Essayist III

Dr. Konrad Meyenberg

Adhesive restorative options:

Restorative space management in the anterior zone with or without orthodontic pretreatment - some clinical considerations and case presentations

Some general considerations

An unfavorable relationship between the form and dimension of the dental arch and the number, dimension and shape of the existing teeth (typical Bolton 3- or 6-discrepancy[1], malformed or undersized teeth, agenesis of teeth, tooth loss due to early trauma) can pose several aesthetic, biologic and functional problems. In many cases, an optimal result cannot be achieved with orthodontic, restorative or reconstructive means alone. Furthermore, patient desires, capacity of compliance and financial conditions are important factors to be included in the treatment concept[2-6].

For all options discussed below the clinical sustainability is well documented in the literature. They all show high survival rates and low complication rates in the hands of the experienced clinician.

From the multitude of longterm studies, systematic reviews and case documentations, it can be extrapolated that both ***resin bonded bridges***[7-18] and ***veneers***[19-25] behave similarly well and may reach ***10 years survival rates*** of 95% or more and reintervention rates over 10 years lower than 5%-10%, given proper indication and handling[10,11,22,26] .
The cost-effectiveness of resin-bonded bridges extrapolated over the lifetime of a patient is also very favorable compared to full-crown bridges and single tooth implants[18]. Since currently the standard extension of a resin-bonded bridge is 2-unit (1 wing) and not 3-unit (2 wings) anymore, the risk of secondary caries because of loose wings is no longer relevant[17].
The standard materials for resin-bonded bridges are either zirconia or lithium-disilicate-glass-ceramics[11,13-16].
Glass ceramic veneers seem to perform slightly better than feldspathic veneers, indicating that materials with increased strength show better clinical performance[25]. There are also attempts from the industry to use even

stronger materials like ***Zirconia*** to fabricate veneers as well. However, since there neither are long-term results nor sufficient clinical experience available it should be considered today as an experimental procedure.

Direct restorations with composites are today an indispensable attractive non-invasive way of reshaping teeth. The essential techniques for success are widely available and very well documented[26-30]. The multitude of parameters such as type of adhesive materials and procedures, handling properties, curing techniques, operator skills et cetera have an explicit important influence on the outcome. In line with this, a recent systematic literature review shows quite unhomogenous results. Some data however reach the same level as veneers[31]. In the light of easier modes of reintervention, and given a proper indication, direct composites cannot be regarded as principally inferior to veneers anymore.

The ***goals of modern treatment concepts*** must include high longterm success, minimal invasiveness and high potential for reintervention with minimal risk of complications as *medical-ethical foundation*[23]. This is the case with the aforementioned options.

This essay will concentrate on the available restorative and reconstructive adhesive options, but will not discuss the detailed implantologic or orthodontic options, which are presented in separate essays.

Restorative or reconstructive corrections without preceding orthodontic treatment?

If the goals of the patient cannot be achieved with orthodontics alone, the question remains whether they could be achieved with restorative and reconstructive measures alone as a significant simplification of the whole process. The premise for this however is that the occlusion is rated as stable on the long run.
As long as this is possible in a minimally invasive and reintervention-friendly way, restorative or reconstructive treatment alone is an attractive option for the patient to minimize the risks of arch instability, tooth position instability and relapse after orthodontic treatment, in addition to the unavoidable lifetime dentoalveolar and jaw basis changes.
From a periodontal and preventive standpoint, this is acceptable as long as the roots are in a favorable position, and the tooth crowns must not be prosthetically retruded but would be protruded and enlarged. A favorable root position means that the emergence at the gingival level is correct and in line

with the adjacent teeth. A clear no-go for prosthetic compensation alone is a situation with heavily crowded teeth.
Above all if teeth are conoid or slightly lingually inclined, the minimal-invasive adhesive options are inviting.

Orthodontic treatment alone to completely avoid restorative or reconstructive corrections?

It looks tempting at first glance to avoid any restorative or reconstructive corrections and close gaps irrespective of missing or undersized teeth. If the functional and aesthetic analysis of the existing teeth allows it, this is the preferable option.
There is no evidence that space closure compared to space opening in the case of missing upper lateral front teeth would lead to an increased rate of TMJ-problems, recessions, abfractions and abrasions[33-36].
However, this may in some cases lead to aesthetically less satisfactory results[6].
In the light of the aging dentition, it must also be taken into account that a simple orthodontic concept of just closing gaps without respect to proper dimensions and proportions of the respective teeth in regard to adequate arch and face dimensions can lead to practically unsolvable aesthetic problems later on, when patients want to improve the aesthetics of the aging dentition, but the size, position and playground for shape improvements is limited by a strongly limited space available due to initially to small teeth.

