Esthetic rehabilitation of a worn dentition with a minimally invasive prosthetic procedure (MIPP)

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Abstract

A minimally invasive prosthetic procedure (MIPP) for the esthetic rehabilitation of the complete arch advocates the preservation of enamel to optimize the adhesive bond of the luting agent to both the tooth surface and the etchable ceramic restoration. When esthetic rehabilitation of a worn dentition is required, a MIPP can be selected to reduce the biological cost of removing additional enamel tooth structure. The fundamental steps to achieve this goal are to: (1) increase the vertical dimension of occlusion (VDO); (2) reduce the thickness of the monolithic ceramic material; (3) preserve the enamel during tooth preparation; and (4) adhesively bond the etchable ceramic restorations. This article presents a comprehensive, minimally invasive prosthetic treatment approach for the esthetic rehabilitation of a severely worn dentition using a lithium disilicate all-ceramic material with partial and complete coverage restorations.

Introduction

The esthetic and functional rehabilitation of patients with worn dentition may require jaw surgery, orthodontics, a surgical crown lengthening procedure, and/or restorative dentistry to reestablish a proper occlusion and create pleasing facial and dental esthetics. For such patients, the use of a multidisciplinary treatment approach and comprehensive systematic analysis is highly recommended in order to formulate the best treatment options for improving function and esthetics.

The systematic, diagnostically driven approach should include the evaluation of facial and dental esthetics, occlusal function, tooth structure, and the biological status of the pulp and periodontium.¹

Using a checklist, as described by Fradeani,² will ensure the comprehensive collection of data from the face, dentolabial relationship, teeth, and soft tissues in order to create the blueprint for the successful esthetic, functional, and biological integration of the restorations.²

The prosthetic challenge with restoring severely worn dentitions is to preserve as much of the already diminished tooth structure as possible, and to maintain teeth vitality while also providing enough interocclusal space for the restorative material.

Traditionally, cases with worn dentition have been restored using complete coverage for an increased retention, often in combination with pulp extirpation, post and core positioning, and a crown-lengthening surgical procedure.

Nowadays, thanks to the development of adhesive dentistry and following the concept of a minimally invasive approach, it is possible to restore the dental structure using partial restorations.

Historically, partial coverage restorations (PCRs) were typically fabricated with gold.³ Today, clinicians have a variety of ceramic materials from which to choose when a PCR is indicated for either anterior or posterior teeth. Restoring advanced erosive lesions with a minimal reduction or a nonretentive partial tooth preparation design, coupled with additive adhesive bonding techniques, may be the best alternative. However, even full-contour ceramic coverage (full veneer) with reduced thickness can be used if bonded to the enamel structure. It is still unknown which restorative material is best, though the preference of ceramics to replace tooth structure has been advocated.⁴⁻⁸

Key elements of MIPP

Vertical dimension of occlusion (VDO)

The esthetic rehabilitation of a worn dentition is challenging because the clinical crowns have become shorter, and the tooth length needs to be increased. Increasing the coronal length is often associated with the increase of the VDO, even though this loss of tooth structure may not automatically indicate a loss of VDO due to a possible compensatory phenomena.⁹,¹⁰ To achieve the restorative, functional, and esthetic objectives, it is perhaps most important to ensure that the proposed increase in VDO will be the minimum amount necessary, in either one or both arches.¹¹,¹² With the
possibility of increasing the VDO, the extent of occlusal tooth preparation can be minimized, while the remaining enamel tooth structure can be conserved for adhesively bonding the ceramic restorations.

The VDO alteration requires a thorough clinical assessment of phonetics, interocclusal distance at rest, and face height, along with facial soft tissue contours. The careful evaluation of the mock-up, followed by the provisional restoration at the increased VDO throughout each phase of treatment, will appropriately test the new height for patient adaptation. If the temporomandibular joints (TMJs) are healthy, and the disks are correctly aligned, then any increase in VDO should not produce symptoms of pain, even with an anterior increase of up to 5 mm. Traditionally, several techniques have been used to determine a new VDO: phonetic sounds (“m” and “s” sounds), interocclusal rest space, an acrylic preoperative appliance, transcutaneous electrical nerve stimulation (TENS), measurements of the cementoenamel junction (CEJ), and the facial proportion method. None of these methods indicate exactly where the new VDO should be established. Speech, particularly the use of sibilants or “s” sounds, is considered the optimal method to assess when a change in VDO has been accepted by the patient. In any case, any discomfort related to a new VDO that may result from a change in muscular length typically lasts for only 1 or 2 weeks. Moreover, in some patients with increased VDO, some relapse to the original VDO may occur, even though these patients are often unaware of this phenomenon and experience no symptoms. A review of the literature shows that changes in vertical dimension are well tolerated in the majority of patients, with no evidence to suggest that only one vertical dimension is correct for each patient.

