Esthetic Rehabilitation of Worn Anterior Teeth with Thin Porcelain Laminate Veneers

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Abstract

Bonded porcelain restorations are a predictable and durable treatment option with which not only esthetic appearance but also the strength and function of teeth can be re-established. One of the most important issues of today's dentistry is the preservation of sound enamel. Following biomimetic principles, employing minimally invasive applications and adhesive technologies are of paramount importance for successful restorations. The mock-up technique is advised for delicate removal of the required space for thin porcelain veneers minimally. Besides minimally invasive preparation, long-term success is determined by the adhesive quality of the laminate veneers. This case presentation demonstrates restoration of anterior dentition where the wear of incisal edges posed a negative effect on the smile of the patient. Before bonded porcelain veneers were adhesively cemented, incisal lengthening with direct resin composite and gingival contouring was performed. By using the mock-up technique, minimal preparations were made with the outline ending in enamel only. For cementation of these restorations, step-by-step adhesive procedures are presented.

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Introduction

The incidence of non-carious tooth wear has shown an increase particularly among the young population.[1] Also, the percentage of adults presenting tooth wear increases from 3% at the age of 20 to 17% at the age of 70 years.[1] The progressive nature of wear, especially when dentin is involved, requires instruction, monitoring, prevention, and restoration of the tooth material loss.

Several treatment options can be proposed to restore the loss of tooth structure of anterior teeth. Full crowns have been proposed for many years as the treatment option of first choice. However, this technique is considered today as an invasive approach. Since macro-retention is needed for such restorations, substantial removal of sound dental tissues are required. Due to the great progress in adhesion to dental tissues over the past few decades, more conservative restorative techniques can be employed. The preservation of dental hard tissues can be achieved with predictable results by using laminate veneers over full crown preparations.[2] When the color of the substrate (teeth) is clinically acceptable, thin porcelain laminate veneers (0.3–0.7 mm) can be used to correct shape, surface structure, texture, and the position of the teeth. However, it is not always possible to mask intensive discolorations with thin laminate veneers. One of the most important steps with these delicate restorations is the adhesive procedure to both the tooth substrate and existing restorations on the tooth as well as the cementation surface of the restorative material. The success of the bonded porcelain restoration is determined on the adhesive quality to these surfaces.

A number of clinical studies have concluded that bonded porcelain laminate veneer restorations delivered good results (over 90% survival) over a period of 10 years.[3-6] Among the failures, different kinds of fracture types were observed: cohesive fractures of the ceramic or adhesive failures between the tooth and the restoration surface. The majority of the failures were however observed in the form of fractures of the restoration.[3] Adhesive failures are rarely seen when enamel is the substrate.[3-6] In principle, bond strengths of luting cements to enamel are usually up to 40 MPa, sometimes even exceeding the cohesive strength of the enamel itself.[7] Other failures seen with laminate veneers are related to microleakage.[3-6] Marginal defects were often noticed when the laminate veneers ended in existing direct composite restorations.[5] However, with the new composite surface conditioning techniques examined with *in vitro* studies, the problem of failures involving adhesive cementation to aged resin composite restorations could be solved.[8-10] Unfortunately, the clinical studies often do not provide information on the conditioning of such underlying composite restorations.[3-6]

The present case report describes the treatment of wear in the anterior dentition with thin porcelain laminate veneers. Important steps of the treatment procedures included communication with the patient, gingival alignment, minimal preparations using the mock-up technique, and surface conditioning of different substrates during bonding of such thin laminates.

Fig 1 Natural smile of the patient before treatment.

Fig 2 Intraoral anterior view of teeth before treatment.

Fig 3 Incisal lengthening of teeth from 12 to 22 with direct composite restorations.

Fig 4 Natural smile of the patient with direct composite restorations.

Case presentation

A 32-year-old female patient was referred to the dental clinic. She complained of discomfort caused by her worn anterior teeth. According to the patient anamnesis and self-reported history, the reason for wear was identified as bruxism, due to the stress she had experienced in the past few years. Clinically, incisal wear was apparent from tooth 12 to 22, and dento-alveolar compensation was visible on teeth 11 and 21. Tooth wear was only diagnosed in the anterior region (Figs 1–3). After thorough diagnosis and planning, a comprehensive treatment plan that incorporated all the wishes of the patient was devised. The treatment procedure consisted of the following stages: *1)* lengthening of the incisors with direct resin composite, *2)* gingival alignment, *3)* waxup/mock-up and communication on form and position of the incisors and cusps, *4)* minimally invasive preparation of hard dental tissues using depth cutting burs, *5)* cementation of the bonded porcelain restorations, and *6)* follow-up controls.

