



Clinical evaluation of 546 tetracycline-stained teeth treated with porcelain laminate veneers

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KEYWORDS

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Summary Objective. The purpose of this study was to evaluate the clinical result of 546 tetracycline-stained teeth restored with a porcelain laminate veneer system (Cerinate, Den-Mat, USA) for aesthetic reasons.

Methods. Tetracycline-stained teeth (546) were restored with a porcelain veneer system, and bonded with Ultra Bond resin cement. The restorations were recalled after 0.5, 1.5 and 2.5 years, respectively. Modified Ryge criteria were used to evaluate the veneers marginal adaptation, interfacial staining, secondary caries, postoperative sensitivity and the patients' satisfaction of the colour of the restorations.

Results. This study found that 99% veneers had excellent marginal adaptations; and less than 1% veneers required rebonding in the first 6 months; the colour of the veneers was stable and no evident staining was found. Almost all patients were satisfied with the colour match of their restorations 1 year after placement.

Conclusions. The research indicated that the porcelain veneer restoration system under investigation provided a reliable and highly satisfactory choice for the aesthetic restoration of tetracycline-stained teeth.

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Introduction

During the past 20 years, dentists have applied veneers to teeth using various techniques to correct esthetic problems. The many materials

and techniques available for veneers can be divided into three categories:^{1,2}

1. free-hand-placed, direct composite resins;
2. performed acrylic laminates;
3. laboratory-fabricated acrylic resins, composite resins, porcelains and glass ceramic veneers.

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Though many veneer techniques are acceptable, porcelain and other all-ceramic veneers are rated as the best veneer restoration.³ The technique of

etching and silanating porcelain veneers before they are luted with composite resin, has become popular since Simonsen, and Calamia et al.⁴⁻⁶ first reported it in 1980s. The use of porcelain veneers and other all-ceramic restorations to restore discolored or malformed anterior teeth has become a significant component of esthetic dentistry in the past decade.^{2,3} Although some dentists were initially concerned as to potential longevity,⁷ many clinical studies have testified to the porcelain veneers' clinical life expectancy.^{2,3} However, many of these studies were primarily concerned about the overall applications of porcelain veneers, and little specific research had been focused on the treatment of discolored teeth. In this study, we evaluated 546 medium to heavily tetracycline-stained teeth of 54 patients treated with a porcelain laminate veneer system (Cerinate, Den-Mat Corporation, USA). The purpose of the study was to evaluate the clinical result of porcelain veneers used in the treatment of discolored teeth, for which the opaque materials are often necessary.

Materials and methods

Selection of patients and pre-operative preparation

All participants of this study were selected from among the Fourth Military Medical University Dental Hospital patient population. All patients hoped to have their teeth treated for the tetracycline stain or other aesthetic concerns such as fluorosed enamel, tooth discolouration after endodontic treatment, etc. Only those teeth treated for tetracycline staining were recalled for the purpose of this study. All the patients selected porcelain veneers after they were informed about other possible choices, including: veneering with direct light curing composite resin and indirect composite resin; placing full-coverage crowns; bleaching the teeth, etc. To avoid the immediate adverse effect of bleaching on the bond of porcelain veneer materials to bleached tooth structure,⁸⁻¹⁰ three patients were excluded from the study for their restorations were finished after their teeth had been bleached with a night guard bleaching technique. No patient was excluded because of the staining was too severe.

Once the patient was entered into the study, his or her teeth were cleaned to remove extrinsic stains and dental calculus. Patients were informed about the need for good gingival health and the patients were educated in effective plaque control. Because patients generally asked to have their

stained anterior teeth treated simultaneously, the shade was matched to shade of the patient's complex or premolar shade. To simplify clinical evaluation and relate the degree of discolouration to the opaquing approach, the discolouration was just classified in this study as (1) slight discolouration: slight to medium yellow staining and no opaque porcelain was employed when the veneers were being built up; (2) severe discolouration: deep yellow, gray even black staining and opaque porcelain was incorporated when the veneers were being built up.

Both pre-operative and postoperative photographs were taken for each patient in order to evaluate the change in appearance.

Tooth preparation was based on the technique described by Christensen.¹¹ The labial enamel was reduced approximately 0.75 mm in the incisal one-third of the crown, decreasing gradually to 0.25 mm in the cervical region in order to create space for the veneer restoration. No overlap preparation was made at the incisal edge. If the tooth was worn short incisally, it was veneered labially and extended incisally with the veneer restoration, without overlapping to onto the palatal surface. A full coverage crown was recommended for patients if their teeth had lost more than one-third of their length, and these teeth were excluded from the observation. Proximal preparation was ended at the contact area, but when proximal caries were detected or the colour of the tooth was too dark the preparation was extended through the contact areas. After preparation, impressions were taken and poured in die stone and sent to the Cerinate porcelain veneer laboratory in Jinan China, to fabricate the restorations. The first appointment finished after the recall card was completed, including details of the patient's name, address, contact details, etc.