Reduced thickness of monolithic ceramic material

The improved lithium disilicate pressed glass-ceramic material, IPS e.max Press (Ivoclar Vivadent), was introduced in 2005. Its chemical basis is the same as that of IPS Empress 2 (2SiO2-Li2O) (Ivoclar Vivadent), but some of its properties are changed due to a different firing process. IPS e.max Press has smaller and more homogeneous crystals and better physical properties (the flexural strength and fracture toughness being about 10% higher than IPS Empress 2). It is a unique glass-ceramic material in which small, needle-shaped crystals compress the surrounding glass matrix during cooling. This process counters stress before crack propagation starts, and results in relatively high flexural strength (350 to 400 MPa). It can also be pressed or milled using computer-aided design/computer-assisted manufacturing (CAD/CAM). The manufacturer reports that in the posterior area, a 0.8-mm thickness for the core, and a 0.7-mm thickness for the veneering material are required when using a bilayered modality, or a minimum of 1.5 mm for a monolithic lithium disilicate restoration. However, if the final fracture resistance in the bilayered modality is related to the core strength of the lithium disilicate material (400 MPa), it could be
hypothesized that the addition of a veneering layer (approximately 100 MPa) may not significantly increase the fracture resistance of the overall restoration. As such, the use of the monolithic material in occlusion, even with reduced thickness (approximately 0.8 mm) and independently of the preparation design (full contour or PCRs), may provide sufficient strength, even in the posterior areas,\textsuperscript{39} on condition that the ceramic etchable material is bonded mainly to the etched enamel. In fact, a recent article clearly shows that when bonded to enamel (supported by dentin), the load-bearing capacity of lithium disilicate can approach 75% of that of zirconia, despite the flexural strength of lithium disilicate (400 MPa) being merely 40% of zirconia (1,000 MPa). When bonded to dentin (with the enamel completely removed), the load-bearing capacity of lithium disilicate is about 57% of zirconia, still significantly higher than the anticipated value based on its strength.\textsuperscript{40}

In contrast to monolithic restorations, bilayered ceramic restorations, even with the core made with the strongest material on the market such as zirconia, veneered with a weaker overlay porcelain, have been reported to show chipping, fracture, or delamination of the veneering porcelain.\textsuperscript{41} However, a recent study demonstrated no fracture and no chipping of lithium disilicate crowns after a 2-year period,\textsuperscript{42} and no chipping of monolithic lithium disilicate below 900 N and 180,000 cycles.\textsuperscript{43}

Enamel preservation

Tooth preparation design is traditionally considered one of the important factors responsible for the success of ceramic restorations, but evidence-based preparation guidelines are limited for posterior ceramic partial coverage restorations (PCRs). Most guidelines are based on experience with cast-metal PCRs that have been modified to optimize the performance of ceramic PCRs.\textsuperscript{26-29} The recommendation for porcelain restoration thickness in the occlusal area is 1.5 to 2.0 mm.\textsuperscript{30-33} However, these values could potentially be reduced by the use of an etchable monolithic ceramic material with a decreased thickness bonded on enamel.

Consequently, the design of the preparation for PCRs becomes more intuitive contingent upon the interocclusal clearance needed for the ceramic material,\textsuperscript{6} and with the possibility of extension to a full-contour coverage (full veneer) if there is a sufficient amount of enamel.

Adhesive bonding of the restorations

Clinical investigations have also shown that glass-ceramic restorations have improved fatigue resistance in the oral environment, and their bond strength is increased when resin-based luting cements are used.\textsuperscript{33,36,44-49} The reliable bond to enamel achieved with the adhesive technique has greatly impacted preparation design, resulting in significant preservation of tooth structure.\textsuperscript{50} The presence of enamel has become an important issue for preparation design.\textsuperscript{51} Increased preservation of enamel promotes a superior bond over dentin, lower postcementation sensitivity, improved support of the ceramic restoration, and reduced endodontic inter-
vention,\textsuperscript{52,53} Thus, the possibility of establishing adequate adhesion between tooth structure and ceramic restorations with adhesive materials may eliminate the need for extending tooth preparations\textsuperscript{54} and, in most cases, for the use of anesthetics.

