Adhesive Restorations, Centric Relation, and the Dahl Principle: Minimally Invasive Approaches to Localized Anterior Tooth Erosion

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Abstract

The purpose of this article is to review biomechanical and occlusal principles that could help optimize the conservative treatment of severely eroded and worn anterior dentition using adhesive restorations. It appears that enamel and dentin bonding, through the combined use of resin composites (on the palatal surface) and indirect porcelain veneers (on the facial/incisal surfaces) can lead to an optimal result from both esthetic and functional/biomechanical aspects. Cases of deep bite combined with palatal erosion and wear can be particularly challenging. A simplified approach is proposed through the use of an occlusal therapy combining centric relation and the Dahl principle to create anterior interocclusal space to reduce the need for more invasive palatal reduction. This approach allows the ultraconservative treatment of localized anterior tooth erosion and wear. *(Eur J Esthet Dent 2007;2:260–273.)*

Tooth surface loss can present in various clinical forms with a wide range of etiologic factors. Among these, dental erosion lesions constitute a growing problem in younger individuals.[1] Dietary acids are increasingly popular (especially soft drinks). Bulimia, consumption of acidic foods, acid reflux, and chlorine exposure (from swimming) are other typical etiologic factors in young patients. While it is paramount to identify the causes of the disease, including possible underlying medical conditions, and institute a preventive regime, the restorative dentist will ultimately have to select the appropriate treatment strategy. In this regard, severe cases of tooth erosion, particularly in young people, present a considerable challenge. Dentin sealing with a filled dentin bonding agent is certainly the most conservative approach proven to reduce the rate of wear and erosion.[2] While it is an efficient and immediate protective measure, the application of dentin bonding agents does not address the real biomechanical issues and long-term prognosis of the eroded tooth. The loss of form, function, and esthetics are additional reasons to consider a true restorative approach to the treatment of erosive lesions. If restoration is necessary, adhesive restorative dentistry, due to its conservative nature, should be used whenever possible.[3–5] Based on the individual circumstances and the perceived needs and concerns of the patient, direct application of resin composites[3,6] and/or bonded porcelain restorations[4,5] can be proposed. The aim of this article is to present biomechanical and occlusal principles that will facilitate the selection or combination of adhesive restorative materials and techniques for the treatment of severe enamel loss in the anterior dentition.

Facial enamel wear/erosion and additive porcelain veneers

A natural tooth's unique ability to withstand masticatory and thermal loads during a lifetime is the result of the structural and physical interrelationship between an extremely hard tissue (enamel) and a more compliant tissue (dentin). Enamel can resist occlusal wear but is fragile and cracks easily. Dentin, on the other hand, is flexible and compliant but is not wear resistant and does not age favorably when directly exposed to the oral environment. Natural teeth, through the optimal combination of enamel and dentin, demonstrate the perfect and unmatched compromise between stiffness, strength, and resilience. The recognition of this relationship has allowed a better understanding of possible alterations of the precious balance between enamel and dentin (Figs 1a to 1c). A significant step was made when researchers focused their attention on the biomechanical side effects of enamel loss or enamel preparation. A number of studies[7–10] analyzing biophysical stress and strain have shown that *(1)* enamel loss or preparation can make the tooth crown more deformable and *(2)* the tooth can be strengthened by increasing its resistance to crown deformation. Based on these principles, tooth reinforcement was first achieved by some form of full or partial coverage (extracoronal strengthening) at the expense of the intact tooth substance.[11–13] Today, adhesive technology has proved its efficiency in simultaneously reestablishing crown stiffness and allowing maximum preservation of the remaining hard tissue in both anterior[14–16] and posterior[17–19] teeth. While studies demonstrated that bonded composite

restorations permit the recovery of tooth stiffness, which was not possible with alloy fillings, it should be remembered that the physical properties of composite veneers are somewhat limited.[12] One limitation is the elastic modulus, which for an average microfilled hybrid can be one eighth to one fourth (approximately 10 to 20 GPa) of the elastic modulus of enamel (approximately 80 GPa). Because of its enamel-like elastic modulus, porcelain used as an enamel replacement proved to be instrumental in the way stresses are distributed within the crown.[16] The well-acclaimed clinical success of porcelain veneers confirms this fact. Porcelain veneers proved able to assume the role of facial enamel, which is essential to the balance of functional stresses in the anterior dentition.[16,20]