Bonding and finishing of the veneers

Patients were recalled for restoration when the etched silanated veneers were ready. Before luting, we reapplied a silane-coupling agent onto the bonding surface of the veneers. After cleaning, teeth were etched with a 37% phosphoric acid solution, rinsed with water, and then dried with compressed air. If the dentine was involved in the bonding surface, care was taken to keep the dentine surface moist for bonding. Tenure (Den-Mat Corporation, USA) bonding agent was then applied to both the etched enamel and dentine surfaces. The luting composite was placed evenly over the veneer's bonding surface before it was placed onto the tooth surface and the veneer was pressed lightly to place

with finger pressure. A soft brush with a fine tip was used to remove excess luting material extruded from the veneers' margins. The veneers were light cured with a light-curing unit (Spectrum 800, Dentsply) at an intensity of 400 MW/cm² for 40 s at both labial and marginal areas respectively. The margins of the veneers were then finished with a Komet super fine polishing diamond bur #858UF or #859UF (Gebr. Brasseler, Germany) and checked with a dental probe. The occlusion was checked and adjusted and the contact areas were separated with a Cerasaw (Den-Mat, USA) if necessary. Next the proximal areas were polished with a Visionflex diamond polishing strips (Gebr. Brasseler, Germany). The patient was initially recalled after 1 week for re-checking occlusion, proximal contact relationships, marginal integrity and gingival margin health. This recall was set as the baseline.

Opaquing approaches and luting composite resins

All veneers were bonded with Den-Mat Ultra-bond veneer bonding material, a dual-curing composite resin, which contains an opaque component. Three opaquing regimes were used to correct the discolouration of the teeth.

Approach 1: If the discolouration was not heavy or the veneer was thick enough to mask the base

shade, no opaque porcelain or composite resin opaque was used; to check that no composite resin opaque was necessary for veneers that had been built up without opaque porcelain, the veneers were first tried to the teeth with the luting composite resin. Only when both patient and operator were satisfied with the shade of the restorations could the veneers be luted, otherwise, the following approach was applied.

Approach 2: To correct the tooth shade, the composite resin opaque was mixed with the bonding composite resin. When this method was used, a try-in step was necessary to verify the shade and densify the correct proportion by volume of the opaque to be incorporated into the mix.

Approach 3: If the discolouration was more serious, an opaque porcelain was applied when the veneer was being built up, and the veneers were luted with the composite resin containing resin opaque, based on the procedure described in Approach 2.

Recall

All 54 patients with 546 veneered teeth were recalled 6 months after they received treatment. Kihn and Barnes¹² recall method, which was also modified from Ryge Criteria, was used to evaluate the restoration. The criteria and evaluation grades that were used are shown in Table 1.

Table 1 The criteria applied to evaluate the restorations.

Characteristics	Rating			
	Alfa (A)	Bravo (B)	Charlie (C)	Delta (D)
Colour satisfaction	Both patient and dentist are very satisfied	Patient or dentist is satisfied	The colour was acceptable	N/A
Marginal adaptation	No visible evidence of a crevice along the margin that the explorer will penetrate	Visible evidence of a crevice along the margin that the explorer will penetrate	Explorer penetrates crevice, reaching dentine, or base is exposed	Restoration is mobile, fractured or missing
Cavosurface marginal discolouration	No discolouration anywhere on the margin between the restoration and the tooth structure	Discolouration present, but has not has penetrated along the margin in a pulpal direction	Discolouration penetrated along the margin in a pulpal direction	N/A
Secondary caries	No caries as evidenced by softness, opacity or demineralisation at the margin of the restoration	Evidence of caries at margin of the restoration	N/A	N/A
Postoperative Sensitivity	No postoperative sensitivity	postoperative sensitivity	N/A	N/A
Gingival tissue response	Healthy and no tooth calculus formed	Calculus or gingivitis detected	Gingival tissue swollen or bleeding	Pocketing present

N/A, not applicable.

Table 2 The veneers (percentage) evaluated at different time period (year).

Time	Baseline	0.5 year	1.5 year	2.5 year
Number	546 (100)	520 (95)	350 (90)	176 (80)

Results

Eighteen male patients and 36 female patients received the treatment and took part in the clinical investigation. Ninety two teeth of 11 patients classified as severely discoloured were restored with veneers containing opaque porcelain. Four hundred and fifty four teeth of 43 patients were classified as slight to medium staining and they were restored with veneers containing no porcelain opaque component. All of the treatments were finished by the first author (JH Chen) or under the guidance of the first author. In order to keep the standardise recall result, the first author did the recall evaluations alone (126 veneers of 12 patients that could be easily evaluated and graded) and took part in all other recall evaluations. When disagreement happened on grading the restorations, a discussion was conducted and the patient's teeth history record was also considered to help the evaluation. A total of 546 teeth were evaluated at baseline. Ninety-five percent of the veneers were

evaluated after 0.5 year; 350 veneers were re-assessed after 1.5 years (approximately 90%); 176 teeth were re-evaluated after 2.5 years (approximately 80%); the recalled veneers and periods are summarized in [Table 2](#).

