Diagnostic wax-up as a guide to ceramic veneer preparations

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Abstract: Tooth preparation, when necessary, is one of the most important considerations in the fabrication of porcelain laminate veneers. Bonding to enamel provides strongest bond values when compared to dentin. This way, the focus on tooth preparation is to be conservative in the reduction of sound tooth structure, aiming longevity. At least two different strategies for tooth preparation can be found in the literature. Simplified protocols included the use of depth cutters guided by the existing tooth surface. That approach did not take into consideration alterations of the tooth due to aging, wear, or loss of enamel and thus led to greater risks for dentin exposure. More sophisticated methods have integrated an additive diagnostic procedure (wax-up or mock-up) to simulate the aimed restoration anatomy. This approach allows for more enamel preservation and, as a consequence, more predictable bonding, biomechanics and esthetics. The present article reviews the existing literature regarding tooth preparation for porcelain laminate veneers, and illustrates in detail the technique for tooth preparation based on a diagnostic wax-up of the final restoration. **Keywords:** Dental veneers. Ceramics. Tooth preparation.

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INTRODUCTION

Porcelain veneer restorations are some of the most conservative esthetic procedures in contemporary dentistry. Since they were first used, almost 30 years ago, the key to long-term success has been their appropriate indication and the use of adequate techniques. Retrospective longitudinal studies have reported a success rate of about 94% at 10-15 years, and tooth preparation, when necessary, plays a greatly relevant role in this technique.[2,4]

The ideal preparation for porcelain veneer restorations should allow dental prosthetic technicians (DPT) to fabricate restorations that integrate to the patient's oral and facial characteristics with perfect marginal adaptation.[5] The preparation of porcelain veneers differs from that of conventional veneers, as in the case of full prostheses, especially in terms of retention and bond strength. Veneers do not primarily require tooth preparation, and preparation design is a secondary factor for porcelain veneers; however, some small amount of preparation may make it easier to position and adapt porcelain restorations during cementation. As it is a minimally invasive procedure, there is substantial preservation of the dental tissue during preparation. Therefore, it as a conservative approach that corresponds to, at the most, 50% of the tissue reduction necessary for full ceramic crowns.[6,7] The longevity of porcelain veneers is directly associated with adhesion to dental enamel. Some studies recommend that the veneers should be about 0.3 to 0.5 mm thick in the middle and incisal thirds, and at least 1.5 mm thick at the incisal surface.[4,5,8] Ensuring the accuracy of these measures is an essential step in dental preparation, because these values are associated with final volume and anatomy of the restorations.[5]

Technical differences in the preparation of porcelain veneers have been described in the dental literature and are discussed in this study.[5,9] Special attention is also given to the illustration of the technique used for the dental preparation required for porcelain veneers according to a diagnostic wax-up, which promotes in a more conservative procedure and quite predictable outcomes.

INDICATIONS AND CONTRAINDICATIONS OF PORCELAIN VENEERS

Porcelain veneers should be used as a conservative solution for esthetic problems.[5] They are primarily indicated for darkened teeth with disagreeable shape and contour or reduced size or volume, or for diastema closure.[10] Additionally, porcelain veneers may play an important role in the restoration of teeth that have lost structure due to trauma or disease. In 2002, Magne and Belser[5] described the following classification and corresponding indications for the preparation of porcelain veneers:

Type I: teeth resistant to bleaching;
Type IA: tetracycline discoloration; and
Type IB: teeth unresponsive to bleaching.
Type II: major morphologic modifications.
Type IIA: conoid teeth;
Type IIB: diastema or interdental triangles to be closed; and
Type IIC: augmentation of incisal length or facial prominence.
Type III: extensive restorations.
Type IIIA: extensive coronal fracture;
Type IIIB: substantial loss of enamel by erosion or wear; and
Type IIIC: generalized congenital malformations.