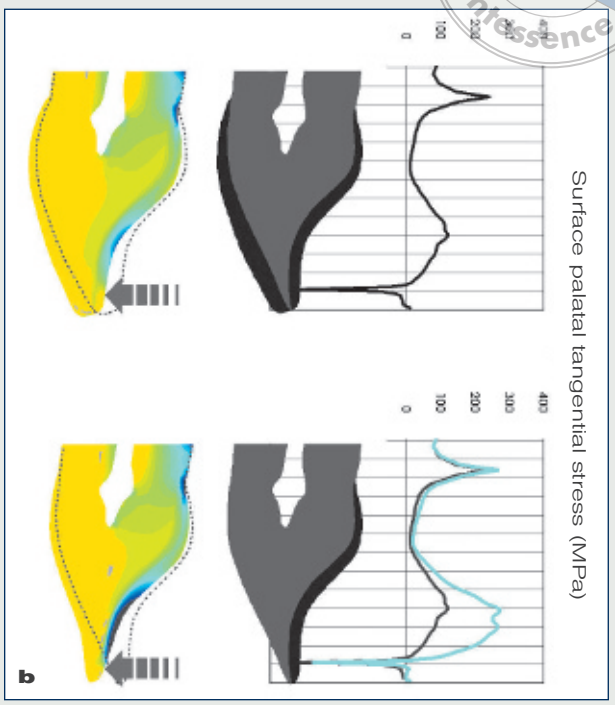


Fig 1b Tooth preparation (bottom) by total facial enamel removal was simulated in finite element analysis. The plot of tangential stresses proceeds for each tooth along the palatal surface from cervical (top) to incisal (bottom). A dramatic increase in tensile stresses is found in the remaining enamel of the palatal fossa (blue line, teeth loaded palatally with 50 N onto incisal edge, deformation factor X10 on stress mapping). Modified from Magne and Douglas.[16]

Fig 1a Clinical situation featuring severe loss of facial enamel of maxillary anterior teeth (note dentin exposures) and infiltrated Class 3 restorations.

