Biological outcomes and patient-reported outcome measures (PROMs) of minimally invasive full-mouth rehabilitations of patients with erosions and/or abrasions by means of the “3-step technique”: part 2 of the 6-year outcomes of a retrospective clinical study

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Abstract

**Purpose:** To evaluate biologic and esthetic outcomes, as well as the patient-reported outcome measures (PROMs), of full-mouth rehabilitations in patients suffering from generalized erosive and/or abrasive tooth wear following the 3-step technique. **Materials and Methods:** Patients who received a minimally invasive full-mouth rehabilitation according to the 3-step technique and who were treated at the University of Geneva and/or in a private practice were considered for inclusion. The minimum service time of the restorations was 12 months. The biologic outcomes were analyzed by assessing pocket probing depth (PPD), Plaque Index (PI), and bleeding on probing (BOP). Furthermore, secondary caries, tooth vitality, and sensitivity to temperature were evaluated using the modified United States Public Health Service (USPHS) criteria. The esthetic outcomes were rated with the White Esthetic Score (WES). Finally, PROMs were evaluated using visual analog scales (VAS).

**Results:** A total of 19 patients with 406 restorations (149 direct composite resins, 110 indirect composite resin/ceramic onlays, and 147 composite resin/ceramic veneers) were examined after a mean follow-up of 71.8 ± 28.6 months. Periodontal parameters were good (mPPD = 2.9 ± 0.4; mPI = 0.1 ± 0.2; and mBOP = 0.05 ± 0.1). No secondary caries were found, and no abutment tooth had lost vitality. A total of 36 abutment teeth had moderate sensitivity, but none presented pronounced sensitivity. The rehabilitations exhibited good esthetic outcomes (mWES = 8.4 ± 1.9). Patients reported satisfying esthetic results of their rehabilitations (mean VAS = 9.2 ± 1.6) and considered their treatment as comfortable (mean VAS = 8.2 ± 2.1), while the least favorably rated parameter was the cost of treatment (mean VAS = 4.1 ± 3.2). **Conclusion:** Minimally invasive full-mouth rehabilitations of patients with generalized tooth wear by means of the 3-step technique exhibit very good clinical medium-term results with respect to biologic and objective/subjective esthetic outcomes. The patient satisfaction with this treatment was high. *Int J Prosthodont 2021. doi: 10.11607/ijp.7248*
Introduction

In the last years, increasing amounts of clinical studies are showing a worrying incidence of erosive tooth wear already at patients of very young age.(1, 2) Lifestyle habits, especially the increasing consumption of acidic beverages or eating disorders like bulimia and anorexia are factors that greatly influence the incidence of dental erosions.(3-5) Patients suffering from bulimia generally show pronounced loss of dental substance i.e. enamel and dentin, because of repeated acidic exposure, which leads to irreversible and progressive dissolution of the dental substance by the chemical procedures.(6) Additional to the acidic attack, the occlusal function increases the wear of the weakened tooth substances.(7, 8) In patient situations with superficial erosions and/or wear, the enamel is affected. Yet, in the presence of repeated exposure to acids, the loss of tooth substance can extend to the underlying dentine, exposing the dental tubules. The resulting increase in dentine permeability, can lead to tooth hypersensitivity and pain.(9) In severe erosion cases with frequent acid attack, a loss of the tooth vitality can even occur.(7)

Another clinical problem that may be associated with erosive tooth wear is fracture or chipping of the incisal edges of anterior teeth (7, 8), a phenomenon which compromises the esthetic appearance of the patients.(8) Patients suffering of eating disorders are known to have low self-esteem with respect to their body appearance. (10, 11)

A poor dental esthetics may increase they low self-esteem.(12) The loss of tooth substance is often accompanied with a loss of the vertical dimension of occlusion (VDO).(13, 14) Hence, due to erosive tooth destruction not only esthetics, but also masticatory function and comfort may be impaired.
In these patients, hence, a comprehensive dental rehabilitation is frequently needed to restore the oral health, the occlusion and function, and the esthetics.