Case presentation

A 55-year-old woman presented to the first author’s clinic stating that she was unhappy with the appearance of her teeth. In the clinical interview to ascertain her expectations for an improved smile and increased tooth visibility, she emphasized her desire for highly esthetic restorations without the use of metal. A thorough clinical oral and radiographic evaluation was performed. There were no adverse findings during the musculoskeletal examination. Significant intraoral findings included generalized moderate to severe erosion of the cervical, mid-facial, anterior incisal, and posterior occlusal surfaces, generalized attrition, minimal plaque accumulation, and caries lesions on the cervical area of the bicuspids on the mandibular arches, but no extension of any decay in the interproximal area (Figs 1 to 7).

An orthodontic treatment was proposed to intrude the maxillary and mandibular anterior teeth, with the aim of creating an interocclusal anterior space. The orthodontic movement would create room on the anterior sector, while the contact on the posterior area would be maintained. This would allow for a minimally invasive prosthetic treatment.

Since the orthodontic treatment was not accepted by the patient, an alternative plan was proposed to increase the VDO together with the incisal length of the maxillary and mandibular anterior teeth, and to also involve the posterior teeth in the rehabilitation, which, due to the MIPP, would be minimally prepared (Fig 8).\textsuperscript{39} These modifications were evaluated with a direct mock-up in the anterior segment using a flowable composite resin material. The initial study casts were mounted at the new VDO on a semi-adjustable articulator (Denar Mark II, Denar) using an arbitrary facebow transfer and posterior wax record (Beauty Pink, Moyco Union Broach). The diagnostic wax-up was completed in accordance with the clinical findings registered in the esthetic checklist, and communicated to the technician with the use of the laboratory chart.\textsuperscript{55} After duplicating the wax-up, the transparent matrix was fabricated and the final composite resin indirect mock-up was performed prior to the initial tooth preparation in order to evaluate function and esthetics (Figs 9 to 13). Subsequently, an impression of the two arches modified with the composite resin mock-up was taken using irreversible hydrocolloid (Jeltrate, Dentsply) to fabricate the provisional acrylic resin restoration.

Tooth preparation

Tooth preparation was performed with the indirect mock-up in place to assess the final volume of the restoration and properly calibrate tooth reduction of a minimum of 0.8 mm occlusally and 0.4 to 0.6 mm marginally. Posterior tooth preparation was designed to cover only the buccal and occlusal tooth surfaces, while maintaining the interproximal
Figs 1 to 5  Intraoral view of the patient’s teeth. Note the generalized wear of the maxillary and mandibular arch, and some cervical lesions of the mandibular teeth.
Figs 6 and 7  Occlusal view of the maxillary and mandibular arch. Note the two different types of wear: by attrition and by erosion.

Fig 8  A new relationship between the maxillary and mandibular arch after the new position of the mandible in centric relation (CR). Note the space available for the restorative materials.
Figs 9 to 13  A full-mouth indirect mock-up was performed to evaluate the functional and esthetic parameters. Note the new anterior guidance and the new exposure.
contact point (Figs 14 to 17). As the VDO was increased by approximately 3 mm anteriorly, and subsequently approximately 1.4 mm posteriorly on the second molar (0.7 mm of space was gained in each arch in the most posterior area), tooth structure removal on the occlusal surface was limited to only 0.1 mm in the second molar. There was practically no need for preparation to be performed at the occlusal area of the premolar teeth. Anteriorly, in the maxillary arch, due to the amount of space gained and very short length of the patient’s worn teeth, a very conservative preparation was performed to eliminate the undercut and to do full coverage restorations (full veneers), and traditional buccal veneers were performed in the mandibular anterior teeth (Figs 18 to 22). As a result, it was also possible to preserve most of the remaining enamel.

**Figs 14 and 15** With the direct mock-up in place, a calibrated reduction of the posterior teeth was performed. Thanks to the MIPP concept, it was possible to preserve most of the remaining enamel on the posterior abutments. In the buccal area of some of the teeth, the finish cervical line was positioned in the sulcus to include any possible existing tooth structure deficiency and caries in the restoration design.

