Anterior full ceramic crown after a complicated crown fracture of the natural tooth

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Abstract
In the maxillary anterior region, the integrity of the teeth is of great importance to many people. For heavily damaged anterior teeth, all-ceramic crowns are a reliable and proven therapy option for restoring function and aesthetics.

Introduction

The integrity of their anterior teeth is of paramount importance for most patients due to their prominent position. The impairment of teeth in the anterior aesthetic zone by carious defects, chipping or fractures, clearly visible fillings, discolorations, anomalies in shape, alignment and position within the dental arch often results in considerable restrictions for the patients. Therefore, dentists should take into account all aspects of treatment, including a team of different specialists, in order to preserve or restore the natural dentition.

Today, the range of therapies of modern dentistry offers a variety of methods to restore or optimize the function and aesthetics of teeth in the anterior region. These include - depending on the initial situation and depending on the degree of destruction of the individual teeth - polychromatic multilayer direct composite restorations, laboratory-made or industrially manufactured composite veneers, ceramic veneers, partial veneers (additional veneers), veneer crowns, full crowns (metal ceramics, all-ceramics) and orthodontic measures.[1-3]

A majority of today's patients asks for aesthetic restorations and metal-free alternatives to traditional prosthodontic approaches. All-ceramic restorations have gained in popularity during the last 30 years for a number of reasons, especially their favorable optical properties, excellent and durable aesthetic appearance, wear resistance, color stability, chemical inertness and durability, biocompatibility, and strengthening of the remaining tooth structure when they are adhesively bonded.[4-17] This trend has been supported in large part by the increasing number of patients requesting esthetic restorations and metal-free alternatives to traditional prosthodontic approaches.[18]

In the last three decades, many different all-ceramic systems have been introduced to the dental profession.[19] Dental ceramics can be classified according to their material composition, fabrication workflow (e.g. powder-liquid-slurry, slip-casting, pressable ceramics, CAD/CAM millable), or clinical indications.[20-22] Nowadays, the most common clinical indications for all-ceramic restorations consist of inlays, onlays, partial crowns, full crowns, bridges, veneers, posterior occlusal veneers (table tops / posterior cuspal protection restorations), implant abutments and implants[23-36]. These restorations present a scientifically proved, high-quality permanent treatment option for the esthetically challenging anterior and load-bearing posterior regions when the indications and limitations of the respective ceramic systems are respected and an appropriate luting procedure is employed; their reliability has been documented in literature.[18, 32, 37-56] All-ceramic restorations are used meanwhile on a routine basis in everyday dentistry.

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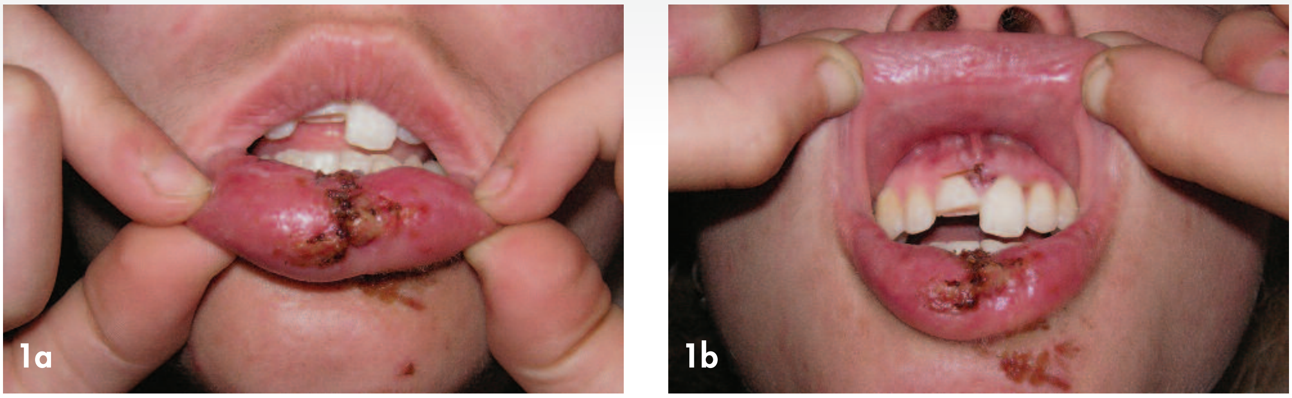

