Minimal Invasive Dentistry: Mock-up and Tooth Tissue Preservation Techniques

Author: Olivier Etienne, Strasbourg

Abstract

The improvement in both ceramic materials and bonding materials over the past ten years has opened up new fields of clinical applications. Among these, ceramic veneers have been the most conservative ones and those which most respect the dental tissue. This maximal preservation of healthy tissue assures both successful bonding to enamel and the possibility of re-intervention at a later date. In order to control the initial preparation better, many types of preparation protocols have been suggested. They all attempt to control the initial tissue penetration by using appropriate diamond burs. The technique of preparation using an aesthetic mock-up is certainly the most successful one in terms of preparation protocol. Indeed, unlike other proposals, this technique is viable, reproducible and easy to work with clinically.

Introduction

During the past 20 years, bonding has no doubt represented a major revolution in dentistry. Constant improvements in terms of bonding to dental tissue, together with technical improvements in ceramic materials, have made it possible to develop aesthetic dentistry with less risk of fracture.

This adhesive revolution has quickly become part of the concept of tissue conservation by providing new types of preparations, mixtures of traditional techniques and new ideas related to bonding. Especially, one crucial clinical factor has become apparent: the difference in bonding quality between dentine and enamel. In fact, due to the nature of these two substrates, enamel bonding is always superior to dentine bonding[1]. The practitioner must always systematically find the best compromise between sufficient thickness, to ensure strength and aesthetics (table 1), and maximum conservation of the enamel on the prepared surface. However, when taking into consideration the variations in ceramic translucency and the original shade of the substructure, a more "aggressive" approach may be necessary in order to better conceal a discolouration[2]. Similarly, pressed-ceramic veneers require more overall thickness than feldspathic ones.

All-ceramic Restorations	**Minimum Thickness (in mm)**		
	Labial	Lingual	Occlusal
All ceramic crowns	1,2	1,2	1,5
Pressed Veneers (leucite, lithium disilicate)	0,8	Not applicable	1,5
Feldspathic Veneers	0,6	Not applicable	1,5

Table 1: Minimum thickness recommended for different ceramic types on a non-discoloured substructure

Whenever clinically possible, it is recommended to favour a minimally-invasive enamel preparation that will enhance the longevity of the restoration[3/4] and prevent post-operative sensitivity. When preparing for this, the varying degree of enamel thickness must be taken into account first (fig. 1). This thickness depends on the patient's age, dental history and, most of all, on possible wear of the enamel. This loss of thickness can be aggravated, either by abrasive compounds (toothpaste with high concentrations of bicarbonate) or acids (acidic drinks, citrus fruits, etc.). In order to optimise the aesthetic result and to get a better

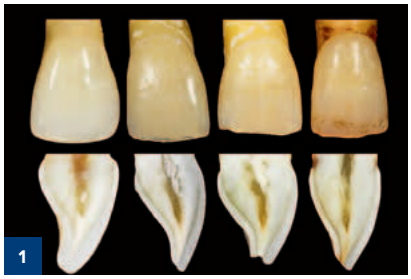

Fig. 1: Labial view and medium sagittal cut of four central maxillary incisors of different ages (from left to right: patients of 19, 32, 42 and 68 years respectively). Enamel thickness is variable between teeth and also in each tooth depending on the height.

preview via the wax-up, detailed clinical observations of the initial wear should be undertaken right from the start.

Normally the natural thickness of the labial enamel of anterior teeth will measure on average between:

Thickness of the labial enamel of anterior teeth	Thickness (in mm)	
	Mininmal	Maximal
Gingival area	0.3	0.5
Middle part	0.6	1.0
Incisal area	1.0	2.1

Table 2: Natural thickness of the labial enamel of anterior teeth.

These average values represent a wide range of variations for each patient and for each individual tooth (table 2).

Evolution of preparation concepts

Taking these basic requirements into account, several clinical propositions have been suggested to minimise the preparation of dental tissue. Mainly, these propositions are based on the idea of progressive reduction or the idea of controlled penetration[5].

I. Progressive Reduction Methods

In progressive reduction methods, a reference point such as an adjacent tooth, the dimension of the cutting tool or a pre-op silicone index are used in order to visually enhance and mechanically control the amount of tooth structure that is to be removed.

The Depth Cut Technique

During preparation of the teeth, the simplest method is to estimate the volume removed by comparison with neighbouring teeth. This three-dimensional visualisation has great operator variability and makes the results not very efficient in terms of tissue conservation.