Incisal lengthening with composite

Direct composite restorations can serve as a tool in evaluating the esthetic demands of the patient.[11,12] Lengthening the teeth where needed using direct resin composite is an objective tool for communication with the patient and the dental technician. The result is visualized and tried in the smile of the patient before an irreversible procedure is performed.[11,12] At this stage, when the patient approves the planned outcome, discussions during or after the treatment are reduced. The length and form of the teeth can be changed easily by the addition or removal of resin composite. By adding the composite on the incisal area, it became clear for the patient that gingival correction was needed to obtain the right tooth dimensions (Fig 4).

Gingival correction

Pink esthetics had to be created along with correction of the white esthetics.[13,14] Beautiful restorations surrounded by an inharmonious gingival display can have a negative impact on the appearance of the smile.[14] The least invasive technique to create an optimal gingival scallop would be orthodontic intrusion of teeth 11 and 21, which is therefore the first choice. However, the patient had undergone orthodontic treatment in her early childhood and she did not permit a second orthodontic treatment.

As an alternative to orthodontics, periodontal plastic surgery is recommended to optimize gingival contours before restorative treatment procedures take place and is among the first objectives during treatment planning.[14] Bone on the maxillary central incisors (teeth 11 and 21) revealed a relative low crest osseous-gingival tissue relationship facially (> 5 mm). In this case, gingivectomy was pursued for crown lengthening as the remaining root was supported by healthy periodontium. There was an adequate amount of attached gingiva available and the post surgery crown-root ratio was sufficient.[15] Atraumatic surgical principles were performed to obtain proper healing including: anesthesia, surface disinfection, minimal atraumatic tissue handling and short operating time. A high frequency electrosurgery device (PerFect TCS II, Coltène Whaledent, Langenau, Switzerland) was used to lengthen the two central incisors (Fig 5). The high voltage current accumulates at the tip of the device to create an arc that is discharged in the tissues.[16] A high power or slow movement through the tissues causes disintegration of the cellular components into oxygen, nitrogen, hydrogen and carbon.[16] This is usually observed clinically as a black line which needs to be avoided (Fig 6). A 6-month observation time was incorporated for healing of the gingival tissues.

Tooth preparation

For laminate veneers three types of preparations have been described, namely: window, overlapped, and feathered preparation. In the related litera-

Fig 5 Electrosurgery of on the gingiva of teeth 11 and 21.

Fig 6 Gingival status.

Fig 7 Waxup for mock-up technique.

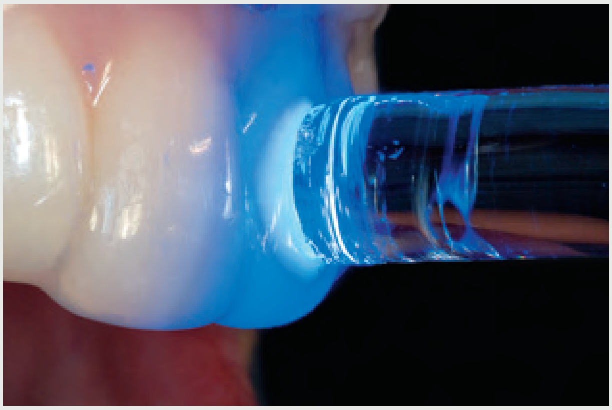

Fig 8 Photo-polymerization of the temporary composite mock-up.

Fig 9 Removal of the excess of composite material.

Fig 10 Intraoral anterior view of mock-up.

Fig 11 Mock-up view during smiling. Note the imbalance of tooth 23 in relation to the lip line.

Fig 12 Length of tooth 13 corrected.

Fig 13 Length of the anterior teeth follows the lower lip line.

ture no consensus is available on which preparation-restoration complex is more fracture resistant. Hui et al[17] concluded that the window preparation was the strongest and most conservative restoration. However, in a cyclic loading test between natural teeth and different laminate restorations with different preparations, no significant differences were found.[18] Moreover, in a clinical study, after 2.5 years no difference was seen between the overlap or window preparation.[19] The incisal overlap preparation was used in this case report, as the dental technician has maximum control of the esthetic characteristics and translucency. In this case, overlap preparation was carried out by removing the direct composite restorations only.