Figure 1a & 1b: Initial situation: 24-year old female patient after trauma. In addition to the fractured tooth 11, there is extensive injury to the lower lip. The first treatment of the soft tissue injury occurred at the venue of the accident abroad.

Figure 2a: One week later, the patient appeared in our dental office. Tooth 11 had a complicated crown fracture with exposure of the pulp.

Figure 2b: The incisal half of the clinical crown of tooth 11 had fractured horizontally.

For single-unit restorations, lithium-disilicate (LS_2) glass ceramic is the material of choice for many dental practitioners because of its good mechanical strength (IPS e.max Press: 470 MPa mean biaxial flexural strength), excellent aesthetic properties and its versatility. It can be used in monolithic form, when maximum strength is required (e.g. table-top restorations for increasing the vertical dimension of occlusion or posterior crowns), or in a layered form (pressed LS_2 coping with additional veneering porcelain) when aesthetics is of utmost importance. Single-unit LS_2-crowns demonstrate an excellent longevity for anterior[57-59] and posterior teeth,[56-59] comparable to the survival rate of metal-ceramic crowns.[60,61]

This clinical report illustrates the restoration of a maxillary central incisor affected by a complicated crown fracture with a veneered lithium-disilicate glass ceramic crown after endodontic therapy.

Clinical case report

Initial situation

A 24-year old female patient presented in our dental clinic with a trauma-related fractured right maxillary central incisor. The accident had already occurred one week earlier abroad, where the patient (medical student) was in the context of a clinical traineeship. Since the collapse occurred in a developing country with medical and dental treatment localities not corresponding to modern standards, the patient decided - after the initial treatment of soft tissue injuries on the spot by a fellow student (Fig. 1 a and b) - to cancel the stay abroad for the dental therapy, because she preferred a treatment in the familiar environment according to modern standards.

During the examination in our clinic one week after the incident, the patient presented a still untreated trauma-injured tooth 11 (Fig. 2 a and b). The clinical inspection showed a

Figure 3: Exposure of the pulp was diagnosed at the mesial aspect of the fracture site.

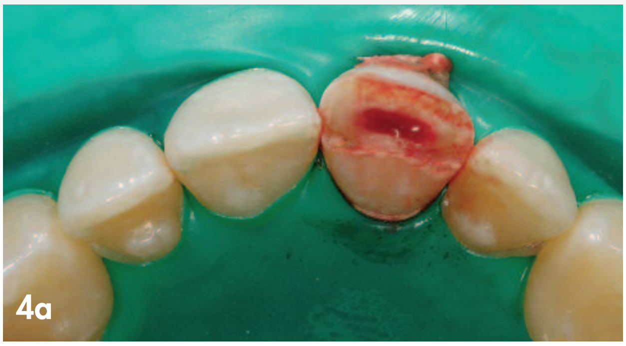

Figure 4a: Root canal treatment was initiated, since the pulp had already been exposed to the oral cavity environment for one week.

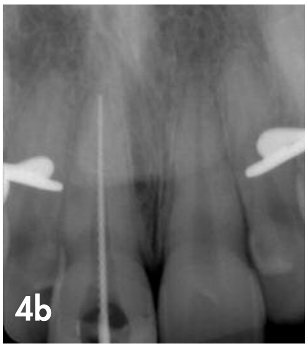

Figure 4b: Periapical radiograph to determine the working length.

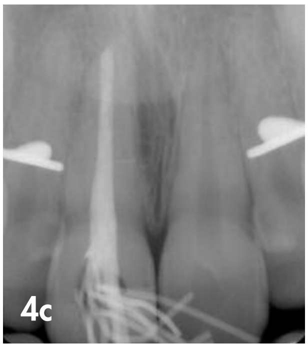

Figure 4c: Control radiograph of the root canal filling in lateral condensation technique.