Restorative and reconstructive options

The 5 restorative and reconstructive options to treat a dentition with anterior gaps may be summarized as follows, as single measures or in combination, and with or without a preceding orthodontic treatment phase.

1. **Gap closure** and substitution of missing teeth: restorative transformation of substituted teeth into homologous teeth with odontoplasty, direct composite, etched pieces or porcelain veneers

2. **Gap opening** and tooth replacement with all-ceramic adhesive bridges, including pontic site development

3. **Gap distribution** and restorative compensation with direct composite restorations, etched pieces or porcelain veneers

4. **Gap shifting** and restorative compensation with all-ceramic adhesive bridges, composite, etched pieces or veneers

5. **Gap compensation** by reconstructive compensation without orthodontics

As ***reconstructive tools*** to be used for the aforementioned options, the following means must be considered:

A) Adhesive form corrections:
Composite restorations[31] or ceramic veneers[34] offer excellent longterm results. Whereas composites will preferably be used in the growing patient or to recontour parts of the clinical crown, veneers will be preferred if the clinical crown as a whole needs a change in shape and dimension, e.g. in a case of a substitution of a central by a lateral incisor, or a color shift is needed which cannot be achieved by external bleaching only (e.g. in a case of a substitution of a lateral incisor by a cuspid)[21].

B) Adhesive tooth replacement
If one tooth is missing, the concept of ***2-unit adhesive bridges*** is widely accepted as the most promising solution[11], if all-ceramic bridges may be used. Either zirconia[13-15] or glass-ceramic[16] frameworks perform well.
If a *3-unit resin bonded bridge* is planned to keep the position of the adjacent teeth or to improve the load capacity, a classical *metal framework with retentive micro-preparations*[7-10] should be considered, since all-ceramic frameworks for this indication do not show a promising longterm outcome[11].
Also if *more than one tooth needs to be replaced*, *metal frameworks* are still preferred. As framework materials, either non-precious or noble alloys can be used[7,9-11,17].

Case presentation and some technical considerations

10 illustrative cases are shown in short to illuminate the considerations and give some evidence from the literature concerning important technical details.

It is evident that as a clinician we need to find answers to the clinical challenges and the related questions, accepting that we will not find satisfying answers to all the questions when we plan a case.

The main consideration therefore is to use a progressive approach. This means the younger the patient the more important is the potential for reintervention, and subsequently the more important are minimally invasive concepts.

For the growing and young adult patient, direct techniques are therefore first choice, whereas for mature patients, degradation and fatigue of tooth substance may be better compensated by slightly more invasive indirect techniques such as full veneers or even bonded partial all-ceramic crowns, when in addition bleaching is not anymore effective to compensate darkened tooth colors.

1. **Gap closure**

restorative transformation of substituted teeth into homologous teeth with direct composite or veneers

Case 1: Both upper cuspids were placed orthodontically at the position of the missing lateral incisors (agenesis). Since the cuspids were rather small and not differing much from the color of the central incisors after external bleaching, which is a good indication for this approach, only incisal shortening and a minimal shape correction with direct composite are necessary in such a case. The correct orthodontic positioning of the cuspid hereby is essential: adequate extrusion to achieve an ideal gingival architecture[6].

Case 2:
The cuspids at the position of the missing laterals were considerably darker than the other front teeth and not well responding to an external bleaching. Therefore, two thin veneers (feldspar porcelain) with minimal preparation were inserted to compensate both shape and color of the cuspids. The missing permanent lower central incisors were replaced with a 4-unit adhesive bridge (pfm-technique).

Case 3 The two upper centrals were lost due to an accident as a young girl. The gap was closed by moving the remaining front teeth towards the midline. Since it was a class II occlusion with prospective missing space in the buccal area, this was an elegant solution. If all teeth had been present, two premolars would have had to be extracted in the upper jaw. The two laterals

in the position of the centrals first were built up with composite, and in a later phase at around 20 years of age rebuilt as centrals with all-ceramic partial crowns.