As the patients affected by dental erosions are frequently young of age, the rehabilitation needs to be less invasive than when using conventional fixed dental prostheses (FDPs) such as all-ceramic or metal-ceramic crowns. (15-17) The preparation of the teeth for full crowns is rather invasive and leads to extensive loss of tooth substance. (18, 19) Thus, the most frequent biological complication found at FDPs in the literature is the loss of abutment tooth vitality, while the second most frequent complication is secondary caries. (18, 20)

To reduce the biologic risks of the abutment tooth preparation, a less invasive treatment concept was developed at the University of Geneva for the rehabilitation of patients who suffered from generalized erosions and wear, published as the “3-step technique” (13, 21, 22). This minimally-invasive concept encompassed a step-wise approach, for full-mouth rehabilitations of patients with erosions and wear. (13) The concept is based on no or minimal tooth preparation and adhesive restorations, which allows for the preservation and the protection of the remaining tooth structure. Clinical problems associated with tooth preparation such as tooth sensitivity, loss of abutment tooth vitality, or abutment tooth fractures can be avoided. (21) As one of the crucial steps within this concept, the posterior occlusal support is recreated and the VDO is augmented using direct composite resin or indirect composite resin/ceramic posterior restorations. (13) This increase in the VDO, opens the interarch space in the anterior regions and allows for the restoration of the anterior guidance and esthetics with a combination of palatal resin composite resin veneers and facial ceramic veneers (defined as “sandwich approach”). (22)
This more conservative full-mouth rehabilitation aims to protect the remaining tooth substance, and to improve the masticatory function and the esthetics without compromising the remaining tooth substance. (13)

Yet, although very promising, clinical studies evaluating this concept and its longevity, its biologic and technical outcomes and the general patient appreciation are still scarce. Before consideration of this novel approach as a true alternative to conventional FDPs, randomised controlled clinical trials, and prospective and retrospective studies are needed for its evaluation. Furthermore, the general satisfaction of the patients with this new approach has also not been evaluated yet. In general, studies on the patient appreciation of rehabilitations with fixed dental prostheses are scarce.

Hence, the aim of the present retrospective study was to evaluate the outcomes of full-mouth rehabilitations according to the “3-step technique” (13, 21, 22) of patients who suffered from pronounced erosive/abrasive tooth wear. The study has two parts, part 1 focussed on the survival rates and the technical outcomes (Torosyan A et al., accepted for publication IJP 2021), while the present part 2 of the study focussed on the biologic and the esthetic results. Furthermore, it was the aim this part to analyse the overall satisfaction of the patients with this treatment with patient reported outcome measures (PROMs).

Materials and Methods

Study design

This retrospective study was based on the comprehensive clinical examination of patients who received a minimally invasive full-mouth rehabilitation according to the “3-step technique”. (13, 21, 22) The study protocol and documentation for this study have been
submitted to the local ethical committee and an approval was obtained (CCER, n° 2016-01716).

For the inclusion of the patients in this study, the following inclusion and exclusion criteria were defined:

**Inclusion criteria**

- Patients treated at the University of Geneva and/or in private practice with a full-mouth rehabilitation according to the “3-step technique” (13, 21, 22)
- Male and female patients with an age range from 18 to 80 years
- Patients who had suffered from different kind of generalized lesions due to erosion (anorexia, bulimia, gastroesophageal reflux disease (GERD) and diet habits) and/or bruxism (clenching, grinding, behaviour disorders)
- Minimum service time of the rehabilitation of 12 months

**Exclusion criteria**

- Partial rehabilitation not according to “3-step technique” (13, 21, 22)
- Less than 12 months of service time of the restoration

For this retrospective study, patient records of the Division of Fixed Prosthodontics and Biomaterials, University Clinics of Dental Medicine, University of Geneva and of a private practice were screened to find eligible patients. Out of a total 45 patients who had received a treatment according to the “3-step technique” (13, 21, 22), 28 (8 females, 20 males; mean age 45.6) fulfilled the above inclusion criteria.
These patients were restored with different types of minimally-invasive restorations applying different materials. (Table 1) For the posterior areas, direct occlusal composite resins, indirect composite resin onlays/inlays or indirect ceramic onlays/ inlays were used. In the anterior areas, direct palatal composite resins, or indirect palatal composite resin veneers were used. In specific cases, additionally indirect buccal ceramic veneers were made.

The eligible patients were contacted by telephone, and informed about the study purpose and procedures.

Thereafter, the patients received the detailed patient information documents via mail and potential questions were clarified via telephone. Finally, the patients willing to participate provided written consent and received a clinical examination appointment.

All clinical and radiologic examinations were performed by two calibrated examiners (DS, AT). The calibration was performed by one senior researcher experienced with clinical follow-up examinations (IS).

1. Information retrieved out of patient records

General information was reviewed with the patient (etiology, date of treatment initiation, date of treatment completion, delivery of nightguard after treatment completion, failures or complications/repairs during function).