Figure 5a: Long-term provisional build-up of the tooth with a direct composite restoration.

Figure 5b: The composite restoration remained until completed soft tissue healing.

Figure 6: After 3 months, the soft tissue situation presented in perfect condition.

complicated crown fracture with exposure of the pulp (Fig. 3), the incisal half of the clinical crown had been completely lost[62, 63]. Patient assessment revealed a sharp painful response to cold thermal stimulus using refrigerant spray and a pathologic response to percussion of the respective tooth.[64] The pulp had already been exposed to the oral cavity environment for one week, the tooth showed unprovoked pain symptoms and root growth was complete; thus, we decided together with the informed patient, to completely remove the infected pulp with subsequent root canal treatment (Fig. 4 a to c).

The patient was informed about various therapeutic approaches (direct composite restoration, ceramic veneer, full ceramic crown, PFM crown) including their respective advantages and disadvantages and associated costs. The patient decided in favor of an adhesively luted glass ceramic

Figure 7a-d: Aesthetic analysis by the dental technician. The distribution of the different shades and translucent or opaque tooth areas in the area to be restored are determined.

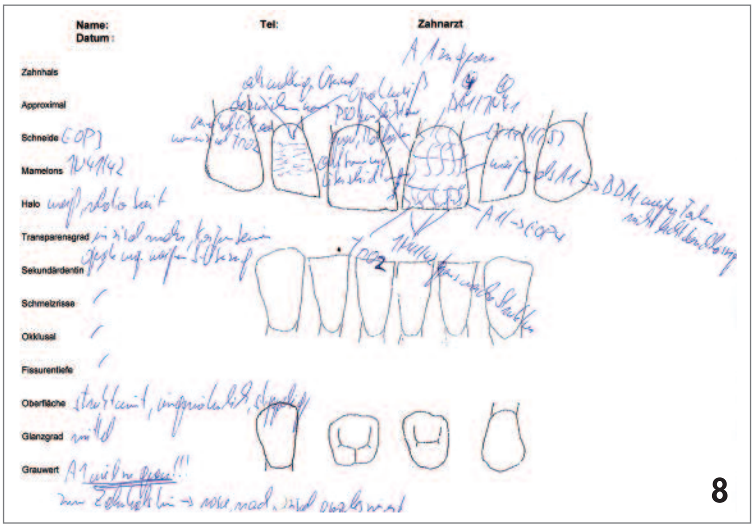

Figure 8: Ceramic layering concept as result of dental aesthetic analysis.

crown made of veneered lithium disilicate ceramics. This restoration type can be recommended as evidence-based treatment in the anterior region.[65] In the literature, survival rates of between 93.8% and 96.8% are reported at 5, 8 or 10 year observation periods.[57-59]

After completion of the root canal treatment, a long-term provisional build-up of the tooth was carried out with an adhesive direct composite restoration (Fig. 5 a and b) in order to spare the patient a preparation and impressions until the soft tissue situation had completely healed. After a waiting period of 3 months, a new clinical examination was carried out, in which the tooth 11 and its adjacent teeth, including the antagonists in the lower jaw, were inconspicuous (Fig. 6). The patient was asked to present herself the next day for shade determination and in general for dental aesthetic analysis in the dental laboratory.[66] A

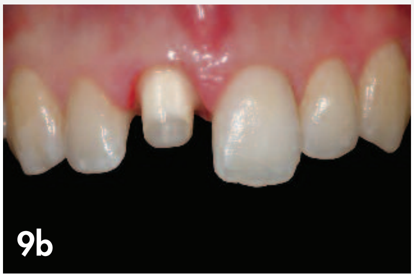

Figure 9a and 9b: Tooth 11 was prepared for a full ceramic crown with a circumferential shoulder with rounded inner edges.