2. **Gap opening**

tooth replacement with **all-ceramic adhesive bridges**, including pontic site development

The following rules for construction should be followed:

Recommended minimal dimensions of the framework in the anterior zone

A) **connector:** height x width ***3x2 mm for Zirconia, 4x4mm for Lithium-Disilicate*** glass-ceramics[11].

B) **gap width:** > 7mm should be considered as an ***increased risk for fracture*** for a 2-unit all-ceramic bridge[11].

C) **wing dimensions:** ***bonding area for the wings*** should reach ***30mm²*** (preferably in enamel only) to properly withstand shear forces under loading, and the recommended ***thickness*** should ideally be ***0.7mm or greater***, both for all-ceramic or metallic frameworks[11].

Case 4: Both upper lateral incisors were missing (agenesis) and elsewhere replaced with bonded 3-unit ZrO2-bridges. These bridges broke and debonded after a short time, as was to be expected.
This is a typical example of what can go wrong if basic rules are violated. It is obvious from the literature that all-ceramic adhesive bridges should principally be constructed as 2-unit bridges[20,22]. In addition neither the wing extension nor the wing thickness were respected. The defects resulting from the inadequate former preparation of the cuspids and inadequate wing area were rebuilt with composite, and the residual defects at the central incisors used as positional grooves for the new frameworks. A shallow palatal groove and rounding off of the palatal enamel ridges at the connector site is helpful to allow proper seating and better stability of the framework. In addition overcontouring of the margins can be avoided.

Due to the limited space for the adhesive wings, a 3Y partially stabilized ZrO2 framework was used. The use of glass-ceramics is not advisable in this case. A thin ceramic veneering is performed on the buccal side of the pontic.

What type of zirconia should be used for adhesive bridges?

3Y partially stabilized ZrO2 is the material of choice.
Generally the use of 4Y- or 5Y-ZrO2 is not recommended. The increased content of cubic (fully stabilized) ZrO2 leads to considerably lower mechanical properties[37-41]. These materials may have a slightly better transparency as one of the aesthetic components compared to 3Y-ZrO2, however the respective refractive index around 2 or more still is much higher than enamel, dentin, cementum and lithium-disilicate glass-ceramic materials (all around 1.5 - 1.6)[40-43,50], which causes still more diffuse internal and surface reflection[44].

The aesthetic appearance of different Zirconias is in a complex way related to the different microstructures and compositions. New developments of 3Y-ZrO2 with nano grain size particles may address the combination of optimal mechanical and optical properties in a more promising way[44].

Adhesive cementation of Zirconia frameworks

The frameworks are sandblasted using a ***tribochemical conditioning*** of the surface with 30 μm particle size SiO2/Al2O3 (Rocatec Plus, 3M Espe, Seefeld, Germany) and a pressure of 2.5 bar (distance 10mm, perpendicular blasting direction) to achieve an active and ideally textured surface. The ceramic surface is then first cleaned in an ultrasonic device (alcohol), and primed with a combination of MDP & Silane (Ceramic Primer Plus, Kuraray, Japan)[45-50]. As cement, the transparent Panavia V5 (Kuraray, Japan) is used after acid etching the enamel and conditioning and priming dentin & enamel with the tooth conditioner of Panavia V5. This approach is the most predictable and easiest to use in the clinic[11].
An important remark must be made here: Panavia V5 in contrast to Panavia 21 does not contain MDP in the pastes itself, therefore the use of the MDP- (and Silane-) containing primer on the Zirconia surface is imperative.

Development of the pontic site area

If we have to deal with an unilaterally missing lateral incisor (agenesis), often the contralateral incisor is smaller than normal or has a conoid shape. This is an ideal indication for an adhesive bridge to replace the missing tooth, since the smaller the gap the better the mechanical situation for a 2-unit bridge.

In addition the edentulous ridge area is easier to condition for the pontic integration or for soft tissue augmentation procedures[51-53]. As standard pontic design, an ovate pontic design should always be preferred due to its aesthetic advantages, its biologic acceptance and ease of cleaning with dental floss[52,54].