2. Clinical examination

The clinical examinations encompassed firstly clinical standardized extra-oral and intra-oral photographs and intraoral optical impressions (Trios 3, 3Shape®, Copenhagen, Denmark). The survival of the restorations and their technical outcomes were assessed (modified
USPHS criteria), these outcomes are reported in a separate manuscript (Torosyan et al. accepted IJP 2021).

The biologic outcomes of the abutment teeth were assessed by evaluating:

I. Probing pocket depths (PPD)
II. Plaque index (PI)
III. Bleeding on probing (BOP)

Furthermore, the following biologic parameters were assessed using the biologically oriented part of the modified United States Public Health Service (USPHS) criteria. (Table 2)

IV. Secondary caries
V. Tooth vitality (using carbon dioxide)
VI. Sensitivity to temperature

Periodontal parameters (PPD, PI and BOP) were assessed with the use of a dental probe (PP12 color coded 3-6-9-12, DEPPELER®, Rolle, Switzerland) and dental floss at four sites per tooth (mesial, buccal, distal, lingual or palatal).

For the radiologic examination of secondary caries, two bite wing radiographs were taken if the radiographs in the patient record were older than 2 years or more. Complementary periapical radiographs were taken in case of presence of endodontic symptomatology, like pain on percussion or a negative pulp vitality-test.

3. Esthetic evaluation

For the objective analysis of the esthetics, a previously published standardised index, the White Esthetic Score (WES) was used. (23, 24) The WES included the following parameters: tooth form, tooth volume/outline, colour (hue and value), surface texture and
translucency/characterization. Using this index, the photos of the restorations were evaluated and the esthetics of the restored teeth was compared to untreated teeth in the same patients if available, or photos of the dentition before the treatment. (Table 3)

4. **Patient reported outcomes measures (PROMs)**

Finally, a subjective evaluation of the esthetic outcomes, and the general satisfaction with the treatment was made by means of a standardised questionnaire with Visual Analogue Scales (VAS), encompassing the following 6 questions (original language French):

1) How comfortable was the treatment itself for you?

2) How do you evaluate your esthetical appearance after the treatment?

3) How do you evaluate the cost of the treatment?

4) Do you feel any tooth sensitivity e.g. to temperature at cold air or hot drinks, or when eating sweets?

5) How did the treatment improve your masticatory comfort?

6) Do you expect technical complications during the year of function as normal events?

Patients were asked to mark their specific degree of satisfaction on a scale from a minimum of 0 (negative, totally unsatisfied) to a maximum of 100 (positive, fully satisfied) when replying to the questions. These marks were converted into percentages for further evaluation.

**Statistical Analyses**

**Database**

All information concerning the patients and their answers to the PROMS were entered in a spreadsheet using an identification number (ID) for each patient.
Another spreadsheet was completed to enter all the information concerning each restoration. The restoration identification number combined the ID of the patient, the tooth, and the surface restored.

The spreadsheets were imported in a statistical package (IBM® SPSS Statistics version 25 (IBM corp.) and merged to create a database containing all the information collected. Descriptive analysis of the patient was performed using the patient as the statistical unit.

For all other statistics, the statistical unit was the restoration.

Distribution of the data

Except for age and follow-up time, all the continuous variables were not distributed according to a Gaussian curve. Kruskall-Wallis and Mann-Whitney tests were therefore used to compare groups.

Results

A total of 19 patients agreed to participate in the present retrospective study (3 females, 16 males, mean age 45.6-years), resulting in an acceptance rate of 67%. Nine patients were considered as drop-out (6 females, 3 males). These patients were not available due to the following reasons: significantly compromised health (n=1), moved away to another country (n=2), did not want to come for examination without further explanations (n=2), did not reply to the invitation to participate in the study (n=3) and finally, due to decease (n=1).

Twelve patients (1 female, 11 males) were treated in the private practice and 7 (2 females, 5 males) at the University. All patients were examined after a mean follow up of 71.8+/-28.6 months. Patients presented different diagnostic reasons for their pronounced erosive tooth wear: 4 had gastroesophageal reflux disease (GERD), 4 had reported acid reflux and
additionally bruxism or parafunction, 4 had bruxism or parafunction, 3 had suffered from bulimia, 2 lost the tooth substance due to acidic nutritional habits and, finally, 2 were categorized as unknown. Eleven patients reported to regularly wear a nightguard.

