PARTIAL CERAMIC CROWNS. ESTHETIC AND TISSUE CONSERVATIVE RESTORATIONS – PART II: ANTERIOR TEETH – LAMINATE VENEERS

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ABSTRACT

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Background: For anterior teeth with large defects or for teeth which need major changes in color, shape or size, laminate veneers are a highly esthetic and comparatively tissue conservative treatment option within a large group of other therapeutic measures. The survival rates of laminate veneers are > 90% over 10 years and in the range of full coverage crowns. For patients with heavy bruxism and/or small clinical crowns the longevity may be reduced.
Objective: to review the main guidelines for dental treatment using laminate veneers.
Data Sources: dental literature (Web of Science, PubMed, Google Scholar) about laminate veneers between 1998 and 2019.
Study Selection: articles, reviews and textbooks about laminate veneers were selected to obtain the most relevant information.
Data Extraction: all data evidence-based about laminate veneers technique were extracted.
Data Synthesis: all data considered important and relevant for the laminate veneers technique were presented step by step in a coherent and concise way.
The conclusions were:

- Preparation should be as conservative as possible (0.3 – 0.5 mm cervical-buccal reduction).
- Special methods for impression taking and for temporization should be applied.
- The ceramic material needs to have optimal esthetic properties including adequate translucency.
- The choice of the luting material is based on optimal bonding (etch & rinse, SE). Solely light curing luting composite materials or flowable composites can be used for optimal and long-lasting esthetics for ceramic thickness of up to 1 mm.
- In order to protect the laminate veneers against parafunctional forces during night sleep a protective splint (night guard) is recommended.

Keywords: Laminate veneers; dental ceramic; esthetics; dental light curing; flowable composite resins.

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1. Introduction

For anterior teeth with cavities extending into large parts of the buccal surface and potentially needing replacement of the incisal edge, the classical treatment method for many years has been a full coverage crown, either made of resin materials, ceramics, or combination of metals with (mainly) ceramics. In anterior teeth with smaller defects, major esthetic problems related to color, shape and size have also been reasons for full coverage of such teeth, consequently removing quite large amounts of sound tooth hard tissue [1]. However, for a number of years, adhesive technology has enlarged the spectrum of treatment options. Adhesively bonded resin-based composites can be used very successfully in many of such cases.
In more complicated cases, partial crown coverage of anterior teeth may be a treatment option, which has been successfully used in posterior teeth [2]. Fig. 1 shows a clinical case, where this technique has been applied. Such restorations are commonly named laminate veneers. They impress with optimal esthetics and require less removal of sound tooth tissue than full coverage crowns [1]. Part I of this article [2] focused on the restoration of posterior teeth with partial crowns, here our results over the recent 20 years and data from the literature with partial crowns in anterior teeth, i.e. laminate veneers are described. The objective of this article is to discuss whether this is a reliable treatment option, and to which critical points attention has to be paid in order to achieve a successful treatment outcome.

2. Definition

For anterior teeth, partial coverage (here mainly the buccal aspect) of the clinical crown by a restoration is also termed "laminate veneer". Some authors

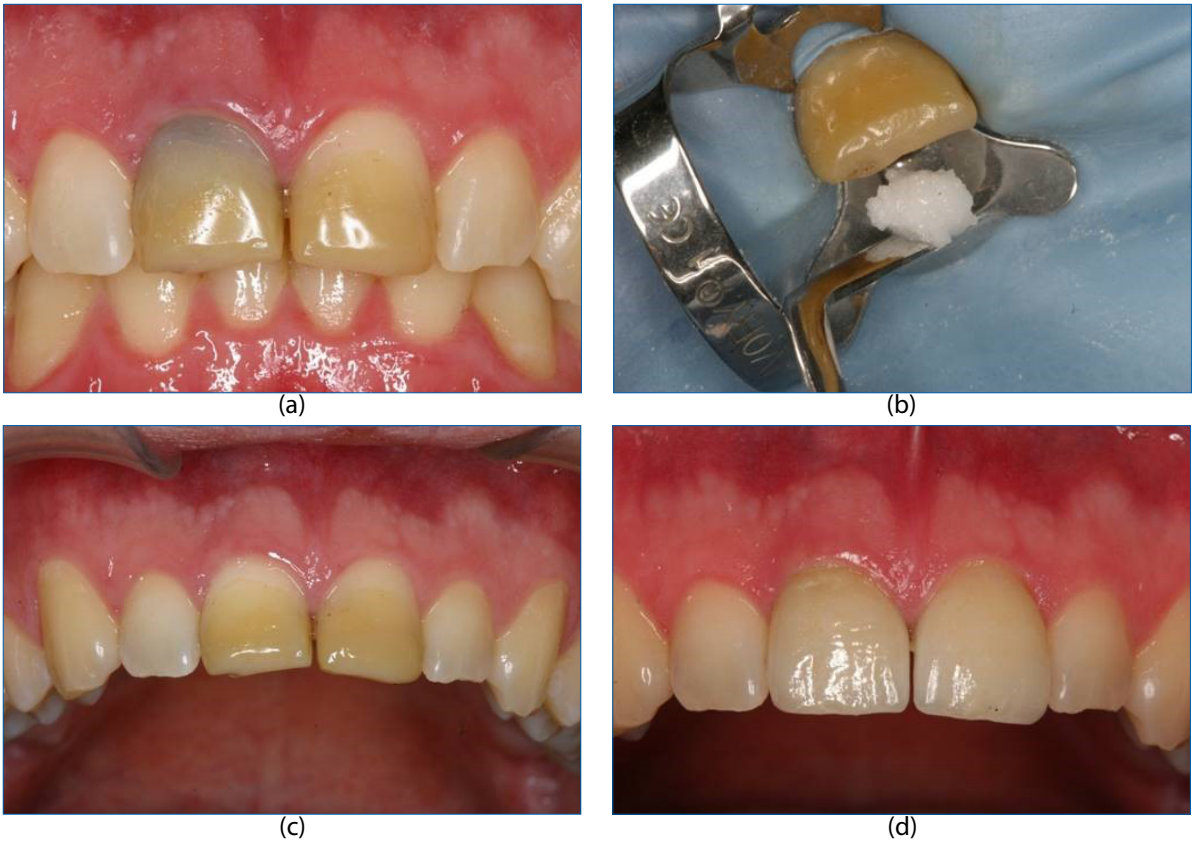


Figure 1. Restoration of severely discolored teeth with extended composite resin restorations (a); during and after internal bleaching (b,c); restored with two laminate veneers (d).

