations; the ideal treatment is a multidisciplinary, monoprofessional approach or, better still, an interdisciplinary approach. The best esthetic result largely depends on the ability of the members of the multidisciplinary team to work together. Efficient communication between team members can present a challenge due to the requirement for continuous communication between the different specialists. Prosthodontist, orthodontist, periodontist, and dental technician need to work together because understanding the various phases of the treatment is fundamental to achieving the desired result. Today, the use of new technologies such as Digital Smile Design (DSD)[8] can improve the communication process between specialists. The previsualization of the final result can be a motivational key, not only to start the treatment, but also to keep the patient involved throughout the process.

The aim of this article is to present a clinical case report demonstrating an accurate operative protocol for the realization of ceramic veneers with a multidisciplinary approach on the basis of the most recent clinical and scientific evidence. The operative sequence is structured as follows:

- Intra- and extraoral esthetic analysis of the patient, with static photographic documentation and dynamic video filming.
- Digital previsualization by means of DSD.[8]
- Clinical previsualization by means of a mock-up[9] or aesthetic pre-evalua-

Fig 1 Initial frontal view of the patient's face.

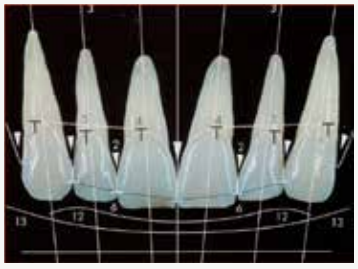
tive temporaries (APTs),[10] based on a diagnostic wax-up.
- Evaluation and treatment of endodontic, mucogingival, and/or orthodontic problems, where necessary.
- Minimally invasive preparation, driven by both the mock-up and the silicone keys made on the wax-up.
- Manufacturing of ceramic veneers (feldspathic or lithium disilicate).
- Try-in and adhesive cementation under rubber dam isolation.

Case report

Clinical procedures

A 40-year-old female patient complained of hypersensitivity in the maxillary teeth and was concerned about gingival recession. She was very motivated and keen to improve her smile (Fig 1). Clinical examination showed cervical abrasions with moderate asymptomatic gingival recessions in the mandibular arch.

Table 2 Esthetic checklist by Magne and Belser[6]: esthetic fundamental (objective and subjective) criteria

	Fundamental objective criteria	**Fundamental subjective criteria (esthetic integration)**
	1. Healthy gingival tissue 2. Interdental closing 3. Dental axis 4. Zenith gingival contour 5. Balance of gingival levels 6. Level of interdental contact 7. Relative dental dimensions 8. Essential characteristics of tooth shape 9. Dental characterizations 10. Surface texture 11. Color 12. Configuring the incisal edge 13. Line of the lower lip 14. Symmetry of the smile	1. Changes in the tooth shape 2. Teeth layout and position 3. Coronal relative length 4. Negative space

In the maxillary arch, however, severe gingival recessions were present, especially on the canines and first premolars, with deeper cervical abrasions that led to hypersensitivity.

Esthetic analysis, based on fundamental objective and subjective esthetic criteria (Table 2),[6] highlighted disharmony and a lack of balance of the dentolabial, dental, and gingival complex (Figs 2 to 5). From a periodontal perspective, the patient showed good oral hygiene habits, although her brushing technique was too aggressive:

- Non-carious cervical lesions were present, caused by an abrasive/erosive mechanism. Consequently, the gingival margin was altered – mainly on the canines and premolars, and moderately on the lateral incisors.
- Wide diastemas were present between the lateral incisors and canines in both arches, and between the canines and first premolars in the maxillary arch.

Fig 2 Initial frontal view of the patient's smile. An inverse smile line can be observed.

Fig 3 View of maxillary anterior teeth showing inadequate relative dimensions among teeth, non-carious cervical lesions, wear of incisal margins, and flat incisal line with loss of embrasures.

Fig 4 Maxillary occlusal view. Wide diastemas can be found between the lateral incisors and canines, and between the canines and first premolars.

Fig 5 Mandibular occlusal view. Wide diastemas can be found between the lateral incisors and canines.

- Inadequate relative dimensions of the teeth were found: the central incisors were small and hardly predominant compared to the lateral incisors; all incisors had an improper height/width ratio – the recessions on the canines and premolars had altered the coronal proportions.
- The teeth suffered from a loss of buccal volume and surface texture; their color was characterized by low value and moderate chromaticity.
- The incisal margins were flat due to wear. The incisal embrasures were lost, resulting in an inverted smile line that caused esthetic disharmony.