About 40% of the total of the treated teeth (226 teeth) had initially been treated with the direct composite resin veneers before they were re-treated in this study. The results are shown in [Table 3](#). Eighty to hundred percent of the patients were recalled and evaluated, so the results are considered to be representative of the treatment. Among the veneers evaluated, only four veneers debonded during the first 6 months. No other debonds occurred after the restorations were rebonded. At 6 months recall, 26 veneers were lightly discoloured at cavosurface margins. No discolouration recurred after these veneer margins were re-polished. Twenty percent of the patients experienced sensitivity during the first 2 weeks but this disappeared within a fortnight in all cases. Both dentists and patients were satisfied with most of restorations shade. Fourteen veneers of two patients restored with the veneers containing porcelain opaque were rated B for their shade match, which was about 15% of the restorations placed for severe tooth staining, but only 2.6% of restorations (one patient with 12 veneer restorations) for slight to medium tooth staining were rated B for shade match. Slight gingival swelling or

Table 3 Results of recall evaluation using modified Ryge criteria.

Rating	Number (percentage) at study checkpoint			
	Baseline (N=546)	0.0.5 year (N=520)	1.5 year (N=350)	2.5 year (N=176)
<i>Marginal adaptation</i>				
A	520 (95)	468 (90)	308 (90)	150 (85)
B	26 (5)	48 (9.2)	42 (10)	26 (15)
D	0 (0)	4 (0.8)	0 (0)	0 (0)
<i>Cavosurface discolouration</i>				
A	546 (100)	494 (95)	350 (100)	168 (95)
B	0 (0)	26 (5)	0 (0)	8 (5)
<i>Secondary caries</i>				
A	546 (100)	520 (100)	350 (100)	176 (100)
<i>Postoperative sensitivity</i>				
A	435 (80)	520 (100)	350 (100)	176 (100)
B	111 (20)	0 (0)	0 (0)	0 (0)
<i>Satisfaction with restoration shade</i>				
A	520 (95)	470 (90)	350 (100)	176 (100)
B	26 (5)	14 (3)	0 (0)	0 (0)
<i>Gingival tissue response</i>				
A	546 (100)	500 (96)	322 (92)	159 (90)
B	0 (0)	20 (4)	28 (8)	17 (10)

marginal gingivitis was noted for 28 veneers (8%) at the 1.5 year recall and 17 veneers (10%) at the 2.5 year recall. Re-contouring to correct plaque retention factors was needed in these cases.

Discussion

A significant body of research has made it clear that grit blasting and etching the porcelain surface combined with the use of a chemical coupling agent co-operate in the bonding of composite resins to porcelains.^{13,14} Based on this research the bonding of composite resins to porcelain materials is now considered routine. The fact that less than 1% of the veneers debonded during the first 6 months of this study also testifies to this. Three veneers had small crack lines of no clinical significance.

Though different opaquing methods were applied to mask the tooth discolouration, no difference was found on the debond rates of the veneers. So, the different opaquing methods did not affect the bonding of veneers to the teeth. Fourteen veneers of two patients with severe teeth restored with the veneers containing porcelain opaque were rated B. This was about 15% of the restorations required for severe staining teeth. However, only 2.6% restorations' (12 veneer restorations of one patient) made for slight to medium tooth staining were rated B. In total, about 5% of the veneers' were rated B for shade match at the base line and this figure decreased to 3% at 6 month recall. Because the porcelain is semi-translucent, it may produce a whitish colour when opaque porcelain is used as a component in the veneer. This was the main reason for dissatisfaction with the colour of the veneer restorations as noted before. Therefore, care must be taken in regard to the colour treatment of the tetracycline-stained teeth. However, because the patients readily detected the change of their tooth shade, it was found they were more easily satisfied with the shade of restorations than the dentists were. No patients rejected the shade of their restorations, so the shade rating of the restorations was mainly decided by the dentists' judgement.

Cutting the labial enamel may give space for veneer restoration, which is important for colour correction and maintaining arch form. This may cause the dentine exposure (usually, dentine near cervical region was easily exposed for the thinner enamel thickness at the region) and sensitivity after the veneers are bonded. This sensitivity, however, disappeared in all cases within 2 weeks.

During patient recalls, we found that good marginal adaptation and correct veneer contour

were very important for gingival health. If the margin of the veneer was over-contoured, the gingival margin would become swollen and inflamed. If no corrective treatment were given promptly, marginal gingivitis and pocketing would occur. The results of this study were similar to previous reports in this respect.^{2,12,15} In this study about 40% of the treated teeth ($N=226$) had initially been treated with direct composite veneers. Attempting to bond porcelain laminate veneers to an existing composite restoration increases the chance of failure.¹⁶ This may be overcome by replacing such restorations at the visit when the veneer is fitted if they are too extensive to be eliminated by standard veneer preparation.

Conclusions

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

1. the porcelain veneer restoration system tested is a reliable and effective treatment for tetracycline-stained teeth;
2. correctly contoured and finished porcelain veneer restorations did not adversely affect health of the margin gingivae. No marginal discolouration was found around the restorations. The veneer restorations were effective in correcting the colour of tetracycline-stained teeth.

Acknowledgements

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