In Case 5, the unilateral missing lateral incisor were replaced with a 2-unit all-ceramic adhesive bridge after orthodontic treatment. Since the tooth color was rather transparent and light at the same time, and the intermaxillary space sufficient for a 4x4mm connector design, a glass-ceramic material (Lithium-Disilicate, Ivoclar, Schaan, Lichtenstein) could be used, with thin buccal veneering of the pontic[16.] As a preparation concept, an almost non-prep design may be used. The enamel is just rounded at the connector site, but no other preparation is required. The downside of a non-prep and non-retentive design is the difficulty of proper positioning the wing during cementation.The ceramic is etched for 20 sec with HF according to the manufacturer's instructions for use (Ivoclar, Schaan, Lichtenstein), a primer containing silane is used and the enamel etched with phosphoric acid[50,55,56]. As cement, a flowable light-cured composite of medium viscosity is used.

The pontic site can be developed with different methods[4,51,52].
If it is a narrow gap between the adjacent teeth before the orthodontic opening, ridge augmentation procedures often can be avoided, when the teeth are slowly separated from each other. A provisional removable denture can be used after completion of the orthodontic treatment to displace and redistribute the soft tissue and to form the papillae.
If this is not sufficient, a tissue augmentation procedure is indicated, mostly soft tissue only[51,53]. The advantage of a pontic mainly is that there is no need for a bony socket as requested for an implant. The site must then be developed to accept an ovate pontic by using the provisional removable partial denture as a scaffold. Underlining the provisional pontic with composite to shape the soft tissue non surgically into the right form is very effective.
However the edentulous ridge will neither increase its vertical dimension during the growth period, nor will it later adapt to the repositioned adjacent teeth during the lifelong eruption. Only the passive eruption of the adjacent teeth will compensate partially in this respect the continuing active eruption, if an ovate pontic with a deep basal part was integrated initially. Often it can be observed over time that the pontic looses its initial tight soft tissue contact due to the effects described above. However this is mostly much better tolerated by the patients than an implant that seems to be in an intruded and

protruded position due to the same longterm effects. The following case may illustrate this process.

Case 6 shows a situation with a missing central incisor after an accident early on in the life of this patient. The ridge was rebuilt using both a xenograft material (BioOss, Geistlich, Switzerland) and a soft tissue graft to build up the ridge.
An adhesive 3-unit PFM-bridge was inserted almost 30 years ago.
After 22 years the bridge still is in place, but we now see the decreased contact between pontic and soft tissue receptor site.

From a mechanical standpoint, 3- or 4-unit adhesive bridges should preferably be supported by a ***metallic framework***[21,22], either non-precious alloys, or noble alloys, which are aesthetically easier to veneer with porcelain. The ***bonding procedure***[57-60] is principally the same as already described above for ZrO2-frameworks. However to prevent a grayish effect of the wings on the abutment teeth, an opaque cement must be used (e.g. Panavia V5 OP, Kuraray, Japan).

4-unit adhesive bridges with a metal framework to replace two missing lower centrals may also be able to stabilize the arch after orthodontics without the need for a wire retainer (Case 2), in contrast to two separate 2-unit all-ceramic bridges, where in most instances a wire retainer should be used together with the bridges.

In Case 7 both upper central incisors were lost early in the life of this patient. After orthodontic aligning of the remaining teeth, a ridge build-up was performed with soft tissue augmentation alone, the pontic area conditioned with a removable partial denture, and a 4-unit adhesive pfm-bridge inserted, which serves also as a retainer in the upper jaw.

3. **Gap distribution**

restorative compensation with direct composite restorations, etched pieces or porcelain veneers:

In Case 8 there is a Bolton-discrepancy, the anterior tooth forms of a young lady were restored using a direct approach with composite. Diagnostics include a direct mock-up with the respective composite, allowing to test both the correct layering to achieve the aspired colors and the optimal shape, and also to test whether this is realizable in the hands of the clinician. The mock-up is photographed and further analyzed. In addition, optical or analogue

impressions can be taken for documentation, before the planned alterations are realized definitively with the direct composite technique.
It can also be helpful during the orthodontic treatment to evaluate the aesthetic potential of the repositioned teeth by an interim mock-up.

4. **Gap shifting**

restorative compensation with all-ceramic adhesive bridges, composite, etched pieces or veneers:

This is an interesting alternative to avoid aesthetic problems in the zone of the most prominent aesthetic effects. Either a gap is shifted away from the aesthetic zone, or multiple gaps are reduced to one gap, and an additional front tooth is inserted with an all-ceramic adhesive bridge. Thus, multiple restorations or reconstructions to enlarge teeth that are too small can be avoided in favor of one single reconstruction on one single abutment tooth, be it a pontic or a veneer, or simple direct composites on the teeth adjacent to the opened gap.