The patient's occlusal situation showed a good molar class I, with proper anterior overjet and overbite. The interproximal contacts in the posterior sectors were adequate. The curve of Spee was flat and needed no modification.

A multidisciplinary treatment plan was elaborated:

- A nonsurgical periodontal treatment, with motivation and improvement of the homecare routine.
- A full set of intraoral photographs, video clips, and study models were collected. DSD previsualization would guide the wax-up and the subsequent clinical previsualization with a direct mock-up.
- Mucogingival surgery to recreate an anatomic cementoenamel junction (CEJ) and achieve proper root coverage in the maxillary lateral sectors.
- Orthodontic treatment with transparent aligners to optimize space as a function of the prosthetic plan (DSD-driven orthodontics).
- A second mock-up, with a final check of the treatment plan.
- Prosthetic procedure, with teeth preparation driven by a mock-up.
- In the maxillary arch, the creation of six ceramic laminate veneers from canine to canine, plus two additional veneers on the mesial aspect of the first premolars. In the mandibular arch, the creation of six ceramic laminate veneers from canine to canine.
- Try-in and adhesive luting of the veneers.

Esthetic analysis and DSD

DSD[8] is a recent digital previsualization technique that allows the clinician to:

- Efficiently plan the treatment of simple or complex esthetic cases.
- Improve the communication between the dental team members involved in the treatment.
- Obtain better communication with and increase the patient's involvement in the planning of his or her smile, and achieve better patient motivation and understanding of the advantages of the proposed treatment.
- Enhance the predictability of the whole treatment thanks to a digital project, which guides the actual clinical treatment.

DSD is based on a clear intra- and extraoral photographic protocol, leading to a thorough esthetic analysis of certain elements in a specific sequence:

1. Facial analysis.
2. Dentofacial analysis.
3. Dentolabial analysis (incisal edge position, incisal display during smile, smile line, buccal corridor).

4. Dentogingival analysis.
5. Dental analysis (inter- and intra-tooth relationships).[11,12] All the records are arranged in a slideshow by means of general presentation software (Keynote for Apple users; PowerPoint for PC users) or dedicated software (eg Digital Smile System, DSS; cara Smile, Heraeus Kulzer) that will lead to the creation of a digital preview of the smile.

This approach allows for the sharing of the treatment plan among team members (also via the internet), and for creating a captivating visual presentation of the treatment solution. The digital project may be tested and approved even before starting the actual treatment.

Making video clips of an interview with the patient allows the clinician to collect further details that might not be observed from the photographs due to their limitations. Video clip integration provides the opportunity for a dynamic analysis. In addition, three-dimensional (3D) digital models of the mouth can be included.

While defining and planning a patient's smile, it is important to follow fundamental esthetic criteria (Table 2), and the concept of morphopsychology or "Visagism."[13] Visagism applies the principles of visual art to the creation of a custom smile design that can express the patient's personality and lifestyle. This will ensure harmony between the restoration and the patient's general appearance, values, and attitudes. Achieving harmony between psychology, teeth, and face may be defined, in a word, as beauty. A dedicated online software package (Visagismile) can help the clinician to create a customized personal smile design for each patient.

In this clinical case, the digital project (Fig 6) led to an increase of final dental volumes by means of an adequate redistribution of diastemas. This was made possible by a calibrated digital

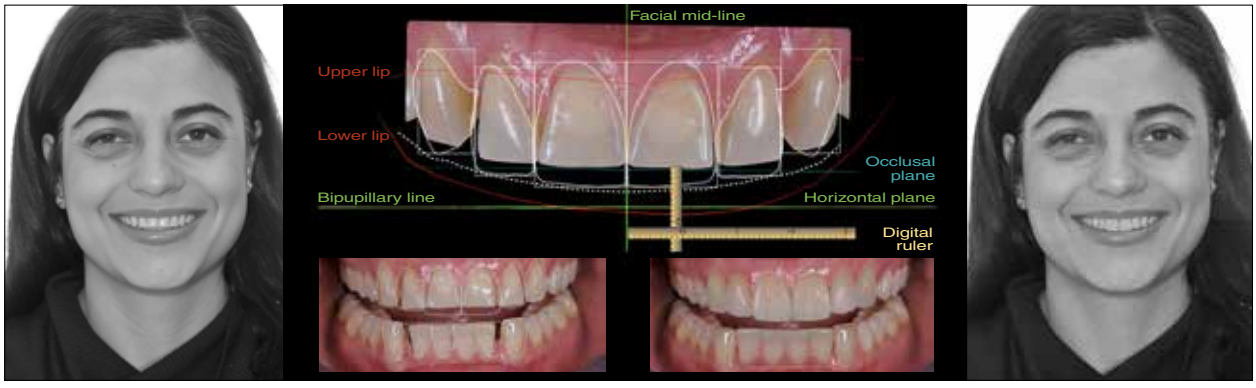


Fig 6 DSD: virtual treatment planning with digital previsualization. The design of the new dental profile is guided by the "facial cross," by extraoral parameters (bipupillary line, lower and upper lips) and by the relationship of rectangles. The amount of the required modifications can be measured by means of a calibrated digital ruler. The obtained measurements will guide the dental technician while performing the wax-up. The final result can be previewed by superimposing custom dental shapes on both intraoral and full-face photographs, thus greatly improving communication with the patient.