In order to improve this procedure, vertical grooves can be cut in the tooth at the beginning of the preparation while visually making sure not to penetrate more than the diameter of the bur[6/7]. As in the previous method, it relies on the contour of the tooth to be restored and therefore has the great advantage of controlling the preparation. If the shape of the tooth can be reproduced in the same proportions then this is the method of choice (fig. 2).

Fig. 2: It is possible to achieve a uniform preparation by using vertical grooves with a thickness that is visually controlled and does not exceed the diameter of the bur. Monitoring with a pre-operative silicone index makes it possible to confirm this uniform reduction.

The Index Technique

Development of this approach involves using the final morphology of the reconstruction as a reference. This is performed before preparation with an aesthetic wax-up built on the initial plaster cast. Using this model as a guide, it is possible to prepare either a thermoformed transparent matrix (ensuring both control of the preparation and, later, fabrication of the temporary veneers by using it as a mould) or to make one or more silicone indexes to check the preparation (fig. 3)[8]. As P. Magne demonstrated, this option[9/10/11] consists of preparing two silicone indexes cut into strips (one for the vertical and one for the horizontal axis); making it possible to assess the reduction of tissue during preparation. This method completely supports the principle of maximum tissue conservation and ensures a predictably consistent outcome. However, this is a complex and time-consuming procedure because frequent use of the control indexes is necessary.

Fig. 3: When using the technique with silicone indexes it is necessary to work out an aesthetic plan beforehand. This is fabricated on a situation model, a duplicate of the study model with the help of a wax-up. Several indexes can be prepared from this model and will be sectioned in their horizontal or vertical axes. To make it easy to reposition these indexes they should cover the gingiva and the surrounding teeth.

II. Controlled Penetration Methods

Contrary to the methods described above, the idea of controlled penetration makes it possible to perform a predictable reduction of dental tissue (table 3) thanks to the use of specially designed burs. Using their shape will physically limit the potential for possible errors.

Reference (ISO)	Diameter of chuck	Diameter of bur (ISO)	Cutting Depth
868 B	1,6 mm	2,0 mm (020)	0,4 mm
834	1,6 mm	2,1 mm (021)	0,5 mm
801 L	1,0 mm (oberer Teil)	2,3 mm (023)	0,65 mm
801 L	1,0 mm (oberer Teil)	2,9 mm (029)	0,95 mm

Table 3: ISO references, diameters and cutting depth of selected burs for veneers preparation

The Direct Technique

The first clinical suggestions for this technique recommend the use of specific burs that limit the depth of penetration due to their shape (fig. 4).

While with this technique the depth of penetration is controlled and known, the initial thickness of the enamel cannot be assessed. Also, with time and through varying aetiological wear and tear there is a natural variation (table 4) between teeth[12/13/14]. Consequently there is no guarantee with respect to enamel preparation.

Teeth	Average enamel thickness according to the dental surface concerned							
	buccal/labial		palatal/lingual		Proximal		occlusal	
	max.	mdb	max.	mdb	max.	mdb	max.	mdb
Incisor	1,0	0,9	0,7	0,6	0,7	0,65	0,9	0,9
Canine	0,8	0,8	0,7	0,6	0,75	0,6	1,1	1,0
Premolar	1,3	1,25	1,4	1,1	1,15	1,05	1,3	1,25
Molar	1,45	1,55	1,6	1,4	1,3	1,35	0,55	0,5

Table 4: Average thickness at the centre of each dental surface according to Naveau et al.[15] (max: maxilla ; mdb: mandible)

The Indirect Technique

The logical evolution of all these concepts was put forward by G. Gürel in 2003[16] : it combines the idea of minimum reduction while considering the volume of the final restorative shape, and also the use of specific burs that make a controlled penetration possible. This technique is based on a simple, but rigorous procedure ensuring a high level of reproducibility irrespective of the clinician[17/18].

Clinical Procedure

Phase I: Aesthetic analysis and wax-up

Smile analysis is an indispensable prerequisite for any planned aesthetic restoration. It is based on several well defined criteria[19/20]. The changes envisaged are illustrated by modelling with composite resin, applying it directly to the dry tooth without the use of an adhesive (fig. 5).

Fig. 4: The diamond burs used for a controlled penetration should be used parallel to the surface. In other words, once there is contact with the shank further penetration cannot be made. This technique suffices when the final shape of the reconstruction is identical to the initial shape.