Case 9 is an instructive example. The lower small front teeth which presented all gaps were grouped to one side, and a fifth front tooth was added adhesively with a bonded bridge. This is an elegant option for the lower front area, where 5 instead of 4 incisors are not obvious to the eye of the beholder.

5. **Gap compensation** by reconstructive compensation without orthodontics

A case may not be indicated for a combined orthodontic-reconstructive approach, if major reconstructive interventions are needed anyway to compensate for missing or malformed tooth substance in a major amount.
If still minimal invasive interventions are feasible, this can be an attractive option firstly to be efficient and effective, and secondly to avoid problems with the potential relapse after orthodontic treatment.

The patient (Case 10) presented with a pronounced Bolton-discrepancy and an equally pronounced amelogenesis imperfecta. In view of the large amount of missing tooth structure, the patient was reconstructed in total by veneers with no to minimal preparations, all-ceramic partial crowns and adhesive full veneer crowns without orthodontic intervention. The lower very small teeth were enlarged with slightly overlapping shapes to hide the dimensions and achieve a believable appearance.

Final remarks

Adhesive dentistry today offers an outstanding potential to resolve also complex cases with minimally invasive techniques, be it direct or indirect. The high potential for reintervention places it at the premium position of restorative and reconstructive dentistry. This includes also the possibility for the patient to choose between different valuable and sustainable options for comparable clinical situations. However in the light of the increasing complexity of optimally managing materials and techniques used in current restaurative and reconstructive dentistry, the individual levels of knowledge and manual skills[61] of the involved clinicians and dental technicians are the key factors for success.

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Figures Case 1-10

CASE 1 initial and final situation, direct composite restorations

CASE 2 initial situation of upper jaw with micro preparation, final lower adhesive bridge

CASE 2 final result

CASE 3 initial situation

CASE 3 micropeparations and direct composites, final veneer-crowns

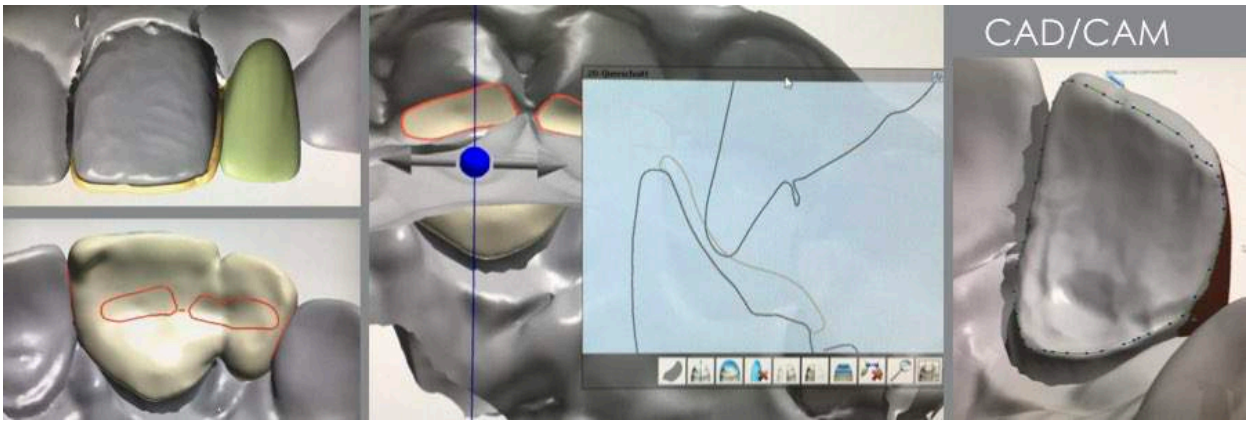
CASE 3 final result

CASE 4 initial situation, failed concept

CASE 4 initial situation, failed restorations

CASE 4 composite build-ups & micro-preparations

CASE 4 provisional RPD, site development for ovate pontics, analogue impression



CASE 4 CAD/CAM processing of Zirconia frameworks, overextension for milling

CASE 4 final Zirconia-bridges

CASE 4 final Zirconia-bridges, palatial aspect, pontics with thin buccal veneering porcelain