In these patients, a total of 365 worn teeth were treated according to the “3-step technique” (13, 21, 22), 188 were anterior teeth (incisors to canines) and 177 were posterior teeth (premolars, molars). For the 365 treated teeth, 406 restorations were made; some anterior teeth had two separate restorations (buccal and palatal veneers). One hundred and forty-nine restorations were made out of direct composite resins (66 in posterior areas and 83 in anterior areas), 110 were indirect onlays and 147 veneers. All details on the frequency of application and the materials used for the restorations and are given in Table 4 and 5. For example of an initial and final clinical patient situation, see Figure 1 and 2.

Biological outcomes

Periodontal situation

In general, the patients had a very good oral hygiene status as demonstrated during the evaluation of the periodontal parameters. The mean PPD (mPPD) was 2.9+/−0.4, the mean PI (mPI) was 0.1+/−0.2 and the mean BOP (mBOP) was 0.05+/−0.1.

The mPPD value was significantly different (p=0.03) at abutment teeth supporting ceramic or composite resin restoration. Furthermore, a significant association between the type of the restoration and the PPD values (p=.000) was found. Indirect onlays presented higher PPD values (mPPD 2.6+/−0.4) than veneers (mPPD 2.4+/−0.3) and direct composite resin restorations (mPPD 2.3+/−0.4). (Figure 3)
In the posterior regions, abutment teeth with indirect restoration (i.e. onlays) exhibited higher pocket probing depths than the ones restored with direct restoration (composite resins) (mPPD indirect restoration 2.6+/−0.4, mPPD direct restoration 2.4+/−0.3; p=.002) (Figure 4). In the anterior region, no differences were found between the mPPD at indirect (veneers) and direct (composite resin) restorations.

The mPI values showed a significant association between the different types of restoration (p=0.35). Teeth with indirect onlays restorations presented more plaque accumulation (mPI 0.2+/−0.2), than direct composite resins (mPI 0.1+/−0.2) and veneer restorations (mPI 0.1+/−0.2).

The location, i.e. the surface of the restorations influenced the mPI values (p=.025). Buccal surfaces had less plaque accumulation than occlusal surfaces.

No significant association was found between the PI value and the material used for the restoration (ceramic or composite resin). Furthermore, there was no association between the mPI and the mBOP values. Neither materials, nor the type and the location of the restorations had an impact on the BOP values. However, the marginal adaptation (MA) of the restorations influenced the presence or absence of BOP (p=.003). At teeth with poor marginal adaptation of the restoration, more bleeding on probing was observed (Figure 5).

**Secondary caries, abutment tooth vitality and abutment tooth sensitivity**

After clinical and radiological examination, no secondary caries was found on the abutment teeth treated with the “3-step technique” (13, 21, 22).

As shown in Table 6 and 7, 297 abutment teeth had positive abutment tooth vitality (Alpha), 46 had a delayed reaction, yet, still positive vitality (Bravo), 8 had negative vitality because of
existing root canal treatment visible on the x-ray (Bravo), and 12 had negative vitality without any x-ray symptoms (Bravo). No abutment tooth was found with a negative vitality test associated with radiologic symptoms for loss of vitality (periapical lesion) (Charlie).

None of the 365 restored teeth had presented severe sensitivity to temperature (Charlie), 36 teeth had moderate sensitivity (Bravo) and 327 had no sensitivity at all (Table 6).

There was a significant association between the occurrence of gastroesophageal reflux disease (GERD) and tooth sensitivity to temperature (p=.000). Patient suffering of GERD had higher incidence of abutment tooth sensitivity to temperature after the treatment. Twenty-seven restored abutment teeth in patients with GERD had moderate sensitivity (Bravo) while in patients without GERD only 9 restored abutment teeth presented moderate signs of tooth sensitivity (Table 8).

In comparison to patients without parafunctional habits, patients with parafunctional habits like bruxism showed significantly less (p=.000) abutment tooth sensitivity to temperature (Table 9).

Nutritional and behavioural origin for erosions (i.e. anorexia, bulimia and diet habits), the type of restoration, the different materials used for the rehabilitation (composite resin or ceramic) and the use of a nightguard were not significantly associated with postoperative abutment tooth sensitivity.