An additive diagnostic waxup (Fig 7) was used to minimize the reduction of sound tooth structure and to compensate for the severe loss of tooth substance. Using the diagnostic waxup transferred to a vacuum mold (Copyplast 2 mm, Scheu-dental, Iserlohn, Germany) (Fig 8) for the mock-up technique, a maximum control on reduction is created by only removing a thin layer of enamel or existing resin composite restoration that was necessary for the thickness of the porcelain laminate veneer (Figs 9–13). The mock-up was made of a flowable resin composite (Grandioflow, Voco, Cuxhaven, Germany) as the composite is easily adapted to the form of the mold.

A chamfer preparation of approximately 0.5 to 0.8 mm is usually advised for the outline of ceramic veneers.[3,20,21] However, a uniform preparation of the buccal surface was not preferred as enamel thickness was varying in the buccal region of the incisors.[21] It has been reported that laminates bonded on sound enamel have a good survival rate since the enamel adhesion is excellent.[7] Therefore, standard depth cutting burs are not advised for laminate veneer preparation,[7] particularly not in older patients where enamel thickness is decreased.[22] In this case, a minimally invasive restoration with a preparation depth of 0.1 to 0.3 mm in the cervical region and 0.3 to 0.7 mm in the buccal region was preferred (Figs 14 to 16). The aim was to confine the preparation to enamel wherever possible, especially at the finishing line (Figs 18 to 20).

Cementation procedures

The surface conditioning sequence of the inner surface of the porcelain laminate veneers and the tooth and/or restoration complex are summarized in Tables 2 and 3. After making the impression, all veneers were fabricated by one dental technician using dye cast feldspathic material (Nobelrondo, Nobel Biocare, Kloten, Switzerland) (Fig 21). The veneers in the cervical area were approximately 0.1 mm in thickness (Fig 22). After split rubber dam placement, all proximal contacts and the marginal adaptation of the porcelain laminate veneers were controlled. It is very difficult to place the thin veneers in the correct angulations and obtain proper contact points. The need for a perfect fit to the preparation is very important, otherwise the resin composite cement layer would be too thick. Therefore it was decided to place the veneers with a full view of the gingiva, in relation to the other teeth. Using a microscope, it was seen that the veneers were placed

Fig 14 Preparation of the depth grooves on the temporaries.

Fig 15 Preparation of the depth grooves in the cervical area using a smaller bur.

Fig 16 Anterior view after depth cutting.

Fig 17 Preparation with coarse diamond bur after removal of the temporaries.

Fig 18 Finishing cervical margins under microscope with ultrafine fine diamond bur.

Fig 19 Anterior view after preparations.

Fig 20 Marginal view of the prepared teeth.

Fig 21 Porcelain laminate veneers ready for cementation.

Fig 22 View of the thin porcelain laminate veneers.

Table 1 The brand names, type, manufacturers and compositions of the materials used in this case report.

Product name	Type	Manufacturer	Chemical composition
Miris2	Microhybrid resin composite	Coltène-Whaledent GmbH, Langenau, Germany	Aromatic and aliphatic dimethacrylate resin, Ba-Al-glass, pyrogenic SiO_2 composite, camphorquinone
NobelRondo	Feldspathic ceramic	Nobel Biocare, Kloten, Switzerland	
CoJet®-Sand		3M ESPE AG, Seefeld, Germany	Aluminium trioxide particles coated with silica, particle size: 30 µm
ESPE®-Sil	Silane coupling agent	3M ESPE AG, Seefeld, Germany	Ethyl alcohol, 3-methacryloxypropyltri-methoxysilane, ethanol
Monobond S	Silane coupling agent	Ivoclar Vivadent, Schaan, Liechtenstein	1% 3-methacryloyloxypropyl-trimethoxy-silane, 50–52% ethanol
Excite	Bonding agent	Ivoclar Vivadent, Schaan, Liechtenstein	Dimethacrylates, alcohol, phosphonic acid acrylate, HEMA, SiO_2, initiators and stabilizers
IPS Empress ceramic etching gel	Hydrofluoric acid	Ivoclar Vivadent, Schaan, Liechtenstein	5% hydrofluoric acid
Variolink Veneer	Resin composite cement	Ivoclar Vivadent, Schaan, Liechtenstein	Urethanedimethacrylate, inorganic fillers, ytterberiumtrifluoride, initiators, stabilizers, pigments

Table 2 Surface conditioning sequence of the inner surface of the porcelain laminate veneers.