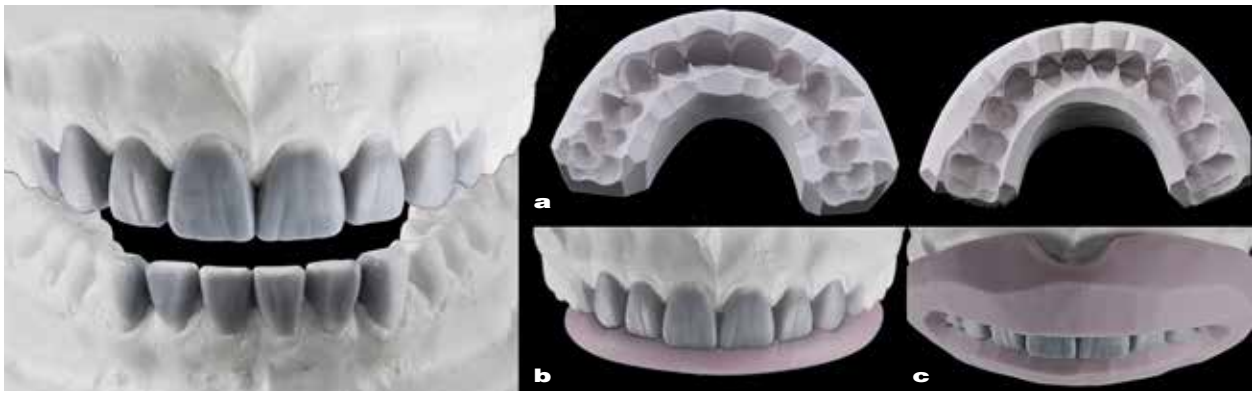


Fig 7 DSD-driven wax-up of maxillary (from premolar to premolar) and mandibular (from canine to canine) anterior groups. Three silicone indices were obtained from the wax-up: **(a)** a complete index for the creation of the mock-up and temporary restoration; **(b)** a palatal index; **(c)** a buccal index, horizontally sectioned as a book. The latter two were used as references during the preparation phase.

ruler that allowed for the quantification of the amount of the modifications needed on every single tooth to obtain an anterior sector in harmony with the patient's lips, surrounding tissue, face, and personality.

Traditional DSD sequences were integrated using ClinCheck software (Align Technology), which allowed for a real 3D control of movement sequence, and a 0.1-mm level of precision in movement and space opening.

Wax-up and clinical previsualization (1st mock-up or APT)

By transferring the "facial cross" from the digital project to the plaster model it is possible to transfer the information about 3D positioning of the mouth. This is of great help to the dental technician during the wax-up phase as it makes it more predictable. Any surgical, orthodontic, and restorative procedure will be esthetically guided by the wax-up.[14] The wax-up allows for the creation of helpful tools to guide the different procedures for the overall treatment: surgical, orthodontic, implant, and preparation guides.

In this case, three silicone indices were obtained from the wax-up: 1) a complete index for the creation of the mock-up and temporary restoration; 2) a palatal index; 3) and a buccal index, horizontally sectioned as a book. The latter two were used as references during the preparation phase (Fig 7).

The next step is to convert the two-dimensional (2D) digital project into a 3D mock-up, which may be either direct or indirect, depending on the case. The mock-up[9] or APT[10] provides a clinical preview of the final restoration. This step is critical in that it evaluates the final volume of the restorations according to esthetics and function, and thus validates the digital project. A direct mock-up is created with the use of a silicone index (at least 95 shore in hardness), with self-curing composite resin (Structur 3, Voco) injected into the index, which is then positioned on the teeth (Fig 8). The

mock-up is then finished and polished directly intraorally (Fig 9). Photographs should be taken and shown to the patient. The mock-up should remain *in situ* for the time required (at least 1 week) for "deprogramming" the patient from the previous situation.[9] The ultimate objective is to obtain the patient's approval and the clinician's evaluation of the project. If corrections are needed, they should be made in this step, either by directly modifying the mock-up or by modifying the wax-up and creating a further mock-up. Once the mock-up is clinically satisfactory, the following step of the treatment may be performed.