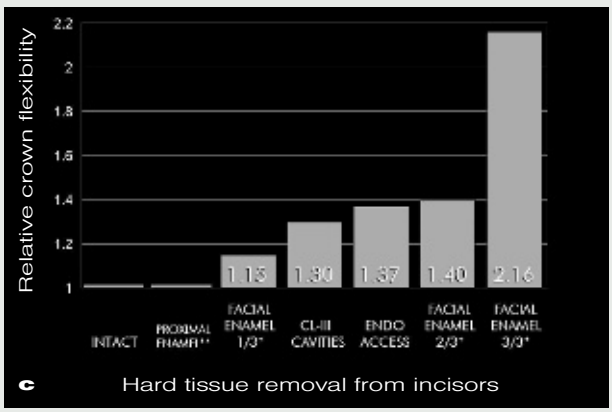
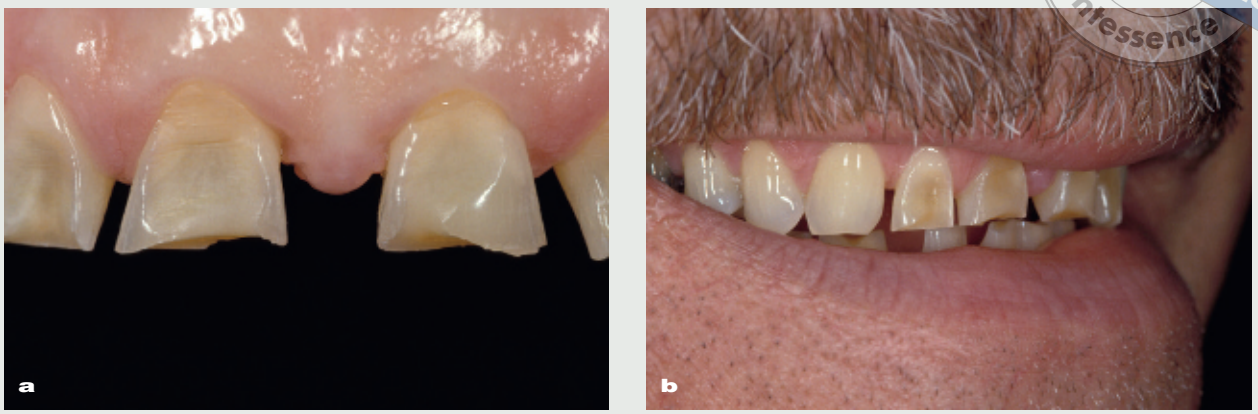
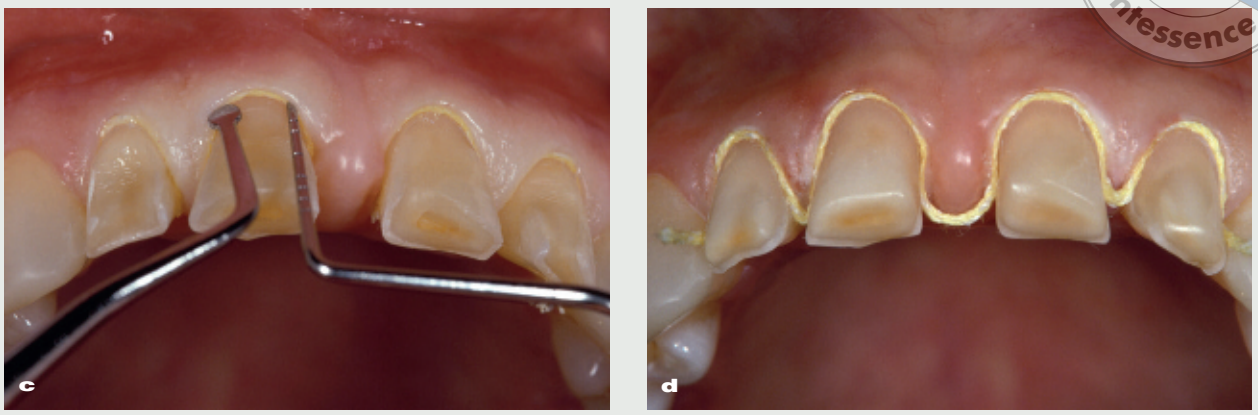


Fig 1c Relative compliance (changes of compliance relative to the baseline) for natural incisors after removal of coronal tissues. Total removal of proximal enamel (second column) does not affect crown rigidity, while total removal of facial enamel (last column) is most adverse.



Figs 2a and 2b Preoperative situation. Severe case of localized erosion and wear with marked and multiple dentin exposures. A conservative approach with bonded porcelain restorations (facial veneers type IIIB according to Magne and Belser[4]) is indicated, provided the dentin exposures are sealed immediately after tooth preparation, before final impressions.

Therefore, it is logical to submit that in cases of severe loss of enamel by erosion and wear, restoring enamel thickness is a combined esthetic and biomechanical endeavor. Adhesive ceramic restorative procedures have the potential to reverse the esthetic manifestations of aging or erosion in teeth (Fig 2)[21] and do not require a significant amount of tooth reduction because of the existing space provided by the missing tissues (additive approach).[21–23] Because the principles of "resistance and retention form" are omitted, the success of the biomimetic approach relies on the bond between the porcelain and the luting resin composite on one hand and the bond between the luting resin composite and the tooth on the other hand. While resin-to-enamel bonding was proved to give predictable results more than 50 years ago, significant resin-dentin bonds have only been measured during the last decade. Essential developments, such as dentin hybridization and immediate dentin sealing[24,25] allowed indirect bonded porcelain restorations to evolve from type I (simple laminates) to types II and III indications (Fig 2).[4,26,27] Immediate dentin sealing (IDS) should significantly enhance the prognosis of indirect bonded porcelain in cases of severe erosion.[24] IDS is a revised application procedure for dentin bonding when placing indirect bonded restorations such as composite/ceramic inlays, onlays, and veneers. Immediate application and polymerization of the dentin bonding agent to the freshly cut dentin, prior to impression taking, is recommended. IDS appears to achieve improved bond strengths,[25,28,29] fewer gap formations,[16,30] decreased bacterial leakage, and reduced dentin sensitivity.[31,32] The use of a filled dentin bonding agent facilitates the clinical and technical aspects of IDS.