**Esthetic evaluation**

*White esthetic score (WES)*

In general, the esthetic outcomes of the rehabilitations were good with a mean WES (mWES) score of 8.4+/-1.9. As shown in Table 10, all esthetic parameters exhibited high mean values.
The mWES value was significantly different (p<0.01) between the material used for the rehabilitations. Ceramic restorations were more esthetic (mWES 9.2+/-1.3) than composite resin restorations (mWES 8.0+/-2.0). Another significant association between the WES and the type of restorations was found. Indirect veneers exhibited high esthetic outcomes with a mWES 9.1+/-1.1 while indirect composite resin/ceramic onlays had a mWES 8.1+/-1.9 and direct composite resin restorations had mWES 7.9+/-2.2 (p<.001).

Furthermore, restoration located in anterior areas (mWES 9.0+/-1.2) were significantly more esthetic than those placed in posterior areas (mWES 7.6+/-2.2) with a p value <0.01.

**Patient reported outcomes measures (PROMs)**

**Visual analogue scale results**

The details on the patient reported treatment evaluations are shown in Table 11. The patients reported favourable esthetic results of their rehabilitations (mean value 9.2+/-1.6). Interestingly, no association between the objective (WES) and the subjective evaluation of the esthetics (VAS) results was found.

The patients considered their treatment outcomes as comfortable (mean value 8.2+/-2.1), felt well informed about potential technical complications they may experience over time (mean value 8.6+/-1.9) and had experienced minor tooth sensitivity (7.9+/-2-7). The least appreciated parameter was the costs of the treatment (mean value 4.1+/-3.2). The patients reported their rehabilitations to be rather expensive.

**Discussion**

The present part of this respective study demonstrated very good medium-term biologic and esthetic outcomes and high patient satisfaction with the minimally-invasive full-mouth
rehabilitations of their pronounced erosive/abrasive tooth wear (“3-step technique”) (13, 21, 22). The biologic integration of the restorations was very good. All abutment teeth were periodontally healthy at the follow-up visit. No secondary caries was found, and no abutment teeth had lost their tooth vitality. However, 10% of the abutment teeth exhibited postoperative sensitivity. Interestingly, the postoperative sensitivity was neither related to the type of restoration nor to the materials used, but to whether or not the patients suffered from GERD as origin of the erosive/abrasive tooth wear.

Furthermore, the objective evaluation of the esthetic outcomes displayed high mean WES values, indicating very good esthetic outcomes of the rehabilitations. Finally, the evaluation of the patient-reported treatment outcomes measures (PROMs) revealed generally high satisfaction rates with the rehabilitations with respect to esthetics, and the general comfort during the treatment. The chewing comfort and the costs of the treatment, however, were not as satisfactory.

The present study showed, that the minimally-invasive full-mouth rehabilitations according to the “3-step technique” (13, 21, 22) with either direct composite resins, or indirect composite resins or ceramic onlays in the posterior region, and palatal and, in specific cases, facial veneers in the anterior regions exhibited very good 6-year clinical outcomes. The favourable biological outcomes of minimally restorations are in accordance to the results of previous research on minimally-invasive types of restorations.(25) The main parameter that influenced the increase of PPD values was the marginal adaptation (MA) of the restorations. Abutment teeth restored with good marginal adaptation, without gaps (Alpha), had lower pocket depth than the ones with restorations having open margins (Charlie) or when explorer caught at the margins without no visible evidence of gaps (Bravo). The detailed
information on all technical outcomes are published in part 1 of this study (Torosyan A et al. 2020, in revision IJP).

Very low amounts of plaque were found at the restored teeth in the present study, the general oral hygiene of the patients was good. It has to be considered, though, that almost all restoration margins were located supra-gingivally with good access to oral hygiene means. Another influencing factor could be, that dental materials like ceramics present low plaque accumulation.(26) In the cases with inflammation, other factors than the restorative materials were most likely the predominant reason. Several studies testing the biocompatibility of restorative materials such as composite resin, lithium-disilicate ceramic and zirconia showed excellent soft tissue cell reaction to the materials, indicating high biocompatibility.(27-29) Another factor influencing the plaque accumulation may be the surface quality of the restorations. One study tested the influence of restoration surface roughness on the bacterial adhesion to the surface. The investigation showed that well-polished surfaces are crucial for low plaque accumulation.(30)

In the present study, no secondary caries was found, neither on the direct nor on the indirect anterior and posterior restorations. In contrast, secondary caries was the second most frequent biological complication of tooth-supported single crowns.(20, 31) One systematic review showed, that the 5-year incidence of secondary caries was 1.8% for all-ceramic crowns (18) and 4.8% for conventional FDPs (31).