1	Hydrofluoric acid etching (1 min)
2	Rinsing with copious water (1 min)
3	Neutralizing agent (5 min)
4	Ultrasonic cleaning in ethanol (5 min)
5	Silane coupling agent application + waiting for its evaporation (1 min)
6	Adhesive application (no photo-polymerization)
7	Cement application on the cementation surface of the laminate veneer

Table 3 Surface conditioning sequence for the tooth and/or restoration complex.

1	Rubber dam application
2	Application of the Mylar strips around the teeth to be conditioned
3	Air abrasion of existing resin composite restorations using silicium dioxide (CoJet Sand)
4	Phosphoric acid (38%) etching of enamel (30 s)
5	Rinsing with water (1 min)
6	Silane application on existing resin composite restorations + evaporation (5 min)
7	Adhesive application on both the tooth and resin composite (no photo polymerization)
8	Positioning the veneer
9	Photo-polymerization (5 s)
10	Removal of the excess resin cement with the probe
11	Application of glycerine gel
12	Photo-polymerization from each direction (each 40 s)
13	Removal of excess resin cement with scaler or scalpel

Fig 23 Porcelain laminate veneers to be treated with hydrofluoric acid and silane.

Fig 24 Hydrofluoric acid etching of the laminate.

with good control of contamination. A shade match with the color of the selected cement was established through the try-in pastes. With no discoloration of the underlying teeth, translucent cement offered the best result.

Surface conditioning of ceramic

After cleaning the try-in cement paste, ceramic laminates were conditioned using a 5% hydrofluoric acid (IPS Ceramic etching gel, Ivoclar Vivadent, Schaan, Liechtenstein) (Figs 23–24). It is known that hydrofluoric acid selectively dissolves the glass or crystalline components of the ceramic and produces a porous irregular surface.[23-25] The microporosities in the ceramic increases the surface area and leads to micromechanical interlocking of the resin composite. The number and size of the leucite crystals at the surface influences the formation of microporosities as a result of acid etching. Leucite dissolves better than the surrounding glass components in hydrofluoric acid. This porous surface increases the surface area and the penetration of resin into the micro-retentions of the etched surfaces, thereby promoting the adhesive bonding.[26]

After etching the laminates with hydrofluoric etching gel, a neutralizing agent (IPS Ceramic Neutralizing powder, Ivoclar Vivadent) was used to neutralize the acidic inner surface of the laminate veneers. After etching with hydrofluoric acid, a significant amount of crystalline debris precipitates on the ceramic surface.[27] The debris contaminates the cementation surface, as the access to the undercuts is then diminished. In a microtensile bond strength test, it was found that ultrasonic cleaning was necessary to remove the debris from the etched surface.[27] Therefore, the ceramics were subsequently ultrasonically cleaned.

Hydrofluoric acid etching was followed by silanization. Using hydrofluoric acid etching with silane, high bond strengths could be created even exceeding the cohesive strength of ceramic and the bond strength of resin composite to enamel.[28]

Fig 25 Silica coating of the direct composite restorations using an intraoral air-abrasion device.

Fig 26 A transparent strip placed around the tooth before cementation.

Fig 27 Phosphoric acid etched surface of tooth 12.

Fig 28 Application of the bonding agent on tooth 12.

Fig 29 Excess removal of composite after 5 s of photo-polymerization.

The process of silanization after hydrofluoric acid etching diminishes the surface tension of the ceramic. Silane is a coupling agent that couples the inorganic particles present in the glass ceramics to the organic matrix of the resin cements. The silanol molecules that are formed after reaction with water react on the silica surfaces, forming covalent bonds.[29,30] The organofunctional group polymerizes with the monomer of the resin composites with the carbon double bonds of the silanol. Reported results were also stable after long term water storage and thermocycling.[25,29] After silanization, 1 min was allowed for evaporation of the ethanol/alcohol and condensation reaction of the coupling molecules.