distinguish between (1) veneers with no or only a minor inclusion of the incisal edge and (2) anterior partial crowns with an extended inclusion of the lingual surfaces [3]. However, this subdivision appears somewhat academic and the terms partial crown in anterior teeth or laminate veneers are used synonymously in this review.

3. Longevity

A number of clinical studies on the longevity of laminate veneers have been published with varying observation times ranging from 40 months to more than 15 years. Similar to partial crowns in posterior teeth, the clinical survival rates of ceramic laminate veneers were rated to be very good and up to 40 months more than 93 % of the restorations were still in situ [4]. As laminate veneers are also used in teeth with existing composite restorations, it was interesting to analyze if such restorations have a negative influence on the general outcome for laminate veneers. Interestingly, no statistically significant differences had been observed in this study [4] between cases with and without composite restoration being present. Slight marginal defects (16 of 87 veneers) and slight marginal discoloration at the margins were observed (12 of 87 veneers), but no secondary caries or endodontic complications [4]. However, in another clinical study increased marginal problems have been reported, when the ceramic margin was in contact with composite fillings [5]. On tetracycline-stained teeth 99% out of 546 ceramic veneers were in situ after up to 2.5 years [6]. Also, after longer observation periods (7-year Kaplan-Meier survival rate) in a prospective clinical study a retention rate between 97.6 and 100% was reported [7].

After 5 years, Aristidis et al. recorded the clinical performance of ceramic veneers (61 patients) concerning esthetics, marginal integrity, marginal discoloration, fracture rate, and patient satisfaction. In this study, 98.4% of the veneers were satisfactory without intervention and the patient satisfaction was very high [8]. After up to 20 years, laminate veneers made of silicate glass-ceramic had an estimated survival probability of 93.5% over 10 years. Significantly increased failure rates were associated with bruxism and non-vital teeth, and marginal discoloration was worse in patients who smoked [9]. In a prospective study over ten years, ceramic veneers maintained their esthetic appearance. None of the veneers were lost. The percentage of restorations that remained "clinically acceptable" (without need for intervention) significantly decreased from an average of 92% (95 CI: 90% to 94%) at 5 years to 64% (95 CI: 51% to 77%) at 10 years. Most of them could be repaired, only 4 % needed replacement [5].

In another long-term study, the clinical performance of ceramic laminate veneers bonded to teeth prepared with the use of an additive mock-up and aesthetic pre-evaluative temporary technique (APT) was evaluated over a 12-year period. Briefly, with

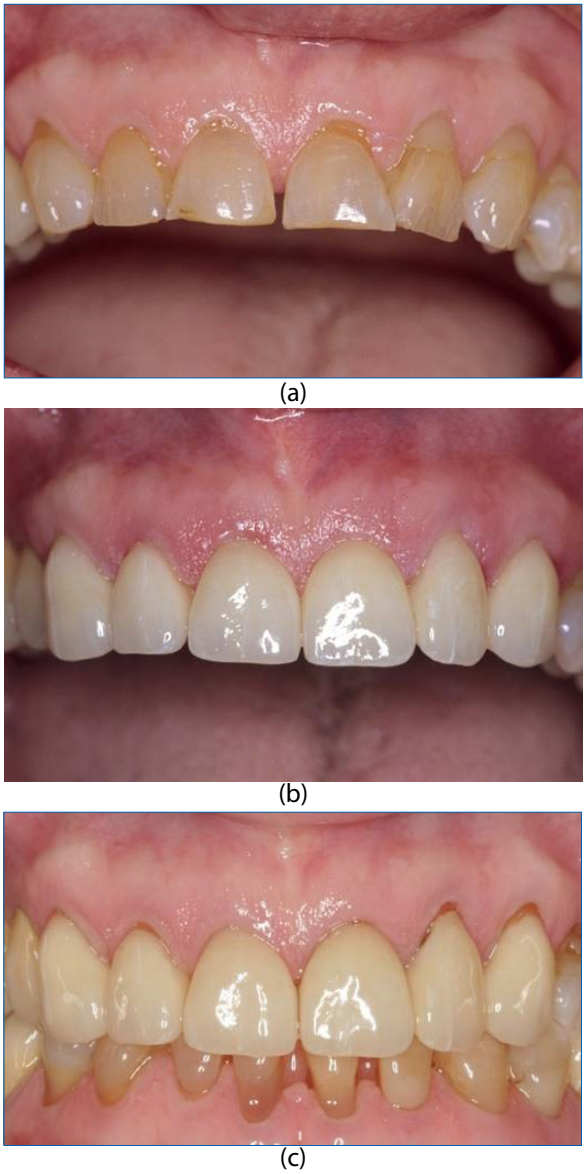


Figure 2. Restoration of severely discolored and abraded teeth (a) with laminate veneers (b) and control after 15 years (c); slight marginal discolorations are visible.

the APT technique the dentist creates an immediate mock up from composite resin in the patient's mouth, in order to design the outline of the veneers together with the patient. Then, this is transferred to the technician who produces a silicone index for further treatment. The preparation is performed in conjunction with this index, allowing for a minimally invasive approach. Sixty-six patients were restored with 580 porcelain laminate veneers. The technique used for diagnosis, esthetic design, tooth preparation, and provisional restoration fabrication, was based on the APT protocol. Over 80% of tooth preparations were confined to the dental enamel. Over 12 years, 42 laminate veneers failed, but when the preparations were limited to the enamel, the failure rate resulting from debonding and microleakage decreased to 0%. Ceramic laminate veneers presented a successful clinical performance in terms of marginal adaptation, discoloration, gingival recession, secondary caries, postoperative sensitivity, and satisfaction with restoration shade at the end of 12 years [10].