Furthermore, the present study showed no loss of abutment tooth vitality after the mean follow-up of the rehabilitations of 6 years. Loss of abutment tooth vitality is considered as the most frequent biological complication at abutment teeth supporting single crowns.(20, 31) The results are in accordance with other studies reporting on minimally-invasive veneers
A systematic review has found an incidence of endodontic problems of 3% with onlay restorations (32, 33). In comparison, the 5-year incidence of loss of tooth vitality was 4.1% for all-ceramic crowns and for conventional FDPs was 6.1%, as shown in systematic reviews (20, 31).

The presently tested concept is based on no or very low invasive abutment tooth preparation decreasing the risk for postoperative tooth sensitivity and loss of abutment tooth vitality. Several studies have demonstrated the impact of tooth preparation for crowns on the dental pulp tissues. It was shown that by exposing more dental tubules, pulpal inflammation and necrosis are caused (35, 36). The less invasive treatment concepts are based on adhesive cementation systems, which may prevent dentine permeability and were shown to provide a pulp protection (35, 37).

Finally, the evaluation of the PROMs in the present study displayed general satisfaction with the treatment comfort and the outcomes.

The satisfaction of the patients with the esthetics of the ceramic veneers was in accordance with results found in a literature review published in 2000 (25). In this review, the percentage of patients that were completely satisfied with the porcelain veneers varied from 80% to 100%.

It has to be considered, however, that the evaluation of the satisfaction with the esthetics is difficult due to the rather subjective evaluation of restorations by laypeople (38). It may be an influencing factor, that most patients in the present study showed non favourable dental appearances before the treatment due to the pronounced destructions.

One limitation of the present concept for the full-mouth rehabilitation is related to the costs for the treatment, which may influence the patient’s acceptance of the treatment. The
present PROMs evaluation has shown that the costs for this rehabilitation were judged less favourable as the general clinical outcomes. Hence, further development of this concept should also include the increase in efficiency and the reduction of costs in order to increase the availability of the present concept to a broader range of patients affected by erosive and/or abrasive tooth wear.

The present study was a retrospective study and, hence, the methods and materials were not standardised. For further in-depth evaluation of the present concept, prospective, randomized controlled clinical trials are needed.

**Conclusions**

Based on the results of this study the following conclusions can be drawn:

- Minimally invasive full-mouth rehabilitations of patients with pronounced tooth wear due to erosions/abrasions by means of the “3-step technique” exhibit very good clinical medium-term outcomes with respect to biologic, and objective and subjective esthetic outcomes, and high patient satisfaction.

- Further development of the present concept should include an increase in efficiency and, thereby, a decrease in associated costs to be more available for a broader range of patients.

**Acknowledgements**

The authors have no conflict of interest with respect to this manuscript. In order to avoid bias, the co-author involved in the development of the tested “3-step technique” (FV) was not involved in the clinical examinations and the evaluation of the data.

**References**


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Figures, Tables and Legends

Figure 1
Photographs of an initial situation.
Patient presented generalized lesions due to erosion with loss of incisal edges and loss of the vertical dimension of occlusion (VDO).

Figure 2
Photographs of a final situation.
Male patient, 55 years. In posterior areas, eroded tooth were restored with indirect ceramic (Lithium disilicate) and composite onlays. Anterior tooth were restored with buccal ceramic veneers (feldspathic) and composite palatal veneers.

Please note, the initial images of the present case (Fig.1) were also given in: Vailati F, Belser UC. Full-mouth adhesive rehabilitation of a severely eroded dentition: the three-step technique. Part 2. Eur J Esthet Dent 2008;3:128-146. (fig 4) / Vailati F, Belser UC. Full-mouth adhesive rehabilitation of a severely eroded dentition: the three-step technique. Part 3. Eur J Esthet Dent 2008;3:236-257 (fig 1)
Figure 4
Kruskal-Wallis Test
Association between probing pocket depths (PPD) and direct or indirect reconstructions in posterior areas. Indirect reconstruction had higher pocket probing depths (p=.002)

Figure 5
Kruskal-Wallis Test
Association between the occurrence of bleeding on probing (BOP) and marginal adaptation of the reconstructions. The BOP was assessed at four sites per tooth (0 = no bleeding, 1= bleeding) and a mean value was obtained for each tooth. Reconstruction presented open margins (Charlie) had more BOP than margins without gaps (Alpha) or when explorer caught at the margins without evidence of gaps (Bravo).