Fig. 5: The aesthetic analysis and the patient's wishes indicate the need for bonded ceramic veneers. With the help of composite resin placed freehand on the labial surfaces an initial chairside impression can be taken. To simulate the shortening of the canines the teeth that are too long are marked with a black felt-tip pen (arrows). The superimposition of the images illustrates the aesthetic advantages of the elimination of the diastema and the realignment of the incisors.

Fig. 6: The diagnostic model is modified according to the instructions given by the practitioner (impressions, photos etc). The wax-up makes it possible to lengthen and re-size the teeth. At this point, it becomes evident that the tissue reduction will not be uniform: the white zones (wax) will be spared more than the zones in ochre (plaster). The new appearance is recorded using a double mix silicone impression made in order to optimise precision. This impression will serve as a mould when making the intraoral mock-up.

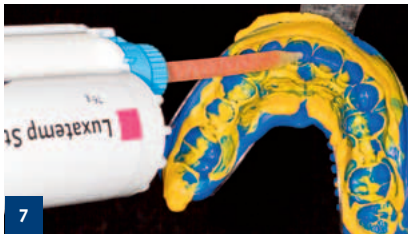

Fig. 7: Details of the wax-up are reproduced by the double mix impression. The resin (Luxatemp Star, DMG) is dispensed into it before repositioning it in the mouth. After polymerization, the aesthetic appearance can be immediately assessed. Because of its variable thickness, the resin layer should not be removed at this point.

Once the desired modifications have been agreed upon (form of teeth, diastema closure, etc.) an impression will enable the dental technician to make a more detailed wax-up (fig. 6).

Based on this model, a rigid matrix can now be made either by using thermoforming or with a silicone impression.

Phase II : Making the mock-up

The mould is filled with a composite resin and inserted over the patient's teeth until polymerization is completed (fig. 7). To avoid clogging up the instruments, it is recommended to use a bis-acryl resin for this mock-up and not a conventional powder/liquid system.

Once in place the matrix will indicate the final restoration and should be left on the teeth as a guide during preparation.

Phase III : A minimally invasive preparation through the mock-up

Depending on the material chosen, the thickness of the restorative material should determine the diameter of the bur and thus the depth of penetration (table 3). Once determined, the horizontal grooves are cut into the labial surface ensuring a penetration parallel to the surface, until there is contact with the smooth part of the chuck on the resin of the mock-up (fig. 11).

Once these labial grooves have been made, the occlusal reduction should be undertaken before removing the mock-up. To visualise the depth limit for the preparation better, the bottom of each groove can be highlighted with a pencil or felt tip marker (fig. 8).

The mock-up is removed leaving only the coloured grooves (fig. 9). These are then joined together and the final preparation design is completed. At the end of the appointment, an impression is taken. Then the mock-up impression can be used to make the provisional restoration.

A preparation based on this principle of tissue conservation ensures that only necessary enamel surfaces need to be adjusted for aesthetic and functional results (fig. 10).

Limitations of the technique

In certain specific cases, when one or more teeth are malaligned from the desired archform, it will be necessary to prepare and reduce these teeth first. This prevents any risk of incorrect positioning of the thermoformed index or the impression when doing the mock-up. To ensure a perfect placement of the mock-up impression over the teeth, one should check first that the initial reduction is enough with the help of a silicone index.

The labial surfaces are fully involved in this technique. However, when it comes to the palatal area, it is difficult to extend this technique for partial crowns. With the help of the silicone indexes, it is possible to visually control the situation in static and dynamic occlusion and to ensure a proper thickness of material.

Conclusion

Saving tooth structure should be the foremost concern because it ensures both a better longevity and, more importantly, makes future interventions more feasible. Each decision and clinical intervention should be made taking a therapeutic gradient into consideration. When it comes to tissue conservation it is fundamental to recognise that bonding to enamel is far superior to that to dentine when indications call for adhesive bonding. In other words, all techniques that make it possible to preserve enamel should be favoured when the thickness of the restoration allows this. The most successful development in this respect is based on the management of the final mock-ups, used as a template for the preparation, associated with drills of optimal shape for a controlled penetration.

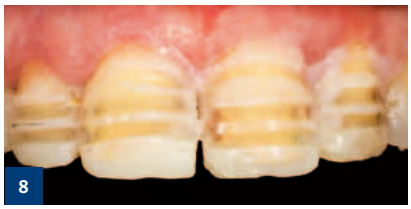

Fig. 8: With the mock-up in place, the bur is moved over the labial surface, in parallel lines, until contact with the shank is achieved. Three to four grooves are sufficient to mark the final depth of the preparation. After establishing the occlusal reference points, the grooves are accentuated with a pencil.