Figs 2c and 2d Clinical view just before tooth preparation while placing a first deflection cord **(c)** and just prior to final impression after placement of a second deflection cord **(d)**. Note the ultraconservative preparation and immediately sealed facial dentin surfaces (smooth texture of sealed dentin on all four incisors), which is a key element in the long-term success of indirect bonded restorations. Palatal surfaces were left intact and unprepared.

Fig 2e Final restorations in feldspathic porcelain.

Localized palatal wear/ erosion and occlusal therapy

One limitation in the use of porcelain restorations is geometry and thickness. It is important to remember that low stress levels are found in surfaces of maximum convex curvature, ie, the cingulum and the facial surface.[20] Therefore, it is concluded that convex surfaces with thick enamel experience fewer stress concentrations than do concave areas, which tend to accumulate them.[20] The palatal surface of anterior teeth is always a difficult area to prepare not only because of its geometry, which provides little retention and stabilization and concentrates tensile stresses (concave), but also

Figs 2f to 2h Clinical situation after placement of the four bonded porcelain restorations, rehabilitating not only esthetics, but also function and mechanical integrity of the anterior teeth. The final outcome was tested beforehand using a provisional acrylic template (not shown).

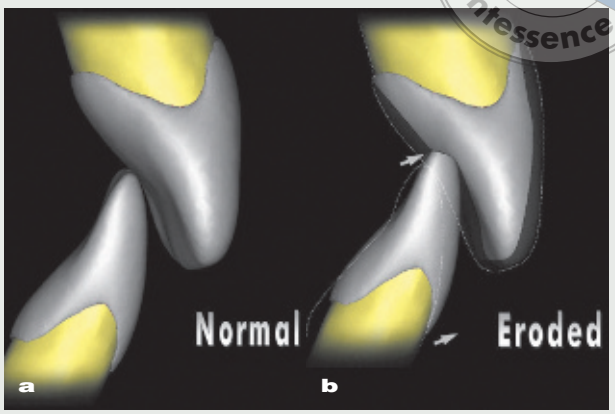
due to the limited space with the antagonistic dentition. Lack of palatal space for the restorative material is particularly challenging in cases of deep overbite and combined facial/palatal erosion (Fig 3). While it may be tempting to proceed to full-coverage crown preparations, such a procedure would result in significant elimination of intact tooth substance, up to two times the elimination of tooth substance compared to a traditional veneer or adhesive preparation.[33,34] In addition, eroded teeth are often short, thin, and flat and may present insufficient retention and resistance (Fig 3e), calling for even

more invasive procedures compromising pulp vitality (eg, intraradicular posts). Finally, full-crown coverage restorations (porcelain-fused-to-metal and all-ceramic) present more secondary caries and are clinically less satisfactory than veneers,[35] perhaps because of the stiff metal/ceramic coping, which makes the underlying tooth structure hypofunctional. Because margins of adhesive restorations are esthetically seamless, preparation finish lines can generally be left equigingival or supragingival and are therefore less likely to generate gingival inflammation compared to traditional full-crown coverages.[35]

Because of these reasons, and in order to reduce the need for more invasive palatal reduction, it is justified to look for the most conservative treatment of the eroded and worn palatal surface through an additive approach.[3] There are several ways of creating palatal interocclusal space to additively restore this volume. In cases of generalized erosion and wear, the bite can be opened through the restoration of posterior teeth. In cases of localized anterior erosion with an intact posterior dentition, it is possible to create interocclusal palatal space using orthodontics. Unfortunately, some patients may not be able to afford these expensive multidisciplinary treatments. In an effort to develop the simplest and most conservative approach to localized anterior erosion and wear, two occlusal principles have been described: centric relation and the Dahl principle.