CASE 4 final result: pontic details, soft tissue

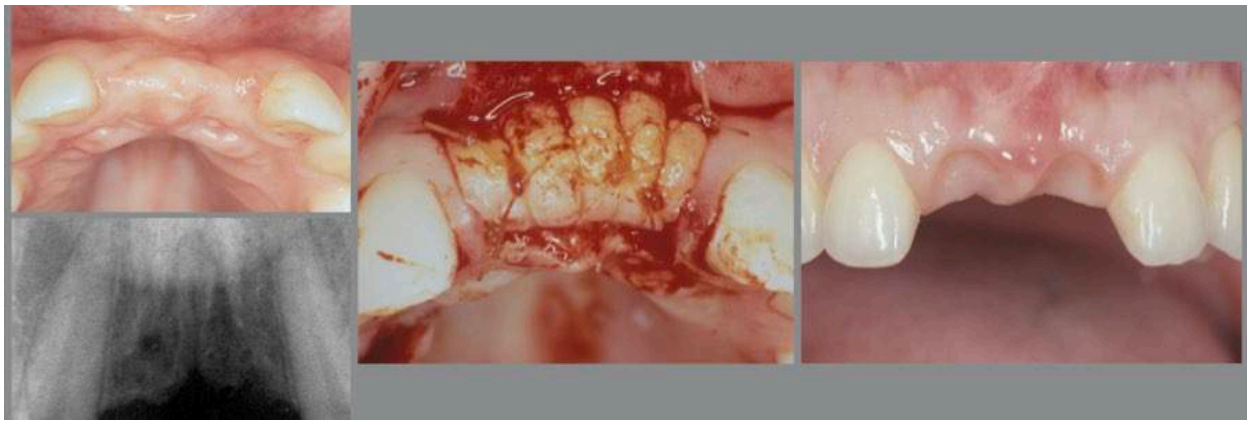
CASE 4 final smile

CASE 5 glass-ceramic adhesive bridge

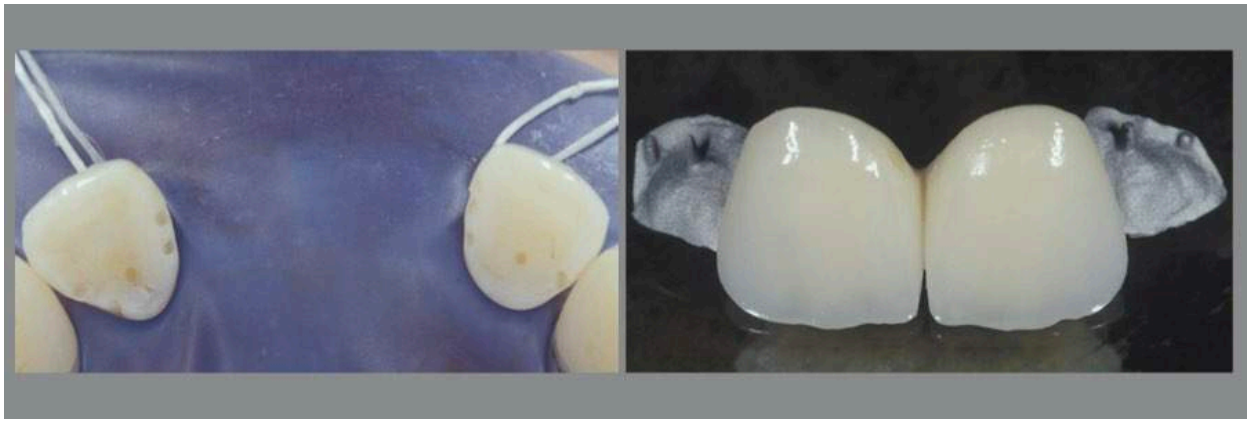
CASE 5 final result

CASE 6 22y year result of pfm adhesive bridge with microretentions, final result 22y

CASE 6 22y year result: analysis of pontic site status over the years



CASE 7 initial situation & site development with soft tissue build-up



CASE 7 micro-preparations for adhesive bridge, metal framework (non-precious alloy)

CASE 7 final result

CASE 8 initial situation after orthodontic treatment

CASE 8 direct mock-up & clinical steps for the final direct composite restorations

CASE 8 final result: soft shapes for an airy delicate look

CASE 8 final smile

CASE 9 initial situation after orthodontic treatment, direct mock-up

CASE 9 final result of glass-ceramic adhesive bridge, adding a 5th front tooth

CASE 10 initial situation, upper teeth provisionally covered with composite as a child

CASE 10 minimal veneer crown & veneer preparations, etched glass ceramics

CASE 10 final result