According to this classification, the use of porcelain veneers with minimal or no prepara-

tion may result in the desired esthetic results in a conservative manner for types I and II. Type III cases require more extensive preparation, as their treatment objectives are more focused on the recovery of proper function. (11)

Below are the contraindications for the use of porcelain veneers:

1. Teeth exposed to heavy occlusal forces, as indicated by moderate to severe wear due to bruxism;
1. Malpositioned teeth. In these cases, the dentist has the ethical obligation of explaining the possibility of correction by orthodontic treatment and of clarifying its benefits before suggesting veneers;
1. Periodontal disease;
1. Highly fluoridated teeth - these teeth may resist acid etching, which may affect restoration retention;
1. Teeth for which color may be modified using bleaching techniques; and
1. Teeth with extensive restorations.[11]

PREPARATION DESIGN

The esthetic demands in our society have intensified the use of porcelain veneers in dentistry. Survival rate of porcelain veneers at 15 years is 93%,[4] and the success of this technique may be assigned to dental structure preservation, reliable adhesion to enamel, good esthetic results and color stability. Despite the high clinical success rate, several factors may affect the long-term prognosis of porcelain veneers, such as the dental surface to which the veneer is bonded, porcelain veneer thickness, type of cement used, parafunctional habits and preparation design.[12]

Preparation design is one of the most controversial aspects of the use of porcelain veneers. Typically, three types have been described: 1) window preparation, limited to the buccal surface of the tooth; 2) preparation with an incisal reduction shoulder; and 3) preparation with incisal reduction shoulder and palatal chamfer (overlap).[1,14]

Window preparation has fracture resistance values similar to those of unprepared teeth.[1,14] This type of preparation may be an option when tooth resistance is the main objective. However, it may result in an incisal edge without enough thickness for the veneers and in reduced remaining dental tissue. Moreover, resin cement bonds to the longitudinally-oriented enamel prisms, which poses greater risks of bonding failure.[1]

To prevent fracture of this thin incisal edge, an incisal reduction shoulder has been adopted. It increases the adhesion surface area and promotes better distribution of occlusal forces.[1,14]

The incisal reduction with palatal chamfer should be avoided because it does not increase resistance nor veneer bonding strength, but results in a thin porcelain veneer in the palatal concavity, an area of high traction forces.[1,14] However, a study using three-dimensional finite element analysis showed that this type of preparation results in better stress distribution.[1,15] A recent in vitro study revealed that the use of a palatal chamfer significantly increased resistance to fracture of restored teeth in comparison to those with an incisal shoulder. However, the method used in that study may be questionable, as there has been no standardization of thickness of bonded restorations, preparation design, specimens used (teeth) or forces applied at cementation, and no attempt to simulate the conditions found in the mouth.[16] Moreover, an in vitro study compared useful life of porcelain veneers under cyclic fatigue and showed that the use of a palatal chamfer significantly increased

useful life in comparison to incisal shoulder preparation.[13] These findings are in contrast to the results of a recent prospective clinical study, which did not find any statistically significant difference between palatal shoulder and incisal shoulder preparations.[17]

The studies about interproximal extension of the preparation have not yielded any conclusive evidence of which technique is better. The current recommendation is to extend preparation to hide the interface between the tooth and the restoration. The amount of extension should be decided by the dentist based on each specific case and tooth.[11] However, there is a consensus in the literature that, in case of diastema closure, preparations should extend proximally and toward the gingiva for better results.[5]

The decision about the cervical limit of preparations should be made according to substrate color. For darker teeth, the ideal is to take the limit of the veneer into the gingival sulcus, whereas in lighter teeth, the preparation may be taken to the gingival or even supragingival level without greater problems.[5]

More importantly, the types of preparations described above for porcelain veneers may be produced using two approaches: one according to the existing dental structure, and the other, according to the desired final restoration volume.

CLINICAL CASE REPORT

A 29-year old man was referred to our service for closure of the diastema in the anterior region of the maxilla after orthodontic treatment. The root exposed under the crown of tooth #11 and the buccal wear of tooth #21 also bothered the patient (Figures 1 a, b, c and d). After clinical examination and analysis of radiographs and diagnostic wax-up (Figure 2), the treatment suggested was diastema closure using resin in teeth #13, #12, #22 and #23, replacement of the crown of tooth #11 and placement of a porcelain veneer on tooth #21.

Using the diagnostic wax-up, a silicone guide was prepared for buccal reduction. (Figures 3 a, b, c and d). This guide should be well adjusted. For adequate stability, the silicone guide should extend posteriorly to two teeth after those that are prepared bilaterally. The buccal reduction guide should be cut horizontally, so that the thickness of reduction in the cervical, middle and incisal thirds can be checked visually (Figure 3e). Using a periodontal probe, the dentist may measure the space available for the veneer starting at the guide, so that a thickness of about 0.3 mm to .5 mm in the cervical third and 0.5 mm to 1 mm in the middle and incisal third may be communicated to the DPT.