Mucogingival surgery

Where cervical lesions are associated with treatable gingival recessions, a correct treatment plan involves a first restorative step to provide an adequate anatomical CEJ. A surgical step then follows, during which the recessions are recovered to rebalance the gingival scalloped morphology.[15]

In the case presented here, the periodontal treatment started with periodontal debridement, oral hygiene instruction, and patient motivation. The next step began only once all the periodontal indices (PI, BOP, CAL, PD) had elicited adequate periodontal health and a satisfactory homecare routine (especially the brushing technique).

In teeth 14, 13, and 24, since an anatomical CEJ could not be found, the level of maximum root coverage (MRC) was predetermined according to a well-defined technique.[16] MRC is defined as the line that the gingival margin will reach and, after maturation, stabilize after surgery. Composite resin adhesive restorations were performed under rubber dam isolation, then accurately finished and polished to recover the anatomical CEJs. In a successive session, the surgical correction of mucogingival defects was performed.

A multiple coronal lateral flap technique[17] was used (Fig 10a). After measuring the depth of the recession, oblique incisions were cut, converging toward the center of rotation (usually the canine). The flap was then raised according to a defined protocol (partial/full-partial thickness) with no relaxing

Fig 8 Direct mock-up molding with rigid silicone index (95 shore).

Fig 9 Clinical previsualization (mock-up) of the maxillary anterior teeth after intraoral finishing and polishing.

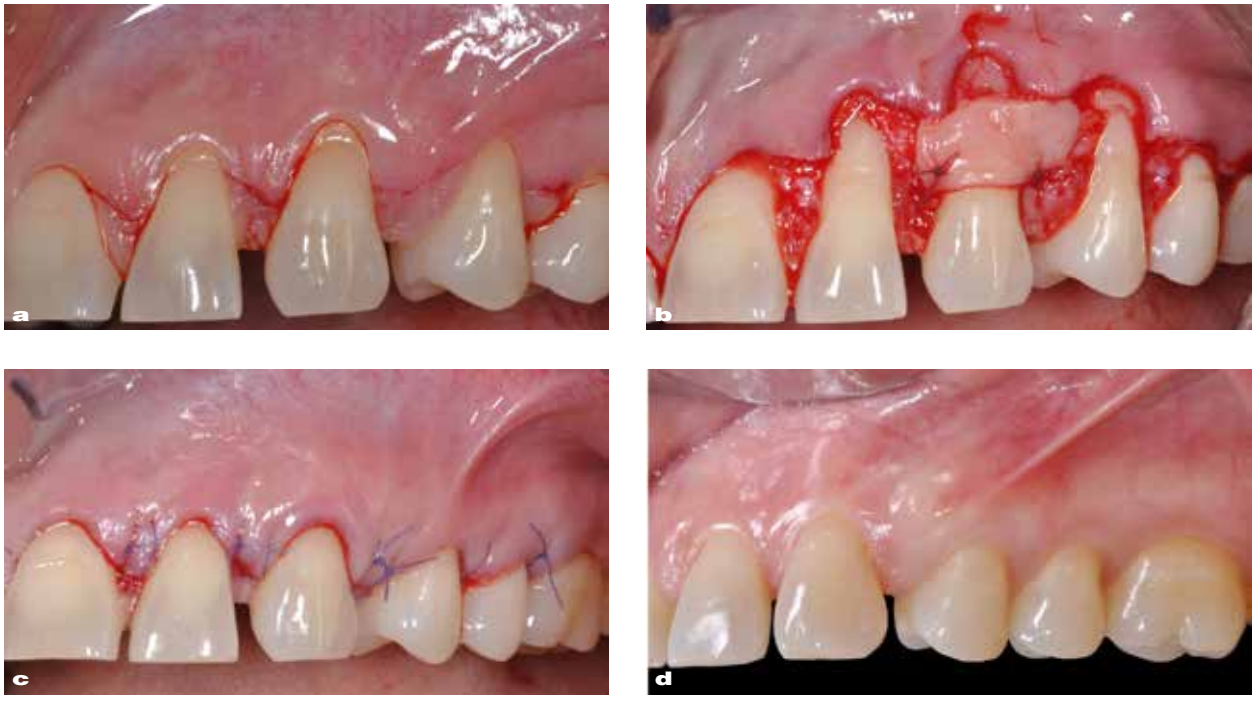


Fig 10 Multiple coronally advanced flap in the maxillary left quadrant. **(a)** After measuring the depth of the recession, oblique incisions are cut, converging toward the center of rotation (ie, the canine). **(b)** After removing the epithelium on the papillae, a bilaminar graft is taken from the palate and, once the epithelium is removed, sutured on tooth 23. **(c)** With proper passivation, the flap is coronally advanced. A 6-0 absorbable PLA-PGA suspended suture is performed. **(d)** After tissue maturation, a complete coverage of gingival recessions can be observed.