**Figs 16 and 17** Preparation design in the occlusal surface was performed avoiding interproximal area involvement, with the aim of maintaining as much enamel as possible.
Figs 18 to 22 A calibrated reduction of the anterior teeth was performed with the mock-up *in situ*. Due to the amount of space gained with the new VDO, CR, and the very short length of the patient’s worn teeth, a very conservative preparation was performed solely to eliminate the undercut. Note the large amount of enamel still present at the end of the preparation.
on the anterior abutments. To optimize the esthetic result and to include any possible existing tooth structure deficiency and caries in the restoration design, in the buccal area the finish cervical line was positioned in the sulcus (intracrevicular preparation). Wherever esthetic and functional needs were not requested, the finishing line was positioned supragingivally. The shell of the provisional restorations was fabricated at the new VDO with the modified indirect technique (MIT), then relined and cemented temporarily with dual-curing resin-based temporary cement (Telio CS Link, Ivoclar Vivadent).

The patient’s comfort, speech, and appearance were reassessed after 1 month, and final impressions were taken. After placement of a double cord in the sulcus (Ultrapak, Ultradent), the final impressions were taken with a polyether material (Impregum Penta DuoSoft, 3M ESPE) using a light-activated custom tray (Palatray LC, Heraeus Kulzer) and the single-impression double-mixing technique. Then, an intraoral facebow and centric relation (CR) records were taken at the new VDO, such that the stone cast replicas of the provisional restoration were able to be cross-mounted with the master cast of the tooth preparation.

Figs 23 and 24  Posterior restoration on the stone model before the bonding procedure.
Adhesive cementation

Cementation followed a precise protocol. Retraction cords were placed in the sulcus of every abutment to minimize the humidity from the crevicular fluid and to act as a barrier for the penetration of the resin cement to the base of the sulcus. In addition, rubber dam was used whenever possible (Figs 23 to 26). The inner surfaces of the restorations were etched with hydrofluoric acid 4.5% (Ivoclar Vivadent) for 20 s, thoroughly rinsed with water, and put into an ultrasonic bath with distilled water for 3 min. After thorough air drying, the intaglio surface was silanized (Monobond-S, Ivoclar Vivadent) and dried for 60 s. Tooth preparations were cleaned with pumice and rubber burs (OptiClean, Kerr), etched for 30 s on enamel and 10 s on dentin with 37.5% phosphoric acid (Ultra-Etch, Ultradent), rinsed, and dried. Fitting surfaces, restorations, and teeth were coated with the adhesive system (OptiBond FL, Kerr), and, thanks to the reduced thickness of the ceramic restoration, a light-polymerized composite resin cement (Variolink Veneer, Ivoclar Vivadent) was selected to lute the restorations (Figs 27 to 37).

Discussion

Worn dentition is often due to abrasion, erosion, and attrition at the occlusal, facial, lingual, and (less often) interproximal surfaces. Minimizing the removal of additional tooth structure while also fulfilling the desire for highly esthetic restorations presents a challenge when the existing tooth structure is already diminished.

When remarkable wear is present only on the anterior teeth, orthodontic treatment should be the first choice in order to reestablish esthetics and function. The aim of orthodontic treatment is to recreate a new relationship between the anterior teeth so as to gain some space to lengthen them and, in this way, recreate an adequate overbite-overjet, and minimize the removal of tooth structure.

In case of generalized wear of the maxillary and mandibular arch, a full-mouth rehabilitation is advised. In this instance, the challenge was to attain mechanical retention/resistance form with minimal tooth preparation while preserving enamel and reducing the occlusal thickness of the ceramic restoration without compromising its strength or esthetics. This goal can be more easily achieved

Figs 25 and 26  After etching, it is possible to appreciate how much enamel is still present on the buccal and occlusal surfaces of the posterior teeth.
Figs 27 and 28  Finished and polished lithium disilicate anterior restorations.