Figure 6
Kruskal-Wallis Test
Association between probing pocket depths (PPD) and marginal adaptation. Reconstruction with high marginal adaptation without gaps (Alpha) had lower pocket probing depths than reconstruction presented open margins (Charlie) or when explorer caught at the margins without evidence of gaps (Bravo).
Table 1
Details of the different materials and brands used for the reconstructions found in patient treated according to the «3-step technique».

<table>
<thead>
<tr>
<th>Material type</th>
<th>Brand(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium Disilicate</td>
<td>IPS e.max Press, Schaan, Liechtenstein</td>
</tr>
<tr>
<td>Feldspathic Ceramic</td>
<td>Vitadur, VITA, Bad Säckingen, Germany</td>
</tr>
<tr>
<td>Cad/Cam Resin nano ceramic</td>
<td>Lava Ultimate, 3M Espe, ST Paul, MN, USA</td>
</tr>
<tr>
<td>Direct Resin composite</td>
<td>Tetric EvoCeram/EvoFlow, Ivoclar Vivadent, Schaan, Liechtenstein</td>
</tr>
<tr>
<td></td>
<td>Miris, Coltène Whaledent, Alstätten, Switzerland</td>
</tr>
<tr>
<td></td>
<td>Filtek, 3M Espe, ST Paul, MN, USA</td>
</tr>
</tbody>
</table>

Table 2
Details of the USPHS criteria used for the evaluation of the biological outcomes

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Alpha</th>
<th>Bravo</th>
<th>Charlie</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary Caries</td>
<td>No caries</td>
<td>Initial lesion at reconstruction’s margin without cavitation</td>
<td>Deep carious lesions</td>
</tr>
<tr>
<td>Tooth Vitality</td>
<td>Positive</td>
<td>Positive (slow) or negative without x-rays signs or with root canal treatment</td>
<td>Negative (without root canal treatment) and x-rays signs</td>
</tr>
<tr>
<td>Tooth Sensitivity to Temperature</td>
<td>None</td>
<td>Moderate of low level pain</td>
<td>Severe (high level or persisting pain)</td>
</tr>
</tbody>
</table>

Table 3
White Esthetic Score (WES) parameters evaluated for the restored teeth. All parameters received a score of 2,1, or 0. In case of an optimal esthetic reconstruction, a maximum total WES of 10 is reached.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Major Discrepancy</th>
<th>Minor Discrepancy</th>
<th>No Discrepancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tooth Form</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Tooth Volume/Outline</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Color (hue/value)</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Surface Texture</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Translucency</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Maximum total WES score</td>
<td></td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

Table 4
Distribution and frequency of the different types of reconstruction used for the patient’s rehabilitations according to «3-step technique».

<table>
<thead>
<tr>
<th>Type</th>
<th>Anterior area</th>
<th>Posterior area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct composite</td>
<td>83</td>
<td>66</td>
</tr>
<tr>
<td>Indirect onlay</td>
<td>0</td>
<td>110</td>
</tr>
<tr>
<td>Buccal veneer</td>
<td>55</td>
<td>0</td>
</tr>
<tr>
<td>Buccal lingual veneer</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Palatal veneer</td>
<td>87</td>
<td>0</td>
</tr>
<tr>
<td>Buccal palatal veneer</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>230</td>
<td>176</td>
</tr>
</tbody>
</table>
### Table 5
Details of the distribution and frequency of the different materials used for indirect reconstructions.

<table>
<thead>
<tr>
<th></th>
<th>Layered composite</th>
<th>CAD/CAM resin nanoceramic (Lava ultimate)</th>
<th>Lithium disilicate (IPS e.max Press)</th>
<th>Feldspathic ceramic (Vitadur)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect onlay</td>
<td>40</td>
<td>32</td>
<td>28</td>
<td>10</td>
</tr>
<tr>
<td>Indirect veneer</td>
<td>71</td>
<td>26</td>
<td>4</td>
<td>46</td>
</tr>
</tbody>
</table>

### Table 6
Results for the biological outcomes.
Secondary caries, tooth vitality and tooth sensitivity to temperature evaluated on a total of 356 restored teeth. The evaluation of tooth vitality was not possible on 2 teeth, due to trauma occurred before the treatment.