incisions. The epithelium of the anatomical papillae was removed and the root surfaces adequately conditioned. Bilaminar grafts were taken from the palate and, once the epithelium was removed, sutured on teeth 14 and 23 (Fig 10b). Suspended sutures were made with 6-0 absorbable polylactic acid-polyglycolic acid (PLA-PGA) thread (Fig 10c). After complete healing, a thorough morphological recovery of the periodontal and dental complex was obtained, showing a harmonious gingival margin and adequate proportion among the clinical crowns of the treated teeth (Fig 10d).

Orthodontic diagnosis and treatment plan

Preprosthetic orthodontic treatment is a key phase in the multidisciplinary protocol, especially in the following situations:[18]

- In case of rotations, in order to avoid dentinal exposure during the preparation of severely rotated or tipped teeth.
- To align the gingival height by means of tooth intrusion or extrusion.
- To redistribute space, and to center each tooth in its DSD and mock-up planned volume.

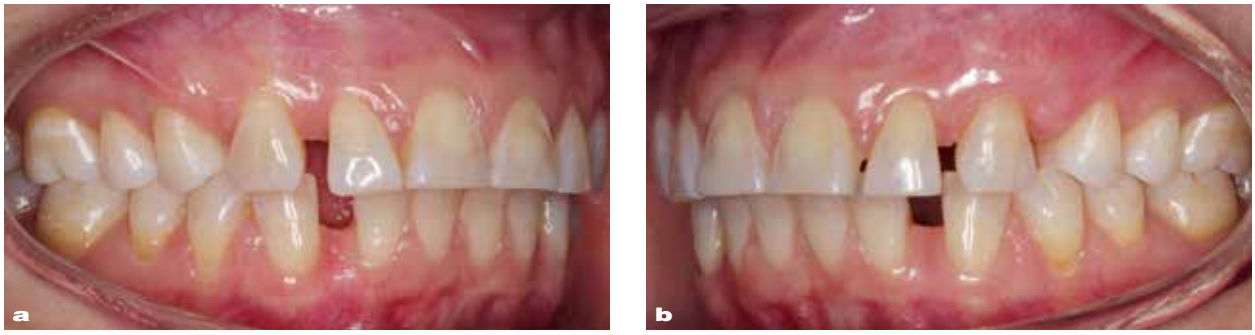


Fig 11 **(a and b)** Lateral views showing a stable molar class I, with proper anterior overjet.

In the presented case, after soft tissue maturation in the maxillary arch, orthodontic records were collected to evaluate and visualize the necessary movements. The main aspects analyzed were:

- Whether or not to improve the intercuspation in the lateral sectors.
- The need for modification of the anterior tooth line.
- The movement needed in both arches to proceed to a good finalization.
- The most effective and efficient device needed in order to obtain such movements, with respect to the patient's esthetic needs.

The cephalometric analysis and lateral views (Fig 11a and b) show a class I occlusion with proper overjet and normal divergence. No temporomandibular joint (TMJ) pain was reported. Protrusive and lateral guidance appeared inadequate due to the parafunction, leading to severe wear of the anterior sector. Nevertheless, muscle excursion in lateral and protrusive movements was within normal range, as was maximum opening. Maxillary and mandibular incisor inclination was also within normal range, and the interincisal angle did not show any relevant change. The projection of the maxillary incisal margin on the nasal spine was good, so no modification of the anterior teeth line was necessary.[19]

The planned movements were obtained with transparent aligners (Invisalign, Align Technology).[20,21] The ClinCheck software is effective in simulating the space opening among maxillary and mandibular incisors, starting from the mesiodistal dimensions previewed with the DSD and the initial wax-up.[22] Different options may be analyzed and virtually tested by means of 3D software. Perfect communication among team members is ensured by simulations that are easily understandable, and by the possibility of sharing previews via the internet. Once the simulation fulfills the clinical objectives, the aligners can be manufactured.

Rectangular vertical attachments were applied, according to the ClinCheck software, to achieve a better movement of the incisors. Treatment lasted 7 months, needing 14 aligners (Fig 12). No refining phase was necessary. Finally, the patient was given two removable retainers and was instructed to wear them for at least 3 months to maintain the result.