Figs 29 and 30  Occlusal view after cementation.
Figs 31 to 33  The final result shows a satisfactory biological, functional, and esthetic integration of the full-mouth rehabilitation.

thanks to the alteration of the VDO, which can be safely increased anteriorly up to 5 mm without detrimental clinical consequences for the patient, who can rapidly adapt to the new height maximum within 2 weeks. This approach allows for the retention of the enamel structure, which will be ideal for the bonding procedure. A second important step to keep enamel in place is the reduction of the ceramic thickness of the lithium disilicate restoration. In the posterior area, the interproximal surfaces were not involved in any demineralization process and so were not prepared, so that the original contact points were retained. There is no scientific evidence to support or reference this type of unique geometrical restoration design that either keeps or opens the contact point. It will be important to evaluate, with finite element analysis, the behavior of this conservative prosthetic solution after the bonding procedure in order to properly evaluate the advantages and disadvantages of maintaining the contact point.

Fig 34  Anterior guidance shows a correct disclusion of the posterior teeth.
Clinically, some advantages of maintaining the contact point are that tooth preparation is easier and less time consuming, preparation is less invasive, the use of temporaries can possibly be avoided, and contact area adjustment during cementation is easier. Some disadvantages include poor mechanical retention, temporary stability, and handling of the final restorations during the try-in procedure.

One of the most important clinical advantages of removing the contact point

**Figs 35 and 36** Initial and final full-mouth radiographs. The ultraconservative MIPP approach guaranteed the maintenance of the vitality of all the teeth.

**Fig 37** A satisfactory integration of the rehabilitation in relation to the lip and to the face of the patient.
is the possibility of checking and removing some initial enamel defects (demineralization/caries) that can sometimes be difficult to diagnose.

An all-ceramic bilayered material over a lithium disilicate coping (IPS e.max Press) was chosen to achieve high esthetics in the anterior teeth. The monolithic form of this ceramic material, with a reduced thickness (0.8 mm), was used for the posterior buccal-occlusal veneer restorations. Monolithic glass-ceramic structures offer some distinct advantages in that they provide excellent esthetics without requiring a veneering ceramic. Therefore, by eliminating the veneering ceramic and only using a 0.8-mm-thick core material with 360 to 400 MPa of flexural strength, greater structural tooth integrity can be achieved with minimal removal of tooth structure and the preservation of enamel.

Moreover, a recent article showed that when supported by enamel, the load-bearing property of minimally invasive lithium disilicate occlusal onlays (0.6 to 1.4 mm thick) can exceed 70% of that of zirconia. This means that, when enamel remains on a tooth surface without any preparation, after a minimum space for the restorative material gained from the VDO increase, a reduced thickness of etchable ceramic could probably be used, as the final strength of the restoration will depend on the bonding procedure.

Presently, a 7-year in vivo prospective clinical split-mouth investigation is being conducted to evaluate the survival rate and long-term behavior of all-ceramic pressed (IPS e.max Press) and CAD/CAM fabricated (ProCAD) PCRs on molars. The 7-year Kaplan-Meier survival rate was 100% for pressed and 87% for CAD/CAM-fabricated PCRs. The evaluation criteria assessed secondary caries, marginal adaptation, marginal discoloration, surface roughness, color match, and anatomic form. The preliminary results for also using all-ceramic material for PCRs in the short- and medium-term clinical observation period are promising.

Though variations in the study design of other similar clinical studies, such as material selection, preparation design, and cementation protocol, limit the validity when comparing these results, overall tendencies exist in their clinical performance. The survival probability results of IPS e.max Press PCRs are comparable to, or better than, the reports on IPS Empress PCRs in the literature. The latter achieved survival rates of 92.7% to 100% in mid-term (2 to 4 years) and 81% to 93.4% in long-term (7 year) evaluation. It therefore appears that defect-oriented tooth preparation in the posterior region for the restoration of a compromised tooth with a partial coverage ceramic restoration such as lithium disilicate is justifiable.

**Conclusion**

In this case, the esthetic rehabilitation of the worn dentition was performed using the MIPP technique, aimed at replacing tooth structure with the least amount of trauma to the already structurally compromised dentition. The increase in VDO required less tooth structure removal, allowed for the maintenance of the enamel, and created more interocclusal space for the ceramic restoration.
Partial coverage lithium disilicate posterior restorations (buccal-occlusal veneers) with a reduced thickness (0.8 mm) in the molar region were adhesively bonded. To fully understand the potential of this technique, long-term studies using a minimal thickness of lithium disilicate materials for both full restorations and PCRs are needed to assess wear and fracture.

References