In a recent systematic review and meta-analysis, 13 publications have been included. The estimated overall cumulative survival rate was 89% (95% CI: 84% to 94%) in a median follow-up period of 9 years. The estimated survival for glass-ceramic was 94% (95% CI: 87% to 100%), and for feldspathic porcelain veneers, 87% (95% CI: 82% to 93%). It was not possible to perform a meta-analysis of the influence of enamel/dentin preparation on failure rates. Fracture or chipping of the ceramic was the most frequent complication, providing evidence that ceramic veneers are a safe treatment option that preserves tooth structure [11]. Fig. 2 shows an exemplary case, where laminate veneers had been controlled after 15 years.

All these results are in the same order of magnitude as survival data reported for all ceramic full coverage crowns, e.g. 95.4% - 94.5% after 5 years (reinforced glass ceramic: Empress) [12] or 94.8% or more in situ after up to 10 years (Li-disilicate) [13,14].

Problems may occur in teeth with small clinical crowns, when the size of the teeth shall be enlarged and the area for bonding becomes comparatively small. Heavy bruxism is generally considered to be a contraindication for laminate veneers [9], because strong horizontal forces (1) endanger the bond of the veneer to the tooth structure and (2) may lead to a fracture of thin incisal ceramic. Discoloration of the margins and wear of the luting material are also reported in the literature [5], especially for smokers [9]. The accuracy of fit with the aim of a small primary marginal gap, which has to be filled with the luting material, will reduce the wear. Furthermore, the correct choice and use of the luting material seems to be an important factor (see below). The above mentioned meta-analysis showed the following rates: debonding: 2% (95% CI: 1% to 4%); fracture/chipping: 4% (95% CI: 3% to 6%); secondary caries: 1% (95% CI: 0% to 3%); severe marginal discoloration: 2% (95% CI: 1% to 10%); endodontic problems: 2% (95% CI: 1% to 3%); and incisal coverage odds ratio: 1.25 (95% CI: 0.33 to 4.73) [11]. For non-vital teeth there is a slight chance for further discoloration after the application of laminate veneers, which was reported to result in minor esthetic problems [5].

Thus it can be concluded, that ceramic partial crowns/laminate veneers are a reliable treatment method in anterior teeth. They show survival rates, which are in the same order of magnitude as for full coverage crowns, but more sound tooth tissue is conserved. However, special techniques must be followed in order to keep failures at a minimum.

4. Which Ceramic?

In part I of this review the different ceramics available for ceramic partial crowns have been described and the reader is referred to this publication [2].

In anterior teeth, mechanical properties do not play such a great role as in posterior teeth; instead, esthetic considerations are of major concern. Esthetic properties are mainly related to the translucency of ceramics [15], which is defined as the extent to which light is diffused rather than reflected [16]. Extensive experiences exist with feldspathic ceramics and glass ceramic reinforced with leucite, less with (monolithic) lithium disilicate reinforced silicate ceramics, some of which are less transparent than glass ceramics [17]. Recently, translucent lithium-disilicate ceramic with two levels of translucency has been marketed, a high and a low translucency material [16]. For full coverage crowns few clinical studies with (monolithic) lithium disilicate ceramics are available and they report positive results [14,18]; for laminate veneers, clinical data using this ceramic are scarce. Zirkonia ceramics are comparatively opaque and are presently not used for laminate veneers [19]. With newer polymer containing/-based materials, which have to be milled, little clinical experience with laminate veneers exists for the time being.

Which ceramic to select? Over the recent 25 years the authors used mainly leucite reinforced glass ceramics, which were pressed and then individualized. If the restorations are produced in a dental laboratory, an experienced technician and a close communication between dentist and technician are essential. It is advisable that the technician should be present when selecting the tooth color and designing the shape of the veneers. Finally, the color of the prepared tooth has to be taken into account.