Fig 12 Orthodontic treatment with space redistribution. Teeth movements were planned with the ClinCheck software and were obtained with 14 Invisalign aligners. The treatment was carried out in 7 months.

Fig 13 Creation of depth grooves on the buccal surface of the maxillary teeth. Round diamond burs are the ideal depth cutters. The depth of the cut is calculated by halving the difference between the diameter of the bur and that of the shaft.

Second mock-up and bleaching treatment

At the end of the retention phase, a second mock-up was created of the new position of the teeth on the base of a wax-up. The mock-up was obtained with a direct technique, by molding the self-curing composite resin in a rigid silicone index taken on the new wax-up.

The final project fully satisfied the patient's esthetic expectations and was correct from a clinical point of view. Definitive restorations then became a controlled process, with minimal modifications compared to the mock-up.

A bleaching treatment (chairside power bleaching, and home bleaching for 2 weeks) was performed to achieve a more favorable color of the dental substrate.

Preparation driven by mock-up (ie, by additive final volume of the restorations)

The preparation phase should be minimally invasive, providing just enough

space for the ceramic restorations, as a function of the ceramic material properties, dental substrate color, need for dental contour modification, and occlusal relationship.

The mock-up was used as a guide for the minimally invasive prosthetic preparation, creating calibrated depth cuts directly on the composite.[9,23,24]

In the maxillary arch, six veneers were planned (from canine to canine), and two additional veneers on the mesial aspect of the first premolars. In the mandibular arch, six veneers were placed (from canine to canine).

Fig 14 Horizontal grooves 0.5- to 0.7-mm deep are created between the middle and incisal thirds of each facial surface. Scalloped grooves 0.3- to 0.5-mm deep are created between the middle and cervical thirds. Each depth groove is marked with a pencil.

Fig 15 Maxillary teeth: step-by-step tooth preparation driven by the mock-up. Removal of the tooth structure between the guiding grooves is performed with round-ended, slightly tapered diamond burs. Preparation is performed both on the facial surface **(a)** and at the incisal margin **(b)**. Prepared surfaces are finished with fine grit burs **(c)**, and polished with silicone points **(d)**. The horizontally sectioned silicone index obtained from the wax-up is used to double check for facial clearance **(e)**.

Fig 16 Final veneer preparation in the maxillary arch after polishing.

In an adhesive preparation driven by a mock-up, the clinician should deal with two parameters:

- The amount of tooth volume increase, planned with the mock-up.
- The thickness of the veneer, according to mechanical properties, substrate color, or planned color.[25]

The extent of tooth reduction (P) is represented by the difference between extra volume (EV) and veneer thickness (LT): P = EV - LT.[10] The preparation is guided by calibrated horizontal depth grooves: a straight one in the middle third of the crown, and a scalloped one in the cervical third. Depth cuts are obtained with two round diamond burs (Fig 13), providing a 0.3- to 0.5-mm deep groove in the cervical third, a 0.5- to 0.7-mm deep groove in the middle third, and at least 1.5 mm for incisal coverage (Fig 14).[9,26] Once every remainder of the mock-up has been removed, tooth reduction is verified with the silicone indices obtained from the final wax-up (Fig 15a to e). The buccal index is horizontally sectioned as a book at the incisal, middle, and cervical thirds. The palatal index is used to assess the 1.5-mm incisal clearance.[6] The prepared incisal margin should preferably show a butt-joint configuration or a palatal mini chamfer.[27] The margin should never be placed inside the palatal concavity because that is where the highest functional stress exists.[28] In the cervical and interproximal areas, a slight chamfer (0.3 to 0.5 mm) is acceptable. Every angle should be rounded, and the preparation should be adequately finished and polished (Figs 16 to 18). Care should be taken to keep the tooth reduction inside the thickness of the enamel. The critical

Fig 17 Mandibular teeth: step-by-step tooth preparation driven by the mock-up.

dentinoenamel junction (DEJ) should also be preserved.[24] The DEJ could be regarded as a fibril-reinforced bond with a very high fracture toughness.[29]

In case of dentinal exposure, whether accidental or unavoidable, the dentin itself should be immediately sealed with a dental adhesive system before taking the impression. Immediate dentin sealing (IDS) improves the bond strength of indirect restorations.[30-34]

To prevent crack onset inside the veneers, the ceramic veneer thickness should be at least three times that of the luting composite material (ceramic/composite ratio of thickness > 3) at the facial location.[35-37] It is also important to obtain a good internal fit of the restoration (approximately 100 µm).