Figure 9c: Incisal view of the final preparation with a circumferential shoulder of 1 mm depth.

Figure 10: Tooth substance removal was controlled in dynamic occlusion to ensure sufficient thickness of the glass ceramic framework.

Figure 11a and 11b: Placing a retraction cord to displace the marginal gingiva and expose the finish line before taking an impression.

basic requirement for accurate color determination is that the teeth are not dehydrated, otherwise they appear lighter and more opaque.[67-69] As part of the aesthetic analysis by the dental technician, the distribution of the different shades of color and translucent or opaque tooth areas in the area to be restored is determined (Fig. 7a to d). The age-appropriate design of the restoration with corresponding individual characteristics (e.g. enamel cracks, white spots, mamelons, halo effect), the appropriate surface texture and the correct gloss level are also analyzed. In principle, in the dental aesthetic analysis by the ceramist technician already a “virtual layering” of the restoration is done, with determination of the necessary ceramic masses. The result of this “virtual layering” is recorded in the ceramic buildup scheme (Fig. 8). This procedure is done on site in the dental laboratory under ideal lighting conditions - which are often not found in dental practices - by the ceramist technician, who will ultimately also fabricate the restorations. If the color analysis is performed directly by the dental technician and not by the dentist or other practice staff, there is usually no misunderstanding and the responsibilities for this important aspect in the treatment process are clearly assigned. Such a procedure eliminates the risk of communication breakdowns and prevents valuable time from being spent at the dentist's chair on this sometimes longer-lasting and, from the dentist's point of view, unproductive step. Only the direct contact with the patient enables the dental technician to produce an aesthetically perfect matching ceramic crown. The independent aesthetic analysis of the intraoral situation by the ceramist is thus a basic requirement for success.

Tooth preparation

In the next appointment, the tooth 11 was prepared for receiving a full ceramic crown with a circumferential shoulder with rounded inner edges (Fig. 9 a to c).

The strength of all-ceramic restorations is determined by the type of ceramic used with the resulting inherent mechanical stability of the respective ceramic material. Furthermore, the fracture strength is determined by the geometry of the restoration and thus by the shape of the cavity or crown preparation. The basic principle of preparation design for all-ceramic restorations avoids tensile stresses in the material as much as possible and loads the restoration primarily in compression mode by an adequate preparation geometry.[70, 71] Fracture strength of the restorations is determined by size, volume, shape and

Figure 12a: Chairside fabrication of a direct provisional restoration.

Figure 12b: The provisional was seated using an eugenol-free temporary cement.

Figure 13a: Pressed crown framework made of lithium disilicate-reinforced high-strength glass ceramic.

Figure 13b: First bake of the veneering porcelain.

Figure 13c: Second bake of the veneering porcelain.

Figure 13d: Finalized full ceramic crown made of a pressed lithium-disilicate coping and individually layered veneering porcelain.

surface characteristics of the ceramic material and additionally by structural inhomogeneities introduced during the manufacturing process.[72]

The dentist must be aware of the fact that the shape and finish of the tooth preparation have a major impact on the clinical success and longevity of all-ceramic restorations.[73-75] The preparation should exhibit a retention form and resistance form optimal for a ceramic crown:[73, 76, 77]

- height of prepared tooth (abutment height) minimum 4 mm
- occlusal convergence angle between 6 and 10 degrees
- finish line: circumferential shoulder with rounded inner edges or obvious deep chamfer with 1 mm width
- incisal / occlusal reduction of 1.5-2.0 mm (adhesively luted full contour lithium-disilicate crown: minimum 1.0 mm)
- axial reduction depth (sufficient circular crown thickness) of 1.2-1.5 mm
- in the anterior region: a rounded incisal edge
- rounded internal line angles and point angles
- smooth surface texture

Tooth substance removal was controlled in all dimensions. Attention was paid to the possibility of a sufficient palatinal layer thickness of the crown framework to be produced, even in positions which the tooth occupies - in addition to the static occlusion - in dynamic occlusion (Fig. 10).