A silicone guide that adapts to the palatal surface of the teeth is also important to control the incisal reduction of the preparation (Figures 4a and b). Also, the silicone guide should extend to two teeth posterior to the teeth that receive the preparation bilaterally, so that more stability is achieved.[18]

Figures 3 and 4 illustrate the importance of a diagnostic wax-up for porcelain veneer preparation and sculpture with resin in teeth #13, #12, #22 and #23.

Finishing included slight proximal separation for adjacent teeth, so that there is a better definition of margins during impression and easier subsequent fabrication of plaster models in the prosthetic laboratory. Transition angles should be made slightly rounded by drilling with slow-rotation flexible discs.[5] One last and essential procedure before impression is immediate dentin hybridization, or, rather, the identification of possible areas of exposed dentin and their sealing with a dentin adhesive.[14]

These procedures ensure that the adhesive interface is less permeable to the passage of water and more resistant to degradation.[21] They should be performed before the impression is taken, because the increase in the cement film thickness may affect veneer adaptation.

After final impression, the provisional is fabricated using a bis-acrylic composite resin added to a silicone tray made from the diagnostic wax-up (Fig 5). In the case reported here, no provisional cementation was necessary because stability and retention of provisional restorations were satisfactory. However, this should be assessed for each individual case.

A photograph showing the color of dental substrate, as well as of adjacent teeth, should be sent to the DPT (Fig 6).

The preparation sequence described above allows the DPT to meet the highest standards and to fulfill all the esthetic, biological (adaptation) and functional requirements. The final result is shown in Figures 7.

Figure 1: Initial photo - **A)** Smile. **B)** Close-up. **C)** Right side. **D)** Left side.

Figure 2: Diagnostic wax-up.

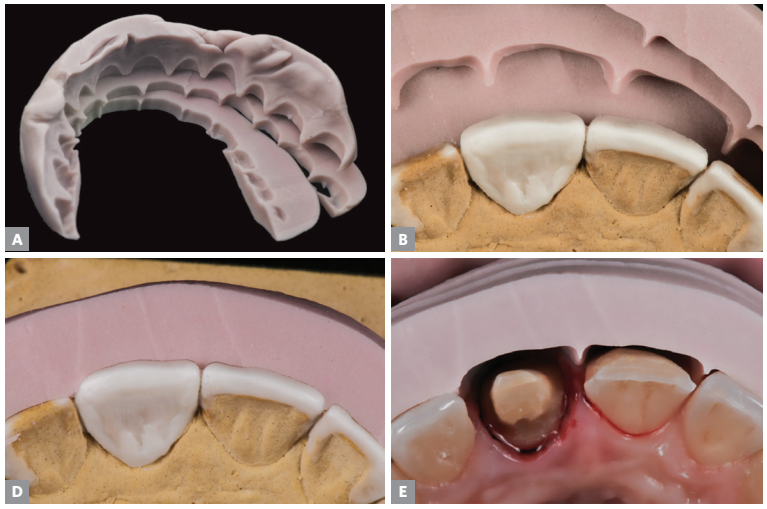

Figure 3: A) Buccal silicone reduction guide. **B)** Buccal reduction guide marked to measure prosthetic space at cervical third. **C)** Buccal reduction guide to measure prosthetic space at middle third. **D)** Buccal reduction guide to measure prosthetic space at incisal third. **E)** Buccal reduction guide in mouth to measure preparation thickness.

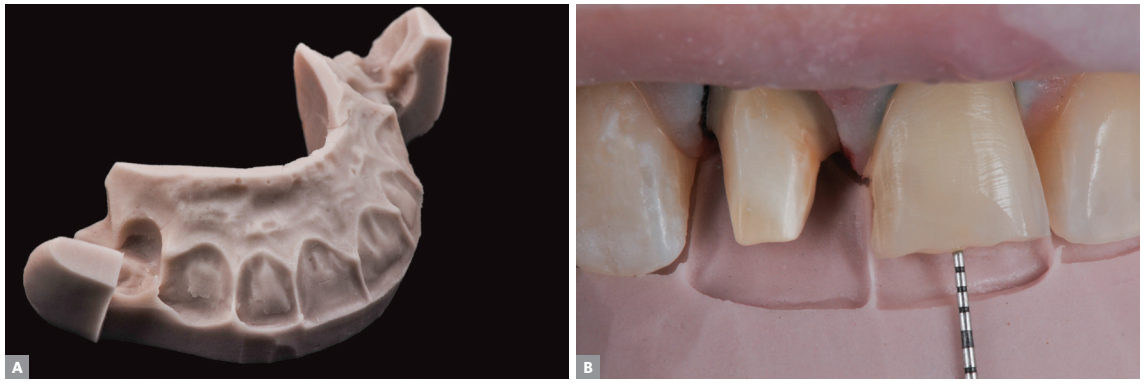

Figure 4: A) Incisal reduction guide. **B)** Incisal reduction guide adjusted to mouth to control incisal reduction of preparation.