5. Which Preparation?

5.1. Ceramic thickness

In contrast to posterior teeth, the thickness of the ceramic is not mainly determined by the masticatory forces, but by esthetics and the idea of tooth substance conservation [20]. The determination of the appropriate ceramic thickness has, nevertheless, to take biomechanical aspects into consideration, which, however, are different in the anterior region of the mouth compared to posterior teeth, which have been described in part I [2]. Obviously, fracture resistance of ceramic will depend, beside other factors, upon the ceramic thickness [21]. Recently, Costa et al. [1] performed in vitro studies using FEA (finite element analysis) comparing 0.3 and 0.8 mm thick lithium disilicate ceramic used for veneering human canines. They found that 0.8 mm thickness was associated with better stress distribution and lower tensile stress concentration than 0.3 mm thickness; thus the authors concluded that higher ceramic thickness may contribute to higher longevity, although the maximum stress values did not overcome the material's limit to failure. Furthermore, Stappert et al. [22] investigated the fracture behavior of veneer ceramic (leucite-reinforced glass-ceramic) of 0.5 mm thickness in preparations with and without different methods of incisal coverage. After dynamic loading simulating 5 years of service, a significantly higher number of palatal cracks was found in ceramic with an extended palatinal preparation design (see also Fig. 4). Such cracks were found in areas of maximum stress concentration in natural teeth [23] and the results are in line with FEA analyses from Magne and Douglas [24] showing highest stress concentrations at the extended palatinal chamfer areas. Therefore, if such a preparation design is chosen, ceramic thickness at the palatinal site should be increased (for leucite-reinforced glass ceramic) to more than 0.5 mm. In vitro studies have also shown that the fracture resistance of laminate veneers with 0.5-mm preparation depth was greater than that of the 0.3-mm and 1-mm preparation depth [25], which, however, for the 1 mm thickness may have been due to the fact that the preparation mainly exposed dentin. It is generally accepted that the preparation should be kept – as much as clinically possible – to the enamel as bonding substrate and over-contour of the veneer should be avoided. On the other side, an adequate material thickness is needed for masking the discolored hard tooth tissues and to give the technician freedom for the esthetic design [26,27]. Form those and other studies it can be concluded that although a ceramic thickness of 0.3 – 0.5 mm has generally been recommended [26], it has to be adjusted to the individual clinical situation. Magne and Belser [20] have therefore recommended that in the cervical area the ceramic thickness should be 0.3 – 0.5 mm, in the middle third around 0.7 mm and at the incisal coverage at least 1.5 mm.

A completely different approach uses prefabricated veneers from ceramics (recently also from composite resins), which are adhesively luted to the unprepared or only slightly roughened enamel [28]. This is meant as a one visit, cost-effective alternative [28]. Reports on clinical outcome are scarce.

5.2. Enamel vs. dentin

As mentioned above, the bond strength of laminate veneers to enamel is generally regarded to be higher than that to dentin [29], although it depends on the adhesive system used. However, it has been recommended that the ideal preparation for laminate veneers should remain within enamel [30]. In a clinical study longevity of veneers with a preparation solely in enamel was better than in dentin, but the difference was not statistically significant [26]. A special problem is the extension into the cervical dentin for esthetic reasons. In vitro studies have shown that similarly favorable marginal adaptations of ceramic veneers to dentin and enamel can be achieved using high viscosity luting composites with their corresponding adhesive systems [31]. Cötert et al. however reported that a supragingival preparation had a significantly positive effect on the overall survival rate [26]. Furthermore, iso-or supragingival margins have a positive effect upon gingival health (Fig. 3).

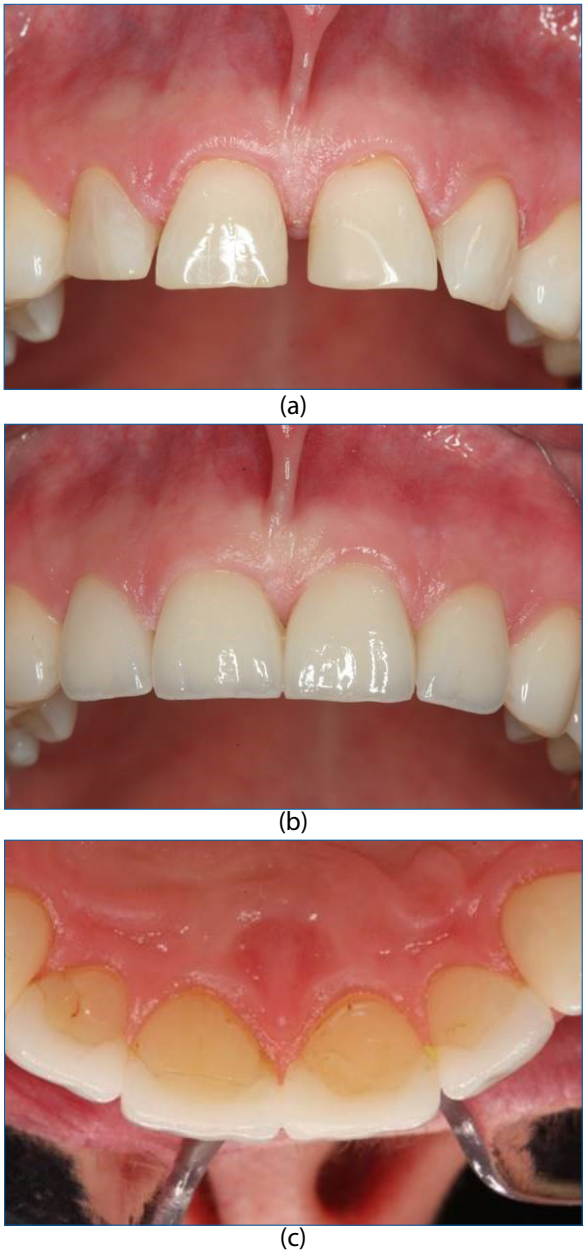


Figure 3. Restoration of a diastema and increasing tooth size (a): Iso- or supragingival preparation leads to optimal healthy gingiva (b): view from buccal; (c): view from palatinal).

Figure 4. Preparation design (from left to right) without incisal coverage, with horizontal coverage and with coverage combined with a small or extended palatinal chamfer/shoulder; view from (A): buccal, (B): approximal and (C): palatinal; palatinal chamfer is visualized by a line;
(Courtesy of Dr. F. Cieplik).