Impression and provisionals

An impression should be taken with the double retraction cord technique.[6] A first compressive cord (Ultrapak No. 000, Ultradent) is positioned in the sulcus before finishing the preparations, and left *in situ* during the impression. A second continuous deflective cord (GingiBRAID 0n, Dux Dental/Kerr, Pentron) is impregnated with aluminum chloride and positioned in the sulcus for a few minutes, then removed in a single step before applying the light body impression material. The impression material should be either polyether or polyvinylsiloxane, used with a simultaneous dual-viscosity (medium and light body) technique. Optical impressions may also be used in association with a thoroughly or partially digital workflow.

Fig 18 Final veneer preparation in the mandibular arch after polishing.

The provisional restoration should be made using a direct technique. The silicone index, obtained from the wax-up, should be used to mold a self-curing composite material in the same morphology obtained with the previsualization mock-up.[10,38,39] The direct provisional restoration, after intraoral finishing and polishing, will be macromechanically retained on the prepared teeth until the luting session.

Laboratory procedure: manufacture of ceramic laminate veneers

Master models should be obtained with three different casts from the same final impression. The dental technician performs multiple sets of individual dies (original, stone replica, refractory replica), a non-separable model, and a soft tissue (alveolar) model. The multidie technique allows for the construction of laminate veneers on removable refractory dies in a stone master cast.[6,40]

A final wax-up is performed, recreating the shape validated with the final mock-up. At this point, the material to be used for the final restorations is cho-

Table 3 Mechanical properties of the natural tooth compared with composite and ceramic materials. Ceramic has a stiffness similar to enamel, so it is the best material (more biomimetic) with which to restore the enamel itself

	Elastic modulus (GPa)	Knoop hardness (kg/mm²)	Linear TCE 20°–50° (x10⁻⁶/C°)	Termal conductivity (cal/sec/cm² (C°/cm))	Strength (MPa)	
					Tensile	Compressive
Dentin	13.2–18.6	68	10–15	0.0015	98	297
Composite	4.5–20.1	22–80	25–68	0.0025	34–62	200–345
Enamel	83.0	343	10–15	0.0022	10	400
Ceramic	64–400 (70–96 feldspathic, lithium disilicate)	460	8–13.5	0.0025	40	150

sen. To obtain biomimetic restorations that emulate the biomechanical and optical properties of the natural tooth (Table 3), ceramics should be the material of choice (feldspathic ceramic baked on refractory, layered computer-aided design/computer-aided manufacture [CAD/CAM] or pressed lithium disilicate).

In the maxillary arch, veneers were made in feldspathic ceramic, layered and baked on refractory (Fig 19). This type of solution provides the highest esthetic result, yet it does not allow any change once removed from the refractory. For this reason, the diagnostic path is of critical importance for the treatment strategy, as it allows a precise definition of the shape and volume of the restorations before their manufacture.

In the mandibular arch, restorations were made in layered pressed lithium disilicate (IPS e.max Press, Ivoclar Vivadent), since their manufacture is sim-

Fig 19 Feldspathic ceramic laminate veneers baked on refractory (maxillary teeth).

Fig 20 Pressed and layered lithium disilicate veneers (mandibular teeth).

Fig 21 Adhesive luting procedure of the ceramic veneers on the dental substrate.

pler for the dental technician, and modifications are possible after the baking (Fig 20).

Try-in and adhesive cementation

In order to evaluate the marginal adaptation, contact points, shape, color, and final esthetic integration, the veneers should be tried in with dedicated try-in pastes (with similar color shades as for the respective composite cements), or with glycerine gel.

The adhesive cementation takes place in the following session. The operative field is isolated by means of rubber dam from premolar to premolar. A supplementary rubber dam clamp (Ivory or Hu-Friedy No. 212) is used to retract the dam on each tooth. Veneers are tried in again and then luted one by one, starting from the central incisors and ending with the canines. Extreme care should be taken with the adhesive luting procedure (Fig 21)[6,41]:

1. Ceramic surface conditioning: 9% hydrofluoric acid (HF) application for 60 to 90 s for feldspathic porcelain, or 5.5% HF for 20 s for lithium disilicate; ultrasonic cleaning in an alcohol bath for 5 min; silane application (coupling agent between the silica particles of ceramic and those of the composite cement), heated in the oven at 100°C for 1 min; bonding application (just before placing the veneer in position); air blowing of excess; no light curing.
2. Dental substrate conditioning: accurate cleaning with soft brushes and a mix of pumice and 2% chlorhexidine solution; airflow with glycine powder; protection of adjacent teeth with U-shaped steel matrix bands, held in place by two wooden wedges; acid etching of enamel with 35% orthophosphoric acid for 30 s; application of bonding, accurately removing the excess with air blow and suction.