Surface conditioning of the teeth/ restoration

The composite surfaces were first silica-coated using CoJet Sand (Fig 25). When existing direct composite restorations are present in the anterior teeth, enhancement by new restorations or overlapping them with the indirect restorations has the disadvantage of removing sound tissue as well as pulpal trauma. With the introduction of silica coating and silanization for conditioning dental biomaterials, it is possible to receive an acceptable and stable bond to composite.[30,31] In a study by Özcan and Vallittu, even aged composite specimens treated with the silica coating and silanization system showed significantly higher bond strength values (46–52 MPa) than specimens treated with phosphoric acid and adhesive only (16–25 MPa).[32] The bond strength of indirect restorations to aged resin composites is, besides surface treatment, dependent on the unconverted C=C double bonds. These unconverted double bonds can contribute to the adhesion of the luting cement to the existing composite restorations. Recent studies demonstrated that conditioning the composites with silica coating, followed by silanization, increased the bond strengths of resin-based materials to indirect composites when compared to acid etching and silanization, or using airborne particle abrasion with alumina followed by silanization.[8,9,30]

After preparation, surface treatment of the teeth was achieved with 30 s etching of the enamel (38% phosphoric acid, Ultradent, USA), and rinsing followed by adhesive application (Excite, Ivoclar Vivadent, Liechtenstein). The adhesive was not polymerized separately but together with the cementation material (Figs 26–28). It is not uncommon that, particularly in the gingival third of a veneer preparation, dentin will be exposed due to the thin initial layer of enamel present at this site.[4] Higher failure rates were seen when dentin was exposed as the cementation procedure becomes more critical and more difficult to achieve than the resin-enamel bonding.[4,34] Therefore, exposed dentin can be protected by means of a dentin bonding agent immediately after preparation.[35,36] The so-called immediate dentin sealing revealed better results *in vitro* than the delayed method.[36] This relatively new technique may prevent bacterial leakage and dentin sensitivity during the temporary phase. However, with the application of thin laminate veneers, involvement of the dentin was diminished. In deeper preparations, this approach could be followed.

Fig 30 Intraoral view of thin porcelain laminate veneers at baseline.

Fig 31 Intraoral view of thin porcelain laminate veneers after 1.5 years of clinical service.

Cementation of the laminate veneers

With thin veneers, thickness of the luting cement can have a relevant influence on the stress distribution in the porcelain veneers. In a finite element analysis, Magne et al[37] concluded that laminate veneers that were too thin with a poor internal fit, resulted in higher stresses at both the interface of the restoration and the surface. This could lead to post-bonding cracks in thin laminate veneers. Therefore, it was advised that the ceramic had to be more than three times the thickness of resin composite cement. On the other hand, after cyclic loading, flaws seemed to occur when a thin laminate (<600 µm) was cemented with an increased thickness of luting composite (>200 µm).[38] When porcelain is prepared very thinly to minimize the preparation of sound tooth structure, a good internal fit has to be created.

Using a resin composite cement, total control on the seating of the restoration was created. During cementation, a quick photo-polymerization of 5 s,

Fig 32 Gingival tissue integration around the thin porcelain laminate veneers.

Fig 33 Lateral view of the laminate veneers during smiling.

Fig 34 Natural smile of the patient 1.5 years after treatment.

prior to total polymerization, helps the clinician to stabilize the restoration and remove the excess luting cement without damaging the restoration surface and the soft tissues (Fig 29). After excess removal, glycerin gel was applied at the margins to prevent formation of an oxygen inhibition layer and thereby total photo-polymerization was performed. Excess of resin composite was removed using scalers, and margins were polished using ceramic polishers. After the end of the treatment, as a preventive measure, a splint was planned. However, upon objection of the patient, this was not pursued.

At baseline and 1.5 years of follow-up, patient satisfaction was noted as very high. A harmonious view was achieved in both frontal and lateral aspects (Figs 30–33). The patient is being monitored for a longer duration.

Conclusions

This case report describes a minimally invasive treatment approach for obtaining both esthetic and reliable function in the treatment of incisal wear. The diagnostic mock-up and the adhesive procedures were important for the outcome achieved. Based on the available information from clinical and *in vitro* studies, a cementation protocol is proposed especially when composite restorations exist next to the enamel.

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