Figure 5: Bis-acrylic resin provisional restoration (Protemp 4).

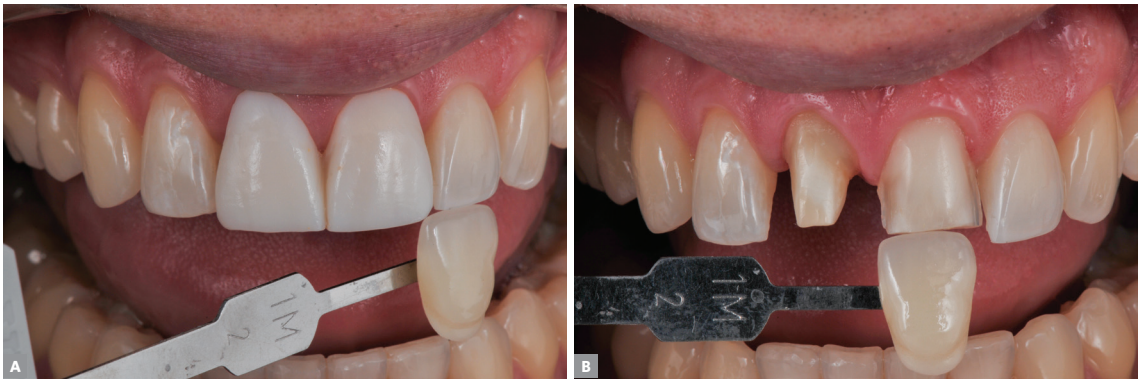

Figure 6: A) Color assessment of adjacent teeth. **B)** Color assessment of substrate.

Figure 7: Final photos.

DISCUSSION

Preparation according to existing dental structure

In these cases, the main objective is to remove a uniform layer of dental structure.[9,22-25] This may be achieved by free-hand preparation, using diamond-coated burs, a silicone guide and an impression of the existing tooth. The same objective may be achieved using this type of bur and controlled depth cutting. This approach precludes laboratory stages and requires very little communication with the DPT, because it is based on the reproduction of an initial condition in terms of morphology and function. However, when existing enamel is thin, or when the plan is to move teeth buccally, a preparation based on the existing dental structure may result in unnecessary exposure of dentin and restorations that are too large (Figure 8).[4,5,20,26] Such error in the diagnostic phase may compromise veneer longevity because of its greater thickness or the weaker bonding to dentin than to enamel.[5,18]

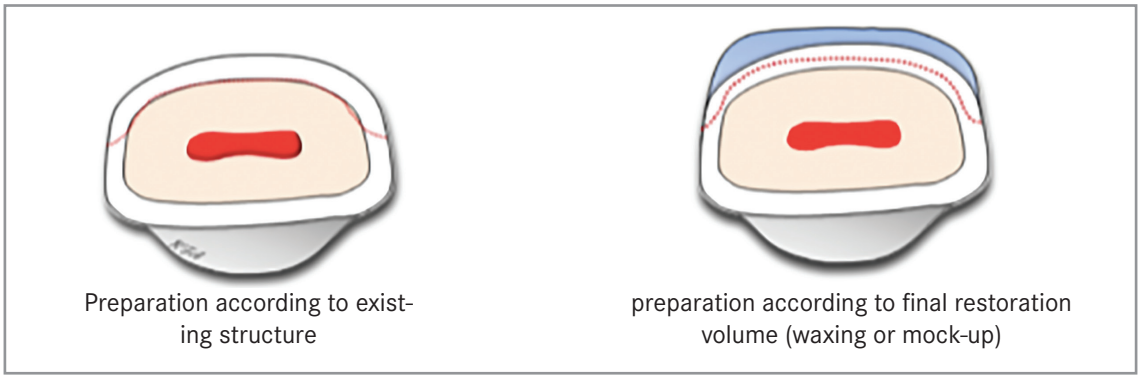

Figure 8: Left – Preparation according to existing dental structure; in these cases, preparation often invades dental tissue. Right – Preparation according to final restoration volume by means of waxing or mock-up; reverse planing tends to restrict preparation to dental enamel, where adhesion is greater (Source: Adapted from Magne and Belser,[5] 2004).

