Clinical Performance of Anterior Full Veneer Restorations Made of Lithium Disilicate with a Mean Observation Time of 8 Years

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Purpose: To evaluate the survival and complication rates of full veneer restorations after up to 11 years of clinical service. Materials and Methods: Six patients (four men, two women, median age 42.3 ± 4.7 years) were restored with a total of 40 adhesively luted anterior full veneers (maxilla: 36; mandible: 6; mostly canine to canine) made of lithium disilicate ceramic. Patients were treated between July 2007 and January 2014. All restorations were examined during annual recall visits using the modified United States Public Health Service criteria for color match, marginal discoloration, secondary caries, marginal integrity, surface texture, and restoration fracture, rated as Alpha, Bravo, or Charlie. Data were statistically analyzed using Kaplan-Meier estimation with log-rank test. Results: Time of clinical service was 68 to 139 months (median: 8.1 ± 2.0 years) without any dropouts. Full veneer restorations in the anterior dentition presented a survival rate of 100% and a complication rate of 12.5% due to reparable minor chippings (technical complication/restoration fracture rated Bravo) of four restorations (one after 11 months, one after 20 months, and two after 66 months) and a crack in one restoration (after 38 months) due to trauma. No further technical (debonding or discoloration) or biologic (secondary caries) complications occurred. Conclusion: Based on the present results, minimally invasive anterior full veneer restorations might be considered as a reliable treatment option, but further clinical data are essential.

Given their satisfying long-term clinical success rates, outstanding esthetics, and low invasiveness, adhesively luted ceramic veneers have become an interesting alternative to conventional single crowns for several indications.1–4 Silicate ceramic materials are considered as the material of choice for replacing lost enamel due to their similar optical and mechanical properties.5,6 However, minimally invasive veneer preparations, as well as adhesive luting, set higher demands on the dentist than classic full crown preparations combined with traditional cementation. The preservation of enamel was identified as a decisive factor for the success of veneer restorations.1,7,8 Specific guidelines apply to veneer preparations, which can be individual in design depending on the clinical situation.5,6,9,10 Substance removal is usually between 0.3 mm (“thin” layer) and 0.6 mm (“thick” layer).11 In certain indications, the transition to a full crown preparation can be fluent, depending on the selection of the type of glass-ceramic. On the other hand, monolithic zirconia ceramics offer new less invasive guidelines in full crown preparations.12 A circular extension of the veneer preparation to a 360-degree design (full wrap or full veneer design) is considered to be advantageous, especially in complex rehabilitations with a need for vertical dimension increase (VDI) in order to cover the worn tooth structure generated mostly as a consequence of a traumatic anterior occlusion and to close the space created palatally by the VDI on the maxillary anterior teeth.13,14 An alternative approach is the three-step technique described by Vailati and Belser...
offers the opportunity to build up the palatal space with composite prior to the restoration of the labial surfaces with adhesively bonded ceramic veneers (“sandwich” technique).15–17

In principle, a diagnostic template derived from the wax-up or a silicone index is indispensable for orientation during the preparation, as this enables an economization of tooth structure removal based on the already defined outer contour of the subsequent veneer.6,8,18 In the case of pronounced discoloration, the preparation depths should be slightly extended in order to provide the dental technician with an adequate masking option.11,19

Esthetic and functional analyses of the patient, also based on articulated plaster casts and photo documentation, provide decisive information for adequate planning of the expansion of veneer restorations. The esthetic demands of the patient should be further taken into account. The planned results of the wax-up base can be tried in and adjusted together with the patient using the intraoral mock-up. Further points that must be included in the design and expansion of veneers (medium wrap, long wrap, or full wrap for full veneer) are: occlusal contact position with analysis of the anterior canine guidance; abrasion of the tooth substance; expansion of fillings and root canal treatments; tooth proportions; position of the midline; Angle class and inclination of the anterior teeth; lip profile; and extension and relationship of overjet and overbite.11

Today, silica-based ceramic veneers represent a successful type of anterior restoration. In a retrospective clinical study of up to 20 years where 50.0% of the patients were diagnosed with bruxism, this veneer type showed clinical survival rates of 93.5% at 10 years and 82.9% at 20 years.4 In a literature review for glass-ceramic veneers clinical survival rates of 93.5% at 10 years and 82.9% at 20 years. However, the author concludes with preparation predominantly in dentin, the survival rate was rarely 100%. Therefore, the author concludes that the ideal preparation for porcelain veneers remains within enamel.7 The first interim clinical results for glass-ceramic full-wrap veneers are promising.20 However, the data available are still insufficient to the best of the authors’ knowledge. The present prospective clinical study therefore investigated the survival and complication rates of full veneers made of lithium disilicate ceramic after clinical service of up to 11 years.

