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Maxillary and Mandibular Rehabilitation in the Esthetic Zone Using a Digital Impression Technique and CAD/CAM-fabricated Prostheses: A Multidisciplinary Clinical Report

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Clinical Relevance

Multidisciplinary treatment planning is an integral part of contemporary dental practice. Collaboration among dental team members is vital to be able to meet the growing esthetic demands of today's dental patients. This involves the use of innovative techniques to accomplish treatment objectives.

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SUMMARY

Interdisciplinary treatment planning is necessary in certain clinical situations to optimize esthetic treatment outcomes. Patients presenting with severe wear of their anterior teeth from iatrogenic influences pose a particularly difficult problem in terms of esthetic treatment planning. Collaboration of practitioners from the disciplines of orthodontics, periodontics, and restorative dentistry is essential for the treatment of patients with complex esthetic dental needs. Careful assessment of clinical situations and corresponding specialty consultations are of utmost importance to achieve

more predictable and esthetic treatment outcomes. The purpose of this clinical case is to report to the readership a novel digital fabrication of computer-aided design/computer-aided manufacturing milled acrylic provisional restorations and final lithium disilicate definitive restorations after orthodontic and periodontal therapy with virtual master impressions, casts, and articulation.

INTRODUCTION

Dental wear, or the loss of noncarious tooth structure, results from erosive, attritional, or abrasive processes but could result from any combination of these.[1] Erosion is the progressive loss of tooth structure by chemical processes; it is typically defined by wedge-shaped depressions, often found in facial and cervical areas. Attrition is the mechanical wear caused by opposing dental hard tissues rubbing against one another in close proximity; it typically results from mastication or parafunctional tooth alignment. Abrasion is an abnormal wearing away of the tooth structure by causes other than mastication (eg, toothbrush abrasion).[2]

The number of adults with severe tooth wear increases with age.[3] The prevalence of tooth wear increases from 3% at the age of 20 years to 17% at the age of 70 years, and there is a significant association between tooth wear and age.[3] Erosion is associated with the most tooth wear in conjunction with other reasons, such as attrition. Adolescent males are among the highest-risk groups for erosion.[1] Structural tooth loss on the palatal surfaces of maxillary teeth is evidence of erosion caused by gastric reflux in gastroesophageal reflux disease, and this is a common cause of erosion in middle-aged men.[1,4]

Worn dentition is a multifactorial disease process that has varying etiologies and is caused by factors in addition to erosion. For example, bruxism, clenching, and parafunction combined with tooth erosion may significantly increase tooth wear.[5]

Different treatments indicated for patients with tooth wear depend on the severity of the worn dentition and possible loss of a stable and reproducible vertical dimension. Regardless, the etiology of the wear needs to be identified and eliminated before extensive treatment planning of indirect prostheses. Once the cause is determined, treatment could range from a conservative direct composite restoration to full mouth reconstruction with indirect fixed prostheses.[6]

Today's all-ceramic restorations have the advantage of being esthetic, strong, and biocompatible with hard and soft tissue. Recently, new developments in glass ceramics have made all-ceramic restorations stronger and more durable in functional occlusion, which has resulted in more predictable clinical outcomes.[7] The demand for all-ceramic restorations has increased because of market awareness and patient awareness of toothlike crowns with real-tooth optical properties. For example, IPS e.max, a pressed lithium disilicate glass ceramic that has optimized translucency, durability, and strength for full anatomic restorations,[7] has been used for restoring worn dentition and has been associated with positive clinical outcomes and higher patient satisfaction.[7]

Clinical situations that require optimized esthetic results need to be evaluated thoroughly, and typically a multidisciplinary treatment planning approach is necessary. Of particular concern are smile line, facial geometry, emergence profile, tissue geometry, tooth axis (zenith points), tooth shape (golden rule), and proportionality.[8] Merging orthodontic alignment and required spacing for restorative dentistry are necessary in many cases for a more predictable esthetic outcome.[9,10] Additionally, orthodontic treatment can provide protective occlusal movements to enhance long-term prognosis of all-ceramic indirect prostheses.[9,10]

Soft tissue geometry and height play a very important role in the esthetic outcome of any clinical situation.[8] Therefore, proper soft tissue evaluation and corresponding treatment are indicated for any patient seeking optimal esthetic outcomes. A smile that has excessive keratinized gingival tissue in combination with short teeth compromises dental esthetics.[11] Appropriate diagnosis and lengthening of the soft or hard tissue crown are indicated for an optimal esthetic outcome.[11]

Emerging digital technology has introduced many new aspects to contemporary dental practices.[12] Recently, digital impressions have emerged as an alternative to conventional polyvinyl siloxane (PVS) impression techniques and materials.[12] Clinical evaluations of intraoral digital impressions have shown very promising results.[12] All-ceramic crowns fabricated using chair-side scanners have superior marginal fit and improved proximal contact points than those fabricated using conventional impressions.[13]

This clinical case report will present the step-by-step treatment of maxillary and mandibular teeth in a multidisciplinary fashion using fixed appliance orthodontic treatment, crown lengthening, and all-