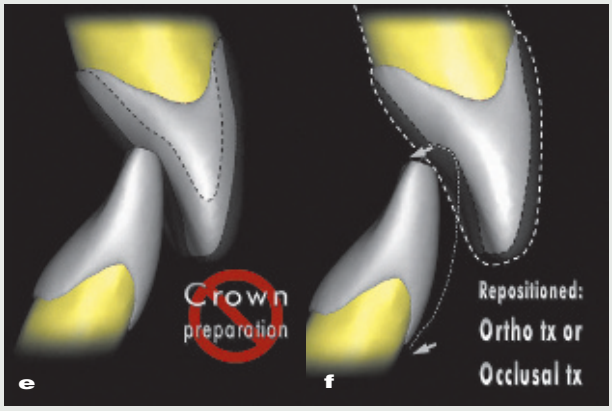
Centric relation

Cardoso et al[3] proposed the use of an anterior deprogrammer (modified Lucia jig) to help reposition the mandible in centric re-



Figs 3a and 3b Localized anterior tooth erosion may result in a deeper bite **(b)** compared to normal anterior relationships **(a)**. This is often the result of an anterior-superior slide of the mandible (arrows).

Figs 3c and 3d Clinical case with obvious facial erosion **(c)** but also marked palatal notches located on the MIP stops **(d)**. Worn and infiltrated existing Class 3 restorations are also visible.



Figs 3e to 3g Aggressive reduction of the remaining tissues occurs when preparing eroded teeth for full-crown coverage (totally contraindicated) **(e)**. Palatal clearance (restorative space) can be regained by orthodontic intrusion or more simply by using occlusal therapy **(f)**. The first step in occlusal therapy is the identification of an anterior slide of the mandible, which can be assessed by gently guiding the patient towards CR **(g)**. Most patients with localized anterior erosion will present with such a slide. A bite splint or an anterior deprogrammer may be used to facilitate this operation.

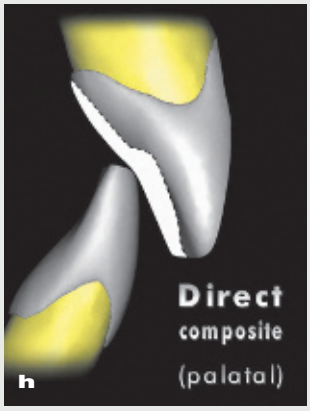
lation (CR) and retain the space for the placement of direct composites. The use of an acrylic jig for recording CR was originally presented by Lucia in 1964[36] and then refined to retain the space required for the placement of restorations.[3,37] Direct composites themselves can be used as an anterior deprogrammer (Fig 3i). Resin composites, because of their resilience and ease of manipulation even in small thicknesses, represent an ideal material to restore the palatal surface.

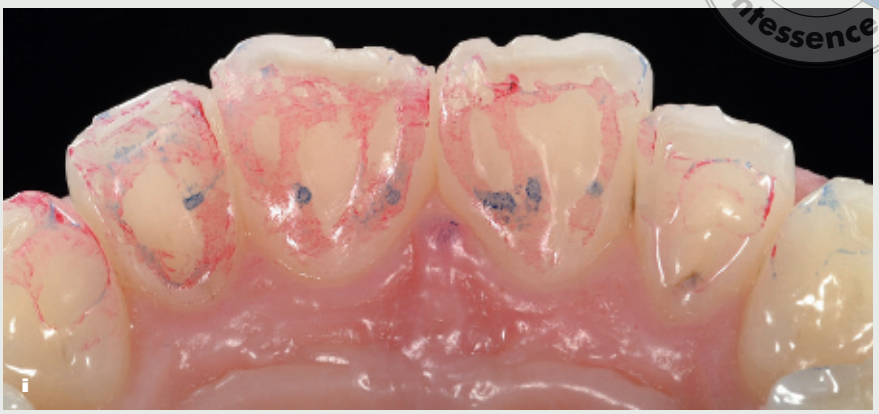
Dahl principle

Dahl[38] proposed creating space in the treatment of localized anterior tooth wear by separating the posterior teeth through an anterior bite plane for about 4 to 6 months. A combination of passive eruption (posterior teeth) and intrusion (anterior teeth) allowed the reestablishment of posterior occlusion while maintaining the anterior space.[39] Dahl originally used a cast metal appliance to separate posterior teeth. The same goal can be achieved today using provisional restorations or adhesive dentistry (direct resin composites).[40,41]