MATERIALS AND METHODS

Within the present nonrandomized prospective clinical study, six patients (four men, two women, median age 42.3 ± 4.7 years) were restored with a total of 40 adhesively luted anterior full veneer restorations fabricated out of lithium disilicate ceramic. Requirements of the Declaration of Helsinki were respected, and all patients gave their informed consent. The study design was approved by the ethical committee (no. 012-12).

Inclusion and exclusion criteria were defined for all patients as follows:

- Older than 18 years and under 70 years of age
- Optimal oral hygiene
- Preparation guidelines for minimally invasive restorations can be fulfilled
- No periodontal disease
- Not lactating or breastfeeding

Prosthetic Treatment

All full veneer restorations were part of full-mouth rehabilitations increasing the vertical dimension of occlusion, restoring the posterior teeth with monolithic lithium disilicate occlusal onlays. A full-mouth rehabilitation was required due to moderate to severe tooth structure loss with significant loss of the vertical dimension, esthetic/functional impairments, and hypersensitivities through combined erosion and mechanical stress. The present clinical study separated the investigation of survival and complication rates of anterior and posterior restorations due to diverse prosthetic restoration types being not directly comparable.

Patients receiving minimally invasive full-mouth rehabilitations of their worn and eroded dentitions were consecutively included in the present investigation to evaluate the outcomes of the anterior veneer reconstructions. Therefore, the treatment started with an aesthetic and functional diagnostic wax-up in centric relation, with a direct intraoral esthetic evaluation using a direct mock-up (with the thermoforming sheet Duran transparent 0.5 mm, Schu Dental). The amount of VDI was determined according to parameters such as the incisal edge position of the maxillary central incisors, the width-to-length ratio of the incisors, the phonetic distance, the freeway space, and the facial profile. After functional evaluation for at least 3 months using a repositioning splint, the posterior and especially anterior transfer into lithium disilicate ceramic was performed as described below. To preserve a sound tooth structure as much as possible, the preparation was guided by the directly placed intraoral mock-up using selected depth cutters.

Minimally invasive preparation guidelines were performed with a tooth structure removal of a minimum of 0.3 mm cervical and 0.8 mm incisal (Figs 1 and 2), but an individual amount was determined for each of the six patients depending on tooth structure loss. The following preparation burs were additionally used:

- Diamond burs for depth marking (8801.314.018, 8801.314.023, and 8878.314.012, Komet Dental), labial preparation, slight chamfer preparations (8856 314 014, Komet Dental), and palatal concavity preparation (8379 314 023, Komet Dental)
etch & rinse technique, Variolink II Professional Set, low viscosity, light curing; Ivoclar Vivadent) (Figs 4 to 6).

Technical, esthetic, and biologic outcomes (including marginal discoloration, secondary caries, marginal integrity, restoration fracture, and surface texture) were assessed at annual recall visits using the modified United States Public Health Service (USPHS) criteria, specified in Table 1.24,25 The parameters measured were rated Alpha (no problem), Bravo (minor complications), or Charlie (major complications with renewal of the restoration). Moreover, clinical variables, such as periodontal parameters (including the Plaque Index [PI], Gingival Index [GI], oral and vestibular probing depth [PD], and bleeding on probing [BOP]), were assessed.26,27 The annual recalls were conducted by a single experienced examiner who did not perform the prosthetic rehabilitation.

Statistical Analyses

Data were analyzed using SPSS v. 25. The survival and complication rates were calculated using Kaplan-Meier survival analysis. A major complication was recorded when the restoration had to be replaced.

RESULTS

Six patients were assessed in recall appointments without any dropouts. The clinical use ranged between 68 and 139 months (median: 97.5 ± 24.5 months). Detailed patient information, including survival and complication rates, is listed in Table 2. Figures 7 and 8 show six maxillary full veneers after 40 months of clinical use without any major complications occurring.
Fig 4  Vestibular view of adhesively luted maxillary anterior full veneer restorations 2 weeks after insertion (baseline appointment).

Fig 5  Vestibular view of adhesively luted mandibular anterior full veneer restorations 2 weeks after insertion (baseline appointment).

Fig 6 (right)  Palatal view of adhesively luted anterior full veneer restorations 2 weeks after insertion (baseline appointment).