5.3. Incisal coverage

Both incisal coverage and non-coverage have been described in the literature (Fig. 4a-c) and the defect size primarily decides which preparation to choose. However, even if from this point of view an incisal overlapping is not necessary, an incisal overlapping has some clinical advantages. First of all, it may improve the mechanical properties of the laminate veneer [32] and it may result in better esthetics [27]. Finally it facilitates proper seating of veneers during luting. Cötert et al. reported that the overlapped incisal edge had a significantly positive effect on the overall clinical survival rate [26]. However, as a result of a meta-analysis of existing literature the estimated survival rate for laminate veneers with incisal coverage was reported to be 88% and 91% for those without incisal coverage [33]. In a more recent meta-analysis by Hong et al. [34] comprising 10 clinical studies, veneers with incisal coverage had a worse prognosis as compared to those without. However, the difference was not statistically significant. Apparently, horizontal mechanical forces which are directed to the incisal ceramic part are responsible for slightly lower survival rates of laminate veneers with incisal coverage. However, not only the thickness and the mechanical properties of the ceramic material play a role, but also the patient. Here, patients with a tendency to bruxism have been reported to have a higher failure rate [9]. This should be taken into account when planning the preparation. The incisal coverage may have different designs: a pure overlap by reducing the incisal part by about 2 mm or a further palatinal chamfer below the 2 mm reduction (see also Fig. 4).

Concerning marginal integrity and fracture resistance, no difference between the two designs has been reported in the literature [22,35], although one in vitro study indicated that deep palatinal chamfer or butt joint preparation will result in a stress concentration at the palatinal area and an increased ceramic thickness is recommended [22].

5.4. Preparation Margins

Proximal preparation design can be classified into "proximal chamfer" and "proximal slice" or "shoulder/butt joint" type preparation. Chamfer type approximal preparations proved in one study to reveal higher clinical success rates [26]. The interproximal extension of the preparation shall comprise the anatomical equator so that the cavity margins are beyond the visible area. It is a matter of discussion, if the contact points shall be resolved or if the veneer margin can be located in the contact point area. According to classical concepts, contact point areas are difficult to clean and thus prone for secondary caries. On the other side, appropriate oral hygiene; e.g. using flosses, can prevent secondary caries at contact point areas (Fig. 5). Resolving the contact point offers more

(a) (b)

Figure 5. Different preparations of the proximal area: (a) between 1.1 and 2.1 contact point was not resolved in order to save tooth structure; between 1.2 and 1.1 and between 2.1 and 2.2 the contact point was opened as a result of the tooth position of the lateral incisors; (b) final laminate veneer restorations.

(a) (b) (c) (d) (e) (f)

Figure 6. Different preparations:(a): shoulder preparation with a palatinal chamfer before preparation; (b,c): preparations; (c,d): inserted veneers; (e): another case of a palatinal chamfer preparation;(f): or incisal reduction without a chamfer.

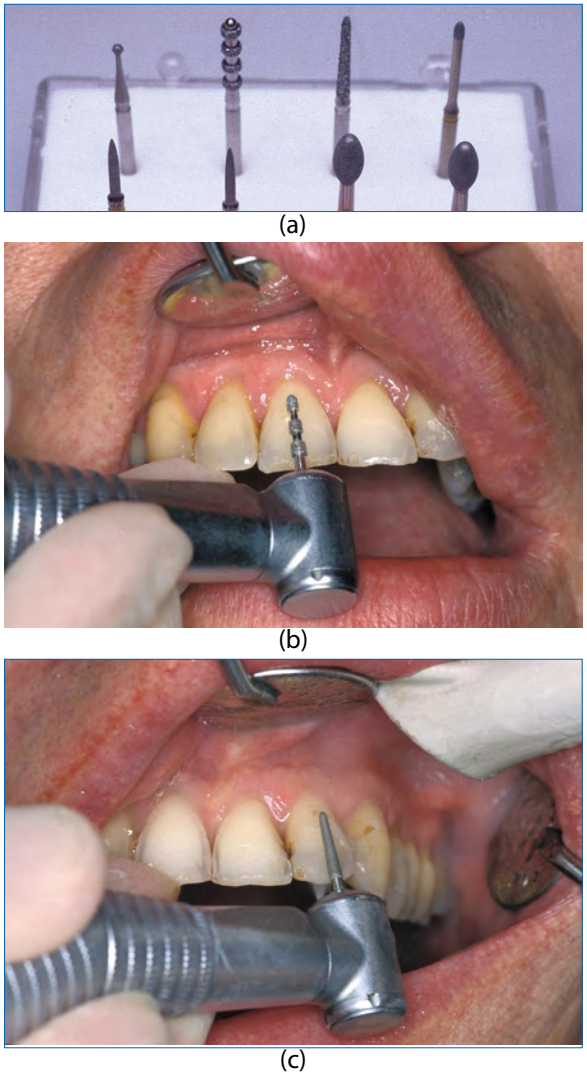


Figure 7. Selected preparation instruments: (a): instrument kit; (b): Instrument for determination the preparation depth;(c): finishing the preparation to improve adhesion.

options for the esthetic design of the interproximal area and the closure of "black triangles [27]. Buccal preparation can be performed as a chamfer or as a shoulder/butt joint (Fig. 6). What is important is that the margin of the preparation is clearly visible/detectable. Incisal overlapping of 2 mm with a palatinal chamfer preparation instead of a feathered incisal edge preparation are recommended by some authors [26,36]. According to a meta-analysis, a butt joint type preparation least affects the strength of the tooth and the chamfer preparation type is more susceptible to ceramic fractures [36].