Combined approach

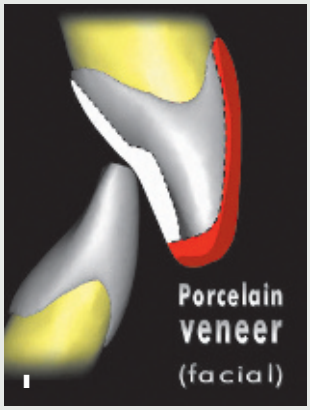
This article presents a combined approach using CR and the Dahl principle, which is summarized in Fig 3. The practical approach first involves identifying that a difference between the maximal intercuspal position (MIP) and CR is present by gently guiding the mandible. An anterior deprogrammer such as a Lucia jig or an NTI (nociceptiv trigeminal inhibition) appliance can be used if necessary to facilitate that step. As mentioned earlier, resin composite restorations reproducing the original anatomy of the palatal surface can also be used as a deprogrammer. While the case presented in Fig 3 focuses on simplicity and demonstrates the use of freehand composite restorations, a more sophisticated method would be to use articulated casts





Figs 3h to 3k The anterior interocclusal space is immediately retained by the placement of direct composite restorations **(h and i)** (red articulating paper was rubbed to outline the new palatal anatomy; blue marks show the new MIP stops), including the replacement of existing Class 3 restorations. Minor occlusal adjustments can be carried out until simultaneous bilateral contacts are obtained on premolars **(j)**. The remaining contacts on the molars will be obtained in a few months through the Dahl principle without additional adjustments **(k)**.

and a waxup along with transparent matrices or silicon indexes to guide the palatal restorative process. These palatal composite veneers could also be fabricated with an indirect technique. The newly established position (slightly posterior to MIP), will usually feature anterior contact on the definitive palatal restorations as well as premature contacts in posterior teeth. Minor adjustments of premature contacts can be made to increase the number of contacting teeth in the posterior dentition. The residual interocclusal space (in the most posterior teeth) should be progressively eliminated through the Dahl principle by the passive eruption of posterior teeth and slight intrusion of anterior teeth. Careful monitoring of the patient is recommended to assure the



Figs 3l to 3p To achieve proper contour, function, and mechanics, anterior teeth can be supplemented with porcelain veneers **(l)**. Following tooth preparation driven by the mock-up **(m)**, the final restorations are provided **(n)**. The situation is totally stable after 4 years of clinical service without any further treatment **(o and p)**.

proper development of the new occlusal situation, particularly the establishment of a stable posterior occlusion. Insufficient posterior occlusal support may lead to incisal occlusal pathology and breakdown of the anterior palatal composites.

After a couple of months of stabilization, anterior teeth can receive adjunct treatment, such as porcelain veneers, if indicated by the alteration of the facial/incisal surface. The final adjustment of the occlusal scheme can be carried out at this stage to take into account the newly established anterior guidance, which can be tested in the form of a provisional mock-up prior to tooth preparation and fabrication of the final veneers.[22,23]

The example shown in Fig 3 should be viewed with a guarded prognosis since no long-term data are available for this type of approach. In the medium- to long-term, palatal wear of the composites may occur. While once considered a major concern for posterior restorations, wear of dental composites has been substantially reduced by changes in formulation and is often considered a solved problem in patients without bruxing and clenching habits. Patients with parafunctional behavior should be monitored carefully because of the increased risk of wear-related failures,[42,43] and supplemental protection with a night guard is recommended. However, the worst-case scenario, in which the patient would wear off significant amounts of the palatal restoration, should not constitute a major concern. Due to the conservative nature of the treatment and successful reparability of the resin composite,[44–47] such problems can be easily addressed. Touch-up treatments can be achieved using the same occlusal principles described above. Preliminary roughening of the surface of the existing composite by airborne particle abrasion (microsandblasting) with aluminum oxide or by tribochemical silica coating (with silane) followed by the use of a bonding resin provide strong repair bonds.[48–50]

Conclusions

While the severe loss of enamel constitutes an alteration to the function, mechanics, and esthetics of anterior teeth, it is also an opportunity for the additive (as opposed to subtractive) restoration of the missing hard tissues. Traditional full-crown coverage could be avoided in all cases in favor of noninvasive approaches combining additive bonded composites and porcelain veneers. The combined use of CR and the Dahl principle will assist in creating adequate restorative space in cases with limited palatal clearance (deep bite).

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