Table 1  Modified USPHS Ryge Criteria$^{22,23}$

<table>
<thead>
<tr>
<th>USPHS criteria</th>
<th>Alpha</th>
<th>Bravo</th>
<th>Charlie</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marginal discoloration</td>
<td>No visual evidence of marginal discoloration</td>
<td>Visual evidence of marginal discoloration at the junction of the tooth structure and the restoration, but the discoloration has not penetrated along the restoration in a pulpal direction</td>
<td>Visual evidence of marginal discoloration at the junction of the tooth structure and the restoration that has penetrated along the restoration in a pulpal direction, renewal necessary</td>
</tr>
<tr>
<td>Secondary caries</td>
<td>The restoration is a continuation of existing anatomical form adjacent to the restoration</td>
<td>Visual evidence of dark discoloration adjacent to the restoration</td>
<td>Renewal necessary</td>
</tr>
<tr>
<td>Marginal integrity</td>
<td>No probe catch</td>
<td>Slight catch on probing, no gap</td>
<td>Highly over- or undercontoured, renewal necessary</td>
</tr>
<tr>
<td>Surface texture</td>
<td>Surface texture similar to polished enamel</td>
<td>Surface texture gritty, similar to a surface subjected to a white stone, or similar to a composite containing supramicron–sized particles</td>
<td>Surface pitting is sufficiently coarse to inhibit the continuous movement of an explorer across the surface, renewal necessary</td>
</tr>
<tr>
<td>Restoration fracture</td>
<td>Restoration is intact and fully retained, no fracture</td>
<td>Restoration is partially retained, polishing or repair is possible</td>
<td>Restoration is completely missing or huge fracture, renewal necessary</td>
</tr>
</tbody>
</table>

Table 2  Survival and Complication Rates of Lithium Disilicate Full Veneers Analyzed with USPHS Criteria

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (y)</th>
<th>Gender</th>
<th>Time in situ (mo)</th>
<th>No. of restorations</th>
<th>Survival rate (%)</th>
<th>FDI position</th>
<th>Complication rating (USPHS rate)</th>
<th>Complication rate (mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>49</td>
<td>M</td>
<td>139</td>
<td>5</td>
<td>100</td>
<td>23</td>
<td>Minor chipping (B)</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>39</td>
<td>M</td>
<td>128</td>
<td>5</td>
<td>100</td>
<td>22</td>
<td>Minor chipping (B)</td>
<td>66</td>
</tr>
<tr>
<td>3</td>
<td>38</td>
<td>M</td>
<td>87</td>
<td>6</td>
<td>100</td>
<td>21</td>
<td>Minor chipping (B)</td>
<td>66</td>
</tr>
<tr>
<td>4</td>
<td>41</td>
<td>F</td>
<td>80</td>
<td>12</td>
<td>100</td>
<td>11</td>
<td>Incisal crack (B)</td>
<td>38</td>
</tr>
<tr>
<td>5</td>
<td>39</td>
<td>M</td>
<td>83</td>
<td>6</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>48</td>
<td>F</td>
<td>68</td>
<td>6</td>
<td>100</td>
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USPHS criteria: A = Alpha; B = Bravo; C = Charlie.
A survival rate of 100% was seen for the adhesively luted and veneered lithium disilicate full veneer restorations, with a total technical complication rate of 12.5% due to reparable minor chippings (restoration fracture rated Bravo) in four restorations (one after 11, one after 20, and two after 66 months) and a crack after trauma in one restoration 36 months after placement (Figs 9 and 10). In cases of reparable chipping (rated Bravo), the specific glass-ceramic surface was silica-coated (CoJet, 3M), silanized for 60 seconds (part of Monobond Plus, Ivoclar Vivadent), and repaired with Heliobond and Tetric EvoFlow shade T (both Ivoclar Vivadent). All composite repairs were performed once, and no second chipping of the performed repair was observed.

No further technical (debonding), esthetic (discoloration), or biologic (secondary caries) complications occurred. All detailed surface and periodontal parameters, including the Pl, Gi, oral and vestibular PD, BOP, and marginal/surface quality of the abutment teeth, are summarized in Table 3.

**DISCUSSION**

The present clinical study investigated the clinical long-time performance of 40 anterior minimally invasive full veneers made of IPS e.max Press with a superior survival
rate of 100% after 8 years. Only technical failures with minor chippings or a crack formation (in total 12.5%) occurred, leading to the conclusion that these restoration types might be a reliable treatment alternative.