Therefore, this approach is recommended only after a careful evaluation of each case, and based on the premise that the final objective of the restoration is limited to the reproduction of volume, shape and function of the existing tooth. These cases usually involve patients with healthy darkened teeth that are unresponsive to bleaching (type I veneers according to Magne and Belser's classification).[19]

Preparations based on the final volume of the restoration

The more advanced dental preparation techniques for porcelain veneers include a diagnostic approach and require ample communication with the DPT.[14,19,27-30]

The first step of this approach is the definition of aim, that is, the desired final restoration shape. After analysis of the patient's history, clinical examination and radiographic study (Figures 1a, b, c and d), a diagnostic wax-up is obtained as the prototype of the final restoration. The diagnostic wax-up should be the reference for dental preparations (Figure 2), which are then made according to the final volume using silicone guides fabricated according to the diagnostic wax-up. This guide controls the amount of structure that should be removed. This basic principle saves a substantial amount of healthy dental tissue, not only enamel, but also the critical enamel-dentin junction.[19]

The diagnostic wax-up allows the dentist to visually predict the final result and transfer it to the patient's mouth by fabricating a bis-acrylic resin mock-up. Moreover, the diagnostic wax-up makes it possible to produce silicone guides that will help to define the exact amount of tooth structure that should be removed so that the tooth may receive the definitive restoration will all correct thicknesses. Differently from other techniques, there is greater predictability in the production of restorations, thus avoiding errors, such as the projection of teeth, unnecessary dentin exposure or inadequate veneer thicknesses. These guides help the dentist at the time of preparation, as well as when using composite resins.

CONCLUSIONS

Although preparations based on the existing dental structure are faster because they do not require laboratory stages, they may result in unnecessary loss of tooth structure. In contrast, preparations based on the final restoration volume, although requiring a greater number of steps and more communication with the DPT, result in more conservative preparations, because silicone guides made according to the diagnostic wax-up are used to control the removal of tooth structure.

The clinical case presented here showed that the removal of dental structure should be defined by the position of the future restoration, so that the dentist removes dental structure selectively in the regions where it is necessary to create space for the restoration. Therefore, a diagnostic wax-up should be used to simulate the desired final result. The bis-acrylic resin provisional, a copy of the diagnostic wax-up, is a fundamental instrument to simulate the final result in the mouth. Using this preview of the final result, it is possible to assess whether the spaces reserved for the restoration will be sufficient to hide the dental substrate and to create the desired shape, as well as to evaluate whether it meets the patient's expectations. Therefore, the procedure becomes predictable and accurate, a substantial amount of sound enamel is saved, the potential of restoration adhesion is maximized, and the thickness of the porcelain veneers is adequate.

References:

1. Andreasen FM, Daugaard-Jensen J, Munksgaard EC. Reinforcement of bonded crown fractured incisors with porcelain veneers. Endod Dent Traumatol. 1991 Apr;7(2):78-83.
2. Beier US, Kapferer I, Burtscher D, Dumfahrt H. Clinical performance of porcelain laminate veneers for up to 20 years. Int J Prosthodont. 2012 Jan-Feb;25(1):79-85.
3. Magne P, Hanna J, Magne M. The case for moderate "guided prep" indirect porcelain veneers in the anterior dentition. The pendulum of porcelain veneer preparations: from almost no-prep to over-prep to no-prep. Eur J Esthet Dent. 2013 Autumn;8(3):376-88.
4. Friedman MJ. A 15-year review of porcelain veneer failure: a clinician's observations. Compend Contin Educ Dent. 1998 June;19(6):625-8, 630, 632 passim; quiz 638.
5. Magne P, Belser UC. Novel porcelain laminate preparation approach driven by a diagnostic mock-up. J Esthet Restor Dent. 2004;16(1):7-16; discussion 17-8.
6. Chun YH, Raffelt C, Pfeiffer H, Bizhang M, Saul G, Blunck U, et al. Restoring strength of incisors with veneers and full ceramic crowns. J Adhes Dent. 2010 Feb;12(1):45-54.
7. Edelhoff D, Sorensen JA. Tooth structure removal associated with various preparation designs for anterior teeth. J Prosthet Dent. 2002 May;87(5):503-9.
8. Zarone F, Apicella D, Sorrentino R, Ferro V, Aversa R, Apicella A. Influence of tooth preparation design on the stress distribution in maxillary central incisors restored by means of alumina porcelain veneers: a 3D-finite element analysis. Dent Mater. 2005 Dec;21(12):1178-88.
9. Cherukara GP, Seymour KG, Zou L, Samarawickrama DY. Geographic distribution of porcelain veneer preparation depth with various clinical techniques. J Prosthet Dent. 2003 June;89(6):544-50.
10. McLaren EA, LeSage B. Feldspathic veneers: what are their indications? Compend Contin Educ Dent. 2011 Apr;32(3):44-9.
11. Radz GM. Minimum thickness anterior porcelain restorations. Dent Clin North Am. 2011 Apr;55(2):353-70, ix.
12. Peumans M, Van Meerbeek B, Lambrechts P, Vanherle G. Porcelain veneers: a review of the literature. J Dent. 2000 Mar;28(3):163-77.
13. Chaiyabutr Y, Phillips KM, Ma PS, Chitswe K. Comparison of load-fatigue testing of ceramic veneers with two different preparation designs. Int J Prosthodont. 2009 Nov-Dec;22(6):573-5.
14. Magne P, Douglas WH. Additive contour of porcelain veneers: a key-element in enamel preservation, adhesion and esthetics for the aging dentition. J Adhes Dent. 1999 Spring;1(1):81-92.
15. Zarone F, Epifania E, Leone G, Sorrentino R, Ferrari M. Dynamometric assessment of the mechanical resistance of porcelain veneers related to tooth preparation: a comparison between two techniques. J Prosthet Dent. 2006 May;95(5):354-63.
16. Schmidt KK, Chiayabutr Y, Phillips KM, Kois JC. Influence of preparation design and existing condition of tooth structure on load to failure of ceramic laminate veneers. J Prosthet Dent. 2011 June;105(6):374-82.
17. Guess PC, Stappert CF. Midterm results of a 5-year prospective clinical investigation of extended ceramic veneers. Dent Mater. 2008 June;24(6):804-13. Epub 2007 Nov 19.
18. Magne P, Magne M. Use of additive waxup and direct intraoral mock-up for enamel preservation with porcelain laminate veneers. Eur J Esthet Dent. 2006 Apr;1(1):10-9.
19. Magne P, Belser U. Bonded porcelain restorations in the anterior dentition: a biomimetic approach. Chicago: Quintessence; 2002.
20. Ferrari M, Patroni S, Balleri P. Measurement of enamel thickness in relation to reduction for etched laminate veneers. Int J Periodontics Restorative Dent. 1992;12(5):407-13.
21. Lin TM, Liu PR, Ramp LC, Essig ME, Givan DA, Pan YH. Fracture resistance and marginal discrepancy of porcelain laminate veneers influenced by preparation design and restorative material in vitro. J Dent. 2012 Mar;40(3):202-9.
22. Cherukara GP, Seymour KG, Samarawickrama DY, Zou L. A study into the variations in the labial reduction of teeth prepared to receive porcelain veneers: a comparison of three clinical techniques. Br Dent J. 2002 Apr 13;192(7):401-4; discussion 392.
23. Garber DA, Goldstein RE, Feinman RA. Porcelain laminate veneers. Chicago: Quintessence; 1988.
24. Garber DA. Porcelain laminate veneers: ten years later. Part I: tooth preparation. J Esthet Dent. 1993 Mar-Apr;5(2):56-62.
25. Weinberg LA. Tooth preparation for porcelain laminates. N Y State Dent J. 1989 May;55(5):25-8.
26. Magne P, Kim TH, Cascione D, Donovan TE. Immediate dentin sealing improves bond strength of indirect restorations. J Prosthet Dent. 2005 Dec;94(6):511-9.
27. Gurel G. The science and art of porcelain laminate veneers. Chicago: Quintessence; 2003.
28. Magne P, Perroud R, Hodges JS, Belser UC. Clinical performance of novel-design porcelain veneers for the recovery of coronal volume and length. Int J Periodontics Restorative Dent. 2000 Oct;20(5):440-57.
29. Notarantonio A. Porcelain laminate veneer: restorative management. Compendium. 2011;32(1):34-8.
30. Pena CE, Viotti RG, Dias WR, Santucci E, Rodrigues JA, Reis AF. Esthetic rehabilitation of anterior conoid teeth: comprehensive approach for improved and predictable results. Eur J Esthet Dent. 2009 Autumn;4(3):210-24.