Fig. 9: The remaining parts of the mock-up are removed and allow the practitioner to get a clear view of the guiding grooves. Preparation will continue until the coloured grooves are completely removed, and completed within the proximal zones in accordance with the aesthetic needs. The impression can be used again, when filled with bis-acrylic resin (Luxatemp Star, DMG), in order to make the provisional restorations.

Fig. 10: Clinical case after one week. The final aesthetic appearance is determined by the volume of the relevant anterior teeth. Preparation through the mock-up has made it possible to create the desired final result.

Fig. 11: The resin mock-up in place over the prepared teeth. The depth of the grooves do not depend only on the diameter of the bur, but also on the aesthetic template (mock-up) used. Once the mock-up is removed the depth of the guide grooves varies. It is now possible to finalise the preparation by joining the bottom of the grooves. The enamel layer is preserved better and the thickness of the ceramic veneer is standardised.

Contact:
Dr. Olivier Etienne
Chirurgien dentiste
1, rue de la Division Leclerc
67000 Strasbourg

Bibliography

1 Stangel I, Ellis TH, Sacher E. Adhesion to tooth structure mediated by contemporary bonding systems. Dent Clin North Am. 2007 Jul;51(3):677-94.
2 Spear F, Holloway J. Which all-ceramic system is optimal for anterior esthetics ? J Am Dent Assoc. 2008 Sep;139 Suppl:19S-24S.
3 Christensen GJ. What is a veneer? Resolving the confusion. J Am Dent Assoc. 2004 Nov;135(11):1574-6.
4 Peumans M, Van Meerbeek B, Lambrechts P, Vanherle G. Porcelain veneers: a review of the literature. J Dent. 2000 Mar;28(3):163-77.
5 Kois JC. New paradigms for anterior tooth preparation: rational and technique. Contemporary Esthetics and Restorative Practice. 1996;2(1)1-8.
6 Seymour KG, Samarawickrama DY, Lynch EJ. Metal ceramic crowns--a review of tooth preparation. Eur J Prosthodont Restor Dent. 1999 Jun-Sep;7(2):79-84.
7 Ahmad I. Protocols for predictable aesthetic dental restorations. Blackwell Science. 1st edition. 2006.
8 Paris JC., Ortet S. et al. Smile Esthetics: a Methodology for Success in a Complex Case. Eur J Esthetic Dentistry. 2011 ;6(1) :50-74
9 Magne P, Magne M. Use of additive wax-up and direct intraoral mock-up for enamel conservation with porcelain laminate veneers. Eur J Esthet Dent. 2006 Apr;1(1):10-9.
10 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 7-8.
11 Magne P, Belser U. Bonded Porcelain Restorations in the Anterior Dentition: A Biomimetic Approach. Quintessence Publishing; 2002.
12 Atsu SS, Aka PS, Kucukesmen HC, Kilicarslan MA, Atakan C. Age-related changes in tooth enamel as measured by electron microscopy: implications for porcelain laminate veneers. J Prosthet Dent. 2005 Oct;94(4):336-41.
13 Lambrechts P, Braem M, Vuylsteke-Wauters M, Vanherle G. Quantitative in vivo wear of human enamel. J Dent Res. 1989 Dec;68(12):1752-4.
14 Grine FE. Enamel thickness of deciduous and permanent molars in modern Homo Sapiens. Am J Phys Anthropol. 2005 Jan;126(1):14-31.
15 Naveau A, Renault P, Pierrisnard L. Pulpe et prothèse fixée à ancrage périphérique. Cah Proth. 2007;138:55-64.
16 Gurel G. Predictable, precise, and repeatable tooth preparation for porcelain laminate veneers. Pract Proced Aesthet Dent. 2003 Jan-Feb;15(1):17-24.
17 Gürel G. Gürel G. The Science and Art of Porcelain Laminate Veneers. Quintessence Publishing, Carol Stream, IL: 2003
18 Gurel G. Porcelain laminate veneers: minimal tooth preparation by design. Dent Clin North Am. 2007 Apr;51(2):419-31.
19 Romano R, Bichacho N, Touati B, eds. The Art of the Smile. Carol Stream, IL : Quintessence Publishing ; 2005.
20 Fradeani M. Esthetic Rehabilitation in Fixed Prosthodontics: Esthetic Analysis. Quintessence Publishing. 2005.