Minimally invasive preparations, such as those for full veneers, place higher demands on dentists than more invasive full-crown preparations.\textsuperscript{1,2,8}

With regard to the enamel preservation, some authors advise that veneer restorations should be refined within the enamel shell.\textsuperscript{7,8,29–35} This procedure seems to make sense because the enamel-dentin interface is biomechanically a very resilient connection that stabilizes the tooth crown and cannot be permanently replaced in its quality by adhesive luting to dentin. In addition, the relative flexibility of the tooth crown increases significantly with the complete removal of the enamel compared to a partial exposure of dentin.\textsuperscript{34} A higher elasticity of the supporting tooth structure may involve a fracture risk due to the higher stiffness of the ceramic.\textsuperscript{31,35}

In clinical practice, however, preparations located in the enamel are not always possible due to anatomical conditions and the degree of tooth structure destruction; e.g., reduced enamel by erosive tooth substance loss and/or carious lesions. In the patients of the present clinical investigation, the maximum preservation of the enamel was of primary interest, but minor dentin spots could not be complied within all preparation sites. The amount of dentin exposure was not quantified in this study.

In addition to the aforementioned necessary enamel structure, there are other major risk factors that must be considered when planning the exact extent and type of restoration, such as bruxism and existing root canal treatments.\textsuperscript{1,4,7,8} In the patients of the present prospective clinical study, most of the risk factors could be excluded; one limitation, however, was that patients with bruxism were not directly excluded, as no specific investigation of bruxism parameters was performed.

Since the veneer restorations were all part of full-molar rehabilitations, the minimally invasive full veneer preparation design was also chosen because of the need of VDI to fill the generated space between the palatal aspect of the incisors of the maxilla and the incisal edges and facial aspect of the mandibular anterior dentition. Adequate anterior canine guidance should be ensured in the anterior full veneer design, including the “freedom in centric posterior concept,” in order to avoid shear load on the posterior all-ceramic restorations.\textsuperscript{36–38}

There are numerous clinical studies, some with very long observation periods combined with a high number of restorations, investigating silicate ceramic veneers.\textsuperscript{1,39} In a systematic review and meta-analysis, the 5-year cumulative estimated survival rate for etchable nonfeldspathic porcelain veneers was identified as over 90%.\textsuperscript{40} No significant differences in strength were detected between different incisal preparation options with or without incisal coverage.\textsuperscript{41}

Fractures and chippings of all-ceramic veneers or of ceramic veneers on frameworks are still among the most frequent causes of complications and do not necessarily lead to a renewal of the restorations.\textsuperscript{3,42} This has been confirmed in the present investigation with veneered frameworks on the facial side. Despite the regular functional checks, a technical complication rate of 12.5% due to minor chippings and one crack as a consequence of an anterior trauma was observed. However, the small chippings of the ceramic veneer could be repaired with silicoating, silane coupling agent, and application of a flowable composite, as described in Results.\textsuperscript{42} All composite repairs were performed just once and checked in at annual check-ups. In addition, the crack after the incisal trauma was not repaired, but continues to be annually checked.

It has to be considered that most of the chippings occurred in one patient, although prosthetic treatment and the occlusal concept were performed identically. A possible explanation for this phenomenon is the reduced compliance of this specific patient, especially in wearing the splint during nighttime, when occlusal stress might be at its maximum. Bruxism could not be excluded, as technical measurements were not performed.

All full veneers are still in situ. The survival rate was therefore 100%, since no restoration had to be replaced. This is consistent with the results from another clinical trial in which full veneers demonstrated a survival rate of 100%.\textsuperscript{20} The question arises as to whether the complication rate would have been lower with unveneered (i.e., monolithic lithium disilicate) full veneers. Further clinical investigations that analyze the comparison between veneered and unveneered veneers, as well as different lithium (di)silicate ceramic materials, are necessary.

There are also other ceramic materials that could have been used as restoration materials, such as the newer highly translucent zirconia or feldspathic ceramics. So far, there are no scientific long-term data available on the novel translucent zirconia materials, especially for veneers. Additionally, this material was not available at the time of the beginning of the present study. In regard to veneers made of feldspathic ceramic, it was stated in a meta-analysis the survival rate of 87.0% was significantly lower than for veneers made of glass-ceramic (94.0%).\textsuperscript{43} This underlines the higher survival rates for ceramics with increased mechanical properties.\textsuperscript{28}

In another retrospective study including 318 veneers made of feldspar ceramics, leucite-reinforced glass-ceramics and lithium disilicate ceramics yielded calculated clinical survival rates of 93.5% after 10 years and 82.8% after 20 years.\textsuperscript{4} Marginal discoloration was analyzed as a minor complication; this occurred in 21.9% of cases, predominantly in smokers. In the present study, no
discoloration of the restoration margins was detected and the survival rate was higher. However, the mentioned clinical studies cannot be directly compared due to the different restoration geometry.