Fig 22 Frontal view of the final result after cementation of the maxillary laminate veneers.

Fig 23 Frontal view of the final result after cementation of the mandibular laminate veneers.

A microhybrid light-curing restorative material, adequately heated in an oven, is used as the luting material. As an alternative, dedicated light-curing resin cements may be used. The restoration is then seated gently by pushing with the finger, and the excess material removed accordingly. In the case of butt-joint incisal margin preparation, a frontal insertion path may be used. In the case of mini-chamfer preparation, the insertion path will be coronoapical.

A delicate margin finishing and polishing should be performed. Slight excess is removed with a box carver, or a No. 12 scalpel blade; then, if necessary, low-grit diamond burs and flexible blades (40 and 15 µm) are used on a reciprocating handpiece. Finally, composite polishers, cups, and synthetic brushes with diamond paste are used.

Once the rubber dam is removed, occlusal relation should be checked in maximum intercuspation, then in laterality and during protrusive movements.

Fig 24 **(a)** Initial frontal view, before treatment. **(b)** Frontal view of the final result, at 2-month recall. Optimal morphologic, functional, and esthetic integration can be observed, as well as excellent periodontal response.

Fig 25 Rest position with ideal exposure of the central incisors.

Fig 26 Full smile with a harmonious smile line.

Conclusions

The final photographs show optimal morphologic, functional, and esthetic integration, with excellent periodontal response (Figs 22 and 23). The functional and esthetic improvement can be appreciated by comparing the before and after treatment photographs (Fig 24a and b). The smile line is harmonious, and the teeth provide ideal lip support (Figs 25 and 26). The patient was extremely satisfied with the result. Psychological improvements were also seen, as there was an increase in the patient's self-confidence (Fig 27).

The scheduling of each treatment phase – also thanks to new, useful virtual tools such as DSD (Fig 28) – represents an effective means for clinician–patient communication, and may provide reliable help for the whole dental team.

The diagnostic and therapeutic protocol described in the present clinical case showed how, by combining different fields of dentistry (hygienic and periodontal therapy, restorative, mucogingival surgery, orthodontic, and prosthetic therapies), an excellent final result

Fig 27 Frontal view of the face, showing an ideal relationship between the teeth and the face.

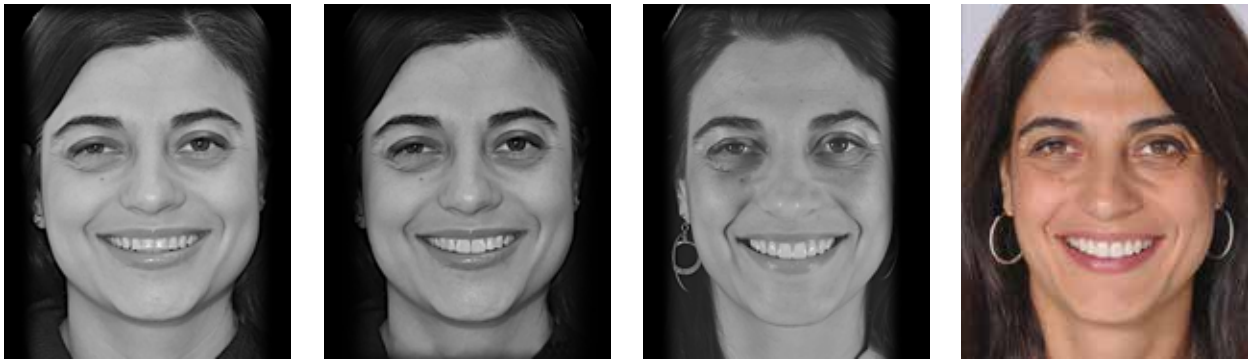


Fig 28 Full-face photographs at different treatment stages: preoperative **(a)**, digital preview **(b)**, clinical preview (mock-up) **(c)**, and final result **(d)**.

Fig 29 Lateral view of the smile, with an ideal dentolabial relationship.

can be achieved (Fig 29). Following this workflow that encompasses accuracy and precision at every step, the treatment with veneers resulted in a highly predictable and professionally gratifying restoration.

Acknowledgment

I am proud to thank all my esthetic team: Dr Fabio Federici Canova for the orthodontic treatment and for his invaluable assistance in the drafting of this article, and the dental technicians, F. Pozzi and A. Quintavalla (PR Italy), for their excellent work. Thanks also to Dr L. Madini (BS) for the English language assistance.

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