<table>
<thead>
<tr>
<th>USPHS criteria</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alpha</td>
</tr>
<tr>
<td>Secondary Caries</td>
<td>365</td>
</tr>
<tr>
<td>Tooth Vitality</td>
<td>297</td>
</tr>
<tr>
<td>Tooth Sensitivity to Temperature</td>
<td>327</td>
</tr>
</tbody>
</table>

### Table 7
Tooth vitality results on the different type of reconstruction. In this present study, 406 reconstructions were placed. It was not possible to evaluated the tooth vitality on 2 teeth (2 buccal veneers and 2 palatal veneers) due to trauma occurred before the treatment. Thereby, tooth vitality was assessed on a total of 402 reconstructions.

<table>
<thead>
<tr>
<th>Type of reconstruction</th>
<th>Indirect onlay</th>
<th>Direct composite</th>
<th>Veneer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td>94</td>
<td>126</td>
<td>97</td>
</tr>
<tr>
<td>Bravo</td>
<td>16</td>
<td>21</td>
<td>48</td>
</tr>
<tr>
<td>Charlie</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>147</td>
<td>145</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>402</td>
</tr>
</tbody>
</table>

### Table 8
Association between tooth sensitivity to temperature and the occurrence of gastroesophageal reflux disease (GERD). Patients with GERD had more risk to develop tooth sensitivity.

<table>
<thead>
<tr>
<th>Tooth Sensitivity to Temperature</th>
<th>GERD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no</td>
</tr>
<tr>
<td>Alpha</td>
<td>205</td>
</tr>
<tr>
<td>Bravo</td>
<td>9</td>
</tr>
<tr>
<td>Charlie</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>214</td>
</tr>
</tbody>
</table>
Table 9  
Association between tooth sensitivity to temperature and the occurrence of parafunctional habits. Patients with parafunctional habits like bruxism, had less risk of abutment tooth sensitivity to temperature.

<table>
<thead>
<tr>
<th>Parafunctional Habits</th>
<th>no</th>
<th>yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td>204</td>
<td>165</td>
</tr>
<tr>
<td>Bravo</td>
<td>35</td>
<td>2</td>
</tr>
<tr>
<td>Charlie</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>239</td>
<td>167</td>
</tr>
</tbody>
</table>

Table 10  
Esthetic outcomes assessed with the White Esthetic Score (WES). Results of the esthetic parameters. The minimum/maximum score, the mean score and the standard deviation obtained for each parameters and for the WES are indicated.

<table>
<thead>
<tr>
<th>WES Parameters</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tooth Form</td>
<td>0</td>
<td>2</td>
<td>1.68</td>
<td>0.582</td>
</tr>
<tr>
<td>Tooth Volume/Outline</td>
<td>0</td>
<td>2</td>
<td>1.85</td>
<td>0.408</td>
</tr>
<tr>
<td>Color (hue/value)</td>
<td>0</td>
<td>2</td>
<td>1.55</td>
<td>0.519</td>
</tr>
<tr>
<td>Surface Texture</td>
<td>0</td>
<td>2</td>
<td>1.60</td>
<td>0.552</td>
</tr>
<tr>
<td>Translucency</td>
<td>0</td>
<td>2</td>
<td>1.67</td>
<td>0.546</td>
</tr>
<tr>
<td><strong>WES</strong></td>
<td>2</td>
<td>10</td>
<td>8.37</td>
<td>1.915</td>
</tr>
</tbody>
</table>

Table 11  
Results of Patients Reported Outcomes Measures (PROMs) for the different parameters evaluated. Degree of patient’s satisfaction were based on a 0 (unsatisfied) to 100 (fully satisfied) scale.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfort of the treatment</td>
<td>3.05</td>
<td>10.00</td>
<td>8.1526</td>
<td>2.14596</td>
</tr>
<tr>
<td>Aesthetic results</td>
<td>3.30</td>
<td>10.00</td>
<td>9.1921</td>
<td>1.56731</td>
</tr>
<tr>
<td>Cost of the treatment</td>
<td>0.00</td>
<td>10.00</td>
<td>4.0579</td>
<td>3.24766</td>
</tr>
<tr>
<td>Sensitivity of temperature</td>
<td>1.20</td>
<td>10.00</td>
<td>7.9500</td>
<td>2.72427</td>
</tr>
<tr>
<td>Masticatory comfort</td>
<td>0.00</td>
<td>10.00</td>
<td>4.9500</td>
<td>3.83174</td>
</tr>
<tr>
<td>Technical incident</td>
<td>3.10</td>
<td>10.00</td>
<td>8.6053</td>
<td>1.92447</td>
</tr>
</tbody>
</table>