5.5. Existing composite restorations

As has been lined out above, clinical studies indicated that the presence of composite resin restorations at the margins may influence the marginal quality [4]. However, data are inconclusive [4,5]. In an in-vitro study, the margins of luted veneers had the same morphological quality towards a composite resin restoration as compared to prepared enamel [37]. In any case, such fillings should be of optimal

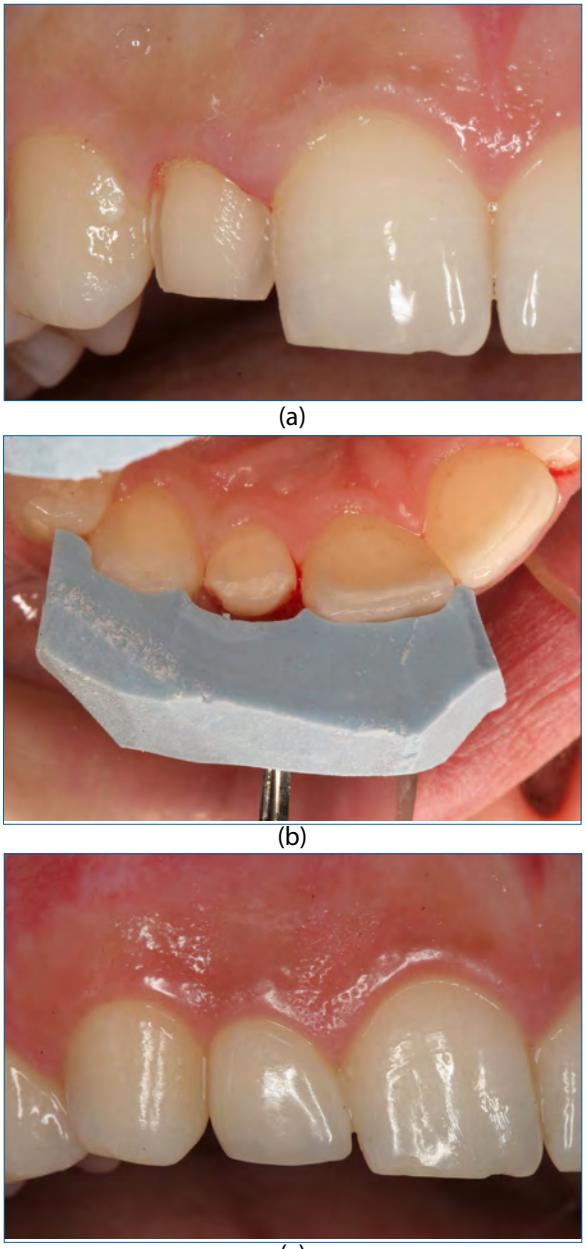


Figure 8. Preparation for a laminate veneer on tooth 1.2 (a); silicone index to control the preparation (b); final restoration (c).

quality and should be roughened. Some authors recommend acid etching to improve the cleaning effect and to roughen the exposed fillers [37].

5.6. Preparation instruments/guides

Special sets of preparation instruments are offered by industry (Fig. 7); A very helpful instrument is the one by which the maximum preparation depth can be defined. One way to control the preparation is to use a guide either made from orthodontic wire [38] or by an impression before the preparation (or from the mock up), which is reduced with a knife to the upper third of the tooth, which is being prepared (Fig. 8). Prepared tooth hard substance should be finished using a fine grid diamond (Fig. 7 c). From all information presented above on the preparation for laminate veneers it can be concluded that a preparation depth of 0.3 – 0.5 mm iso- or slightly subgingival in the cervical area

Figure 9. One-step impression for veneers on teeth 1.2 and 2.2 with foils separating contact points (arrows).

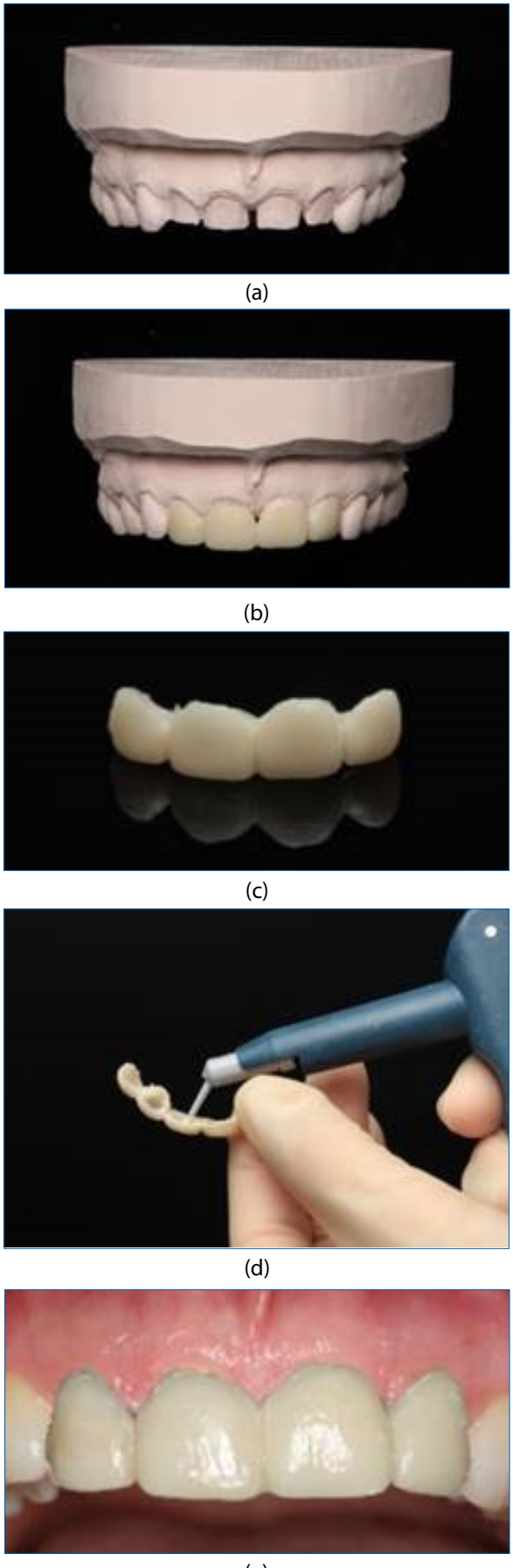
can be regarded as a general rule and thickness can vary from 0.3 mm in the cervical area to 1.5 or more in the incisal area; deviations are, however, possible and necessary in each individual case, e.g. due to tooth decay, extensive tooth discoloration or adjustment of alignment of teeth. Incisal coverage has a tendency to reduce longevity and here the patient situation (e.g. bruxism) should be taken into consideration and special measure like the application of a resin splint to be used as a night guard (see below) is highly recommended.