After tooth preparation

During the fabrication of highly esthetic restorations, the influence of the shade of the prepared tooth on the final result is a decisive aspect. The shade of the prepared tooth substance was documented by the dentist with a digital photo referencing to a special shade guide (IPS Natural Die Material shade guide, Vivadent, Schaan, Liechtenstein). The image file was then made available electronically to the dental laboratory. This enables the technician – who otherwise has no information about the color of the tooth stump - to fabricate a model die similar in color to the preparation of the patient, on the basis of which the correct shade, translucency and brightness values of the all-ceramic restoration may be selected.

In order to achieve a good impression, the marginal gingiva was displaced with a retraction cord (Fig. 11 a and b). After taking impressions of the prepared tooth and the antagonistic dentition, an occlusion protocol with Shimstock foil was made, intermaxillary registration was carried out fabricating an interocclusal record in maximal intercuspal position and a facebow record was performed.[78]

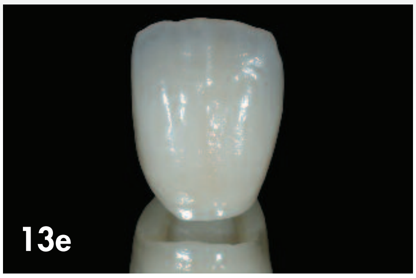

Figure 13e: The ceramic crown exhibits a natural-looking, life-like surface texture.

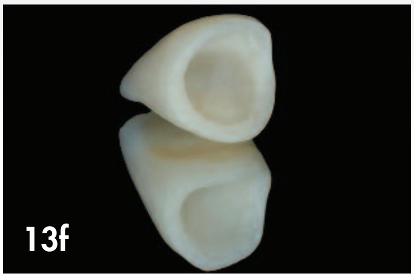

Figure 13f: The circular 1-mm shoulder is clearly detectable.

Figure 13g: Palatal surface of the ceramic crown.

Figure 14: Situation after removal of the provisional restoration. The marginal gingiva presents in perfect condition.

Figure 15: Placing a retraction cord to expose the finish line prior to the adhesive luting procedure.

Figure 16: Etching the inner surface of the lithium-disilicate glass ceramic crown with hydrofluoric acid for 20 s.

A diagnostic template made from a gypsum duplicate of the analytical wax-up using a transparent polyethylene matrix allows the chairside fabrication of a direct provisional restoration with correct dimensions and alignment (Fig. 12 a). The provisional was seated using an eugenol-free temporary cement (Fig. 12 b).

Laboratory work

In the dental laboratory, the ceramic crown for tooth 11 was produced. For this purpose, a crown framework made of lithium disilicate-reinforced high-strength glass ceramic was pressed corresponding to the anatomically correct shape of the respective tooth (Fig. 13 a). This coping was subsequently finalized by individual veneering with layered porcelain (press-layer-technique) (Fig. 13 b to g).

Try-in and adhesive luting procedure

One week after impressioning, the final appointment was scheduled. After removal of the provisional restoration and cleaning of the tooth with a rotating brush and fluoride-free prophylaxis paste, the gingiva presented in healthy condition (Fig. 14). Using colored, glycerin-based, try-in pastes, the aesthetics of the ceramic crown was checked intraorally with reference to hydrated adjacent teeth and the correct shade of the luting resin was determined.[79-81] Subsequently, the precise fit of the crown on the prepared tooth and quality of proximal contacts were checked before minor functional interferences during protrusive and laterotrusive movement paths were eliminated.