In the case of extensive restorations, the three-step technique described by Vailati and Belser could be an alternative to full veneer restorations. This technique first calls for closing the palatal space behind the maxillary anterior teeth that results from increasing the vertical dimension of occlusion with composite. In a second step, the labial surfaces receive adhesively luted ceramic veneers (the so-called “sandwich” technique). Even though no major complications have occurred after an observation period of up to 6 years, clinical long-term results of multi-center studies must be obtained in order to make a final assessment of this technique.

A comparison of survival and complication rates of full veneer preparations in contrast to conventional medium- or full-wrap veneers would also be interesting for the practitioner. Nevertheless, further clinical studies are necessary to substantiate the available results and to further analyze ceramic materials, as no further long-term results on full veneers are available in the scientific literature. Comparisons to the present prospective clinical study were therefore not possible.

One of the main limitations of the present clinical study is the small patient cohort of six patients. Therefore, the validity of the statistical analysis was reduced, and a bias caused by a single patient is high. Further clinical studies with larger populations and a higher amount of full veneer restorations are necessary to support these preliminary findings.

CONCLUSIONS

Based on these analyzed data, minimally invasive adhesively luted glass-ceramic full veneer restorations made of lithium disilicate ceramic might be a reliable treatment alternative to single full crown restorations on anterior teeth, but further clinical studies are essential to assess the long-term clinical outcomes.

ACKNOWLEDGMENTS

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REFERENCES


Literature Abstracts

**Association Between Periodontitis and Cognitive Impairment: Analysis of National Health and Nutrition Examination Survey (NHANES) III**

Periodontitis has been hypothesized to be one of the most common potential risk factors for the development of dementia and cognitive impairment. In order to investigate the relationship between periodontitis and cognition impairment, the National Health and Nutrition Examination Survey (NHANES) database was analyzed after adjusting for potential confounding factors, including age and other systemic comorbidities. In total, 4,663 participants aged 20 to 59 years who had received full-mouth periodontal examination and undergone the cognitive functional test were enrolled. The grade of periodontal disease was categorized as severe, moderate, or mild. Cognitive function examinations—including the simple reaction time test (SRTT), symbol digit substitution test (SDST), and serial digit learning test (SDLT)—were adopted for the evaluation of cognitive impairment. The subjects with mild periodontitis and moderate to severe periodontitis had higher SDLT and SDST scores (indicating decreased cognitive function) compared to the healthy group. After adjusting for demographic factors, education, smoking, cardiovascular diseases, and laboratory data, periodontitis was significantly correlated with elevated SDST and SDLT scores (P values for trends = .014 and .038, respectively) according to generalized linear regression models. This study highlights that periodontal status is associated with cognitive impairment in a nationally representative sample of US adults.

**References:** 49. Reprints: Wei-Liang Chen, weiliang0508@gmail.com — Carlo Marinello

**Immediate Versus Delayed Loading of Mandibular Implant-Retained Overdentures: A 60-Month Follow-up of a Randomized Clinical Trial**

The purpose of this observational, posttrial follow-up study was to evaluate 60-month outcomes of a randomized controlled clinical trial that compared immediate and delayed loading of two unsplinted implants supporting a Locator-retained mandibular overdenture. Patients from the trial treated with either immediate or delayed loading of two implants supporting a Locator-retained mandibular overdenture were recalled for a 60-month evaluation. Patients underwent clinical and radiographic examinations to evaluate the peri-implant soft tissue parameters and bone. Prosthetic maintenance needs and complications were also recorded. Of the 30 patients, 23 were available for recall. The mean radiographic bone level change from baseline to 60 months measured using standardized periapical radiographs was 0.89 mm (± 0.74) and 0.18 mm (± 0.41) for the delayed loading and immediate loading groups, respectively. A statistically significant difference was observed at 60 months, showing a smaller radiographic bone level change in the immediate loading group. No implants were lost between 12 and 60 months. At 60 months, the per-protocol implant survival rate was 100% for both groups. No difference was found in the peri-implant soft tissue parameters and prosthetic needs between the groups. Both immediate- and delayed-loading implants supporting a Locator-retained mandibular overdenture showed similar clinical outcomes.

**References:** 42. Reprints: Gian Pietro Schincaglia, gos0002@hsc.wvu — Carlo Marinello, Switzerland

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