6. Impression

Basically, all routine impression techniques can be applied. However, especially if the contact points are not resolved, a one-step impression technique is advisable. It is helpful for the technician, if a small foil is placed in the contact point area during impression. Fig. 9 shows such an impression using a polyether impression material.

7. Temporaries

While temporaries for partial ceramic crowns for posterior teeth follow widely accepted techniques, temporaries for veneers in anterior teeth are challenging because generally little tooth substance has been removed. A classical method is that the teeth are prepared for veneers on a gypsum model and the dental technician produces such veneers according to the planned design/mock up. If more than one tooth has been prepared the temporaries are produced in one piece. They are then adjusted to the patient by relining with a flowable composite (Fig. 10). If more than one veneer is prepared, this relining will lead to a reasonable bond. If there are doubts, an adhesive can be used on a limited tooth area (spot etching). The use of a thermoforming sheet, which has been prepared on the mock up model and which is filled with a composite has also been recommended. However, meticulous occlusal adjustment in cases of incisal overlapping is necessary due to the thickness of the sheet material. Temporaries can be luted with non-eugenol



(a)

(b)

(c)

(d)

(e)

Figure 10. Temporaries: preparation on model (a); fabrication of temporaries on the model (b); temporaries polished (c); relining with a flowable composite (d); in situ (e).

cements, whereas the postulated influence of eugenol upon the bond strength of adhesives is a matter of discussion [39]. Alternatively, water diluted polycarboxylate cement (Durelon) has been recommended.

8. Which adhesive/ luting material?

8.1. Adhesive technique

Generally, laminate veneers must be luted using an adhesive technique and basically, the same materials and procedures can be used as for partial ceramic crowns in posterior teeth. However, there are some special points which have to be taken care of; optimal adhesion is of utmost importance as well as optimal and long-lasting esthetics. If the preparation is solely in the enamel, etch and rinse adhesives should be used, in other cases selective enamel etching using a universal dental adhesive (see below) is recommended.

8.2. Dual curing or light curing only?

For ceramic partial crowns in posterior teeth, generally dual curing luting composites are recommended [2].

However, especially for veneers, the use of purely light curing flowable composites was described, because a chemical initiating system used in the dual curing products was claimed to have a tendency for discoloration over time.

However, recently no difference was found in a clinical study related to color stability between a light cured resin composite and a dual curing luting material [40]. If veneers are luted with light curing only materials, the optimal quality of cure (polymerization) has to be guaranteed. In own in vitro studies on the curing of luting composites with and without chemical activation we could show that with highly transparent ceramics like leucite reinforced glass ceramics up to 2mm ceramic thickness, composite luting materials can be sufficiently cured without additional chemical curing [17].

The time of light application should be at least two-fold compared to the situation with an additional chemical activation. In a more recent in vitro study 1 mm thick specimens of a leucite reinforced glass ceramic and a lithium disilicate ceramic (slightly less translucent) were luted using composite resins with different shades with 1200 mW/cm^2 and an irradiation time of 20 seconds. The least opaque cements revealed the best mechanical data and there was no difference between the two ceramic materials [41].

In a clinical study, the delivery of laminate veneers using a direct restorative composite rather than a resin cement resulted in significantly less chipping and fractures, higher fracture strength in both accelerated fatigue and load-to-failure [42]. In a further clinical study with feldspathic laminate veneers over 7 years using a light cured composite resin for luting, a 90 % retention rate was observed (patient as statistical unit) or 97.5% (veneer as statistical unit) [43].

Again, the irradiation time was doubled. Therefore, indeed this method can be recommended for luting veneers; the time of light application should, however, be doubled (see below).

8.3. Universal adhesives

Generally, it should be taken into account that the chemical activators of dual curing luting materials are acid-sensitive and that these luting materials should basically not be used together with self-etching adhesives. However, recently, new dental adhesives were marketed containing MDP as adhesive agent.

These adhesives can be used together with an etch-and-rinse, a self-etch and a selective etch approach. Details have been described in part I of this article [2]. They can also be used together with dual-curing luting materials. However, this is manufacturer-specific and the instructions for use must be carefully followed [2] and special dual cure activators may be required. For this group of newly introduced adhesives (Universal adhesives) positive results have been found in a clinical study for partial crowns in posterior teeth [44], but little data are reported so far for laminate veneers.

8.4. Modification of color by luting material

Basically, it is possible to use luting materials with different color and thus influence the color of the restoration (fine tuning). However, the potential of such a fine tuning is limited. If the color of the veneer does not match, the veneer should be corrected. Generally, a rather translucent luting material is recommended in order to optically link the veneer to the tooth structure. If it is attempted to fine-tune the color by the luting material, this must be checked before the actual luting step by using a try-in paste.

8.5. Light curing

Appropriate light curing is essential for the successful outcome of the treatment. General problems of light curing have been delineated in part I [2]. General recommendations for the delivered energy to the composite luting material vary between 16 and 25 J/cm^2.

As the translucency of the veneer/luting composite system is dependent on a large variety of factors [41], recommendations for a prolongation factor are associated with a certain degree of uncertainty.