The method of cementation of the crown to the prepared tooth was by adhesive luting, as opposed to conventional cementation. This gives a positive effect on the overall strength of the restoration, in particular for glass ceramic materials, which are more prone to bulk fracture and chipping effects than zirconia. Ceramic materials with fracture strength less than 350 MPa are not indicated for conventional cementation.[36] Among those are feldspathic porcelains and leucite-reinforced glass ceramics that mandatory have to be placed adhesively using bonding agents and luting resins. Due to the adhesive bond between the ceramic restoration and enamel or dentin, a considerable increase in strength can be obtained because the inner surface of the ceramic restoration no longer acts as a mechanical boundary line at which fracture causing cracks can initiate due to tensile stresses.[82]

Prior to the luting procedure, the marginal gingiva was displaced to expose the complete shoulder using a retraction cord (Fig. 15). Afterwards, the inner surfaces of the lithium-

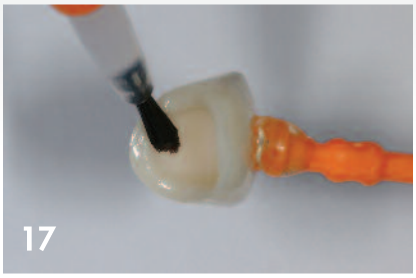

Figure 17: The intaglio surfaces of the glass ceramic crown are treated with a silane.

Figure 18: Etching the tooth surfaces with 37% phosphoric acid.

Figure 19a: Application of an Etch-and-Rinse-adhesive.

Figure 19b: Air-thinning the adhesive.

Figure 20a: The ceramic crown is positioned on the tooth with a dual-curing luting composite.

Figure 20b: The excess resin cement is carefully removed using a foam pellet.

Figure 20c: Placing a glycerin gel on the luting gap to avoid the formation of an oxygen-inhibited superficial composite layer.

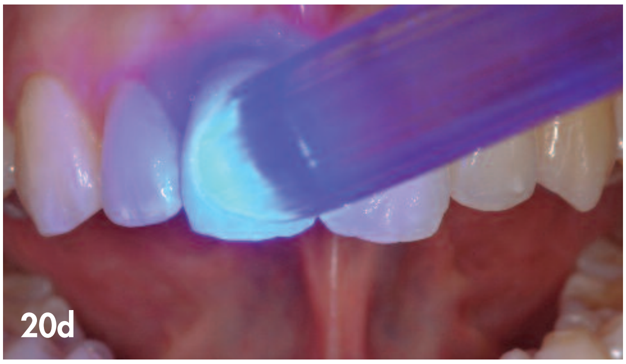

Figure 20d: Light polymerization of the dual-cure resin cement.

disilicate glass ceramic crown were etched with hydrofluoric acid for 20 s (Fig. 16). After thoroughly rinsing and drying the crown, the fitting surfaces were silanized (Fig. 17).[83-86] After adhesive pretreatment of the prepared tooth by conditioning enamel and dentin with 37% phosphoric acid (Fig. 18) and applying an Etch-and-Rinse-adhesive (Fig. 19 a and b), the ceramic crown was adhesively luted using a dual-curing resin cement (Fig. 20 a to d).

Two weeks after placement, the restoration exhibited an optimal functional and aesthetic integration into the neighboring teeth (Fig. 21 a and b). Background illumination demonstrates the excellent light transmittance capacity of the glass ceramic crown, which impresses by having virtually the same optical properties as the surrounding natural dentition (Fig. 22). Ultraviolet light activates the inherent fluorescence properties of the restoration, which are equal to natural tooth structure (Fig. 23). Silicate ceramics exhibit translucency effects and light-optical properties that are comparable to natural hard tooth substance, making them ideal for fabricating restorations that have to meet highest aesthetic demands. The light scattering of silicate ceramics also supports a natural vital appearance of the adjacent gingiva.

Figure 21a: The ceramic restoration exhibits a perfect functional and aesthetic integration into the neighboring teeth.

Figure 21b: The incisal view shows a copy of the natural central incisor.

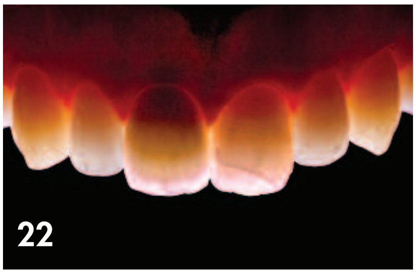

Figure 22: Excellent light transmittance capacity of the ceramic crown, indistinguishable from the neighboring dentition.

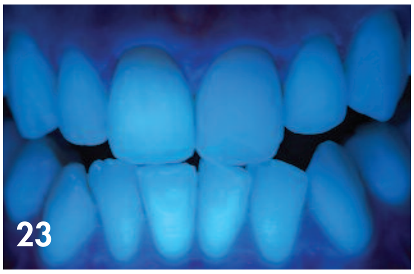

Figure 23: Ultraviolet light activates the inherent fluorescence properties of the glass ceramic restoration, which equals natural tooth structures.

Figure 24: The ceramic crown shows a perfect harmony with the architecture of the lips.

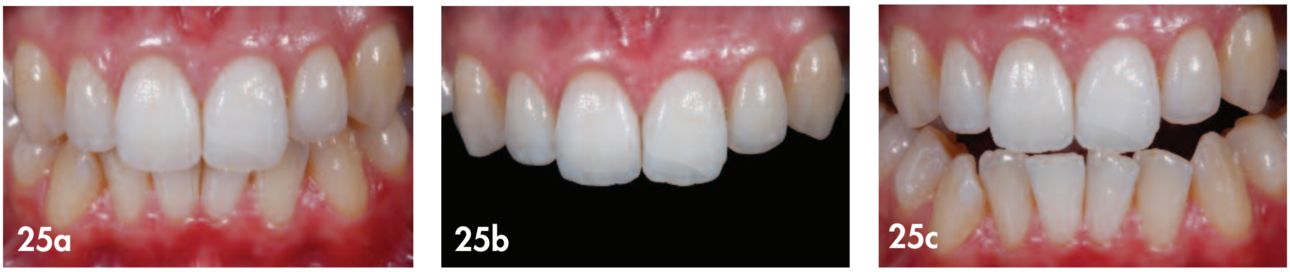

Figure 25a-c: Five years after incorporation, there is still an excellent integration of the crown into neighboring dentition.

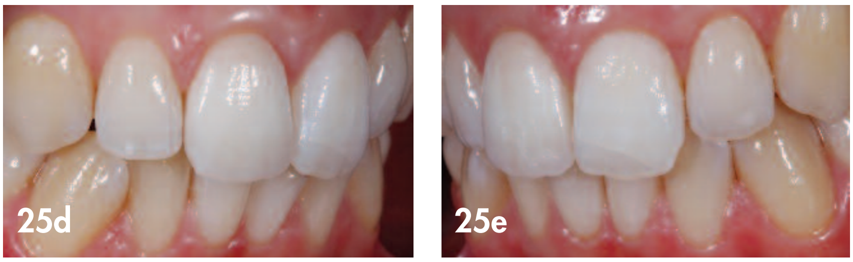

Figure 25d & 25e: In the right and left lateral views, the crown also presents inconspicuously.

Figure 26: The patient was fully satisfied with the result and presented a warm and big smile as a reward for the completed treatment.

The difference to this "pink aesthetics" becomes clear in comparison with metal-supported restorations, which block this light conduction towards the marginal soft tissue and often cause a grayish shading on the marginal gingiva.[87, 88] At the end of the successful treatment, the patient's smile was no longer compromised (Fig. 24).

Five years after adhesive cementation of the ceramic crown, there is still an excellent integration in the surrounding teeth, both in habitual intercuspation and in dynamics (Fig. 25 a to e). The crown still harmonizes in dialogue with the lips (Fig. 26).

Conclusion

All-ceramic restorations have achieved an excellent quality and are an indispensable therapeutic means for modern conservative and prosthetic dental treatment procedures[89]. Aesthetics and biocompatibility characterize these restorations. At the same time, this type of restorations achieve excellent patients' acceptance. Clinical trials exhibit an excellent longevity for all-ceramic restorations if a correct indication is selected and material- and patient-related limitations are observed.[90, 91]

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