However, in the literature prolongation factors of two to -three-fold are described, which would mean for a standard light curing unit with an irradiance of around 1000 mW/cm^2 an irradiation time of at least (!) 40 seconds. The light source must be placed directly on the ceramic. Recently, a number of dental material experts met in Oslo and worked on a consensus statement on 'Light Transmission Through Indirect Restorative Materials' and 'Bioactive

Restorative Materials' [45].

Here are the most important facts:

- There is an exponential decline in the amount of light that reaches the bottom of the restoration as its thickness increases;
- to use the recommended adhesive - cement combinations, particularly when using self-etching universal adhesives together with dual-cure resin cements;
- to recognize that resins that are solely light-cured must receive sufficient light, to check the thickness of the restoration, and to stay within the cement manufacturer's instructions for use;
- to recognize that most "dual curing" resin materials benefit from receiving additional light exposure;
- to recognize that doubling the exposure time will not compensate for the reduction in transmitted light if the thickness of the restorative material has doubled (e.g., from 1.0 to 2.0 mm) [45].

9. Step by Step laminate veneers checklist

- **Case selection/Prevention program:** as has been lined out in part I for posterior teeth, also patients scheduled for laminate veneers must exercise an excellent oral hygiene because luting resins may enhance bacterial growth [46, 47]; smoking is discouraged as this increases marginal staining [9].
- **Indication:** e.g. cavities extending into large parts of the buccal surface and potentially needing replacement of the incisal edge, major esthetic problems related to color, shape, large size diastema or small corrections of dental malocclusions in the anterior part.
- **Pretreatment:** If teeth are heavily discolored; e.g. after endodontic treatment, bleaching of teeth (intracoronally or externally) is recommended well before the preparation for veneers (Fig. 1). As oxygen peroxide products are used for bleaching, clinicians should wait for at least 2 weeks after bleaching and before veneer treatment; during this time, residual oxygen, which may interfere with the resin setting reaction, can diffuse out of the tooth substances.
- **Diagnostic wax up/mock-up:** using composite resin, the effect of a veneer treatment can be simulated and the new size of the front teeth can be controlled together with the patient, e.g. concerning aesthetics and phonetics. An impression can be made and the technician can finalize the mock up and prepare a preparation guide.
- **Check for existing restorations** and replace if not optimal.
- **Preparation:** determine the preparation depths (e.g. 0.3 – 0.5 mm at the cervical buccal area) potentially using special preparation instruments (Fig. 7) and prepare the tooth preferably with a chamfer or a shoulder /butt joint. Use indexes made from mock-up models to control preparation (Fig. 8); use fine grid diamonds for finishing; for gingival retraction, use aluminum chloride chords.
- **Impression:** If contact points are not resolved, place thin foils at the contact point before (one phase) impression taking (Fig. 9).
- **Final determination of the color and the shape** of the veneers taking the color of the prepared tooth into consideration; this should preferably be done together with the technician in the dental practice.
- **Temporaries:** use individually prefabricated temporaries and fix them with a flowable composite resin (Fig. 10); alternatively, temporaries can be produced by filling a flowable composite into a splint, which has been produced on the mock-up model; or one can use an impression made from a mock-up model and fill it with an auto-polymerizing composite resin.
- **Try-in of the restoration:** remove all (!) remaining temporary cementation material from the tooth; cautiously adjust proximal contact points and occlusal surfaces avoiding any high pressure, because ceramic veneers are in this state highly prone to fractures. Use try-in pastes or petrolatum/glycerine in order to have optic connection between veneer and tooth, simulating the luting procedure and then control the color. Perfect color match must result from the veneer itself. Corrections of the color with the luting cement are generally not very efficient.
- **Pretreatment of ceramic/tooth:** Etching of ceramic, silanization and enamel/dentin pretreatment see part I [2].
- **Luting composite:** clean teeth thoroughly again, Ivoclean is a very useful substance; either dual curing cement or flowable composite can be used; in the latter case prolong the irradiation time as indicated by the manufacturer, as a rule of thumb two to three-fold compared to the situation without the ceramic veneer interposed. For the combination of self-etch/Universal adhesives and dual curing luting materials check with the manufacturer's instructions for use. If multiple veneers are to be luted (e.g. upper front), always lute two at a time, beginning with 1.1 and 2.1, then 1.2 and 2.2, etc. Coverage of the margins with glycerin gel before irradiation prevents the formation of a layer of low/non polymerized resins (oxygen inhibition layer).
- **Resin splint:** in order to protect laminate veneers – especially those with incisal coverage – against strong horizontal forces during bruxism during the night a resin splint (normally for the upper jaw) is recommended (Fig. 11).

Authors contribution

GS: Planning and writing the text. MF: Writing and proof reading the text.

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Questions

1. Which is the most important factor for reduced longevity of laminate veneers?

❑a. Extensive bruxism;
❑b. Patients older than 60 years;
❑c. Teeth with endodontic pretreatment;
❑d. Smoking.

2. When is an incisal coverage for a veneer preparation recommended?

❑a. For patients with insufficient oral hygiene;
❑b. For smokers;
❑c. For aesthetic reasons;
❑d. In young patients (younger than 20 years).

3. Preparation depth for laminate veneers is determined by

❑a. Patients 'demands;
❑b. Presence of composite restorations;
❑c. Size of defect, tooth discoloration and adjustment of teeth alignment;
❑d. Size of the tooth.

4. Luting of ceramic veneers can be done using

❑a. Always light curing only composite resins;
❑b. Light curing only composite resins together with a transparent ceramics up to 1 mm thickness;
❑c. Generally self etch adhesives with dual curing composite luting materials;
❑d. Light curing only composite resins together with transparent ceramics of up to 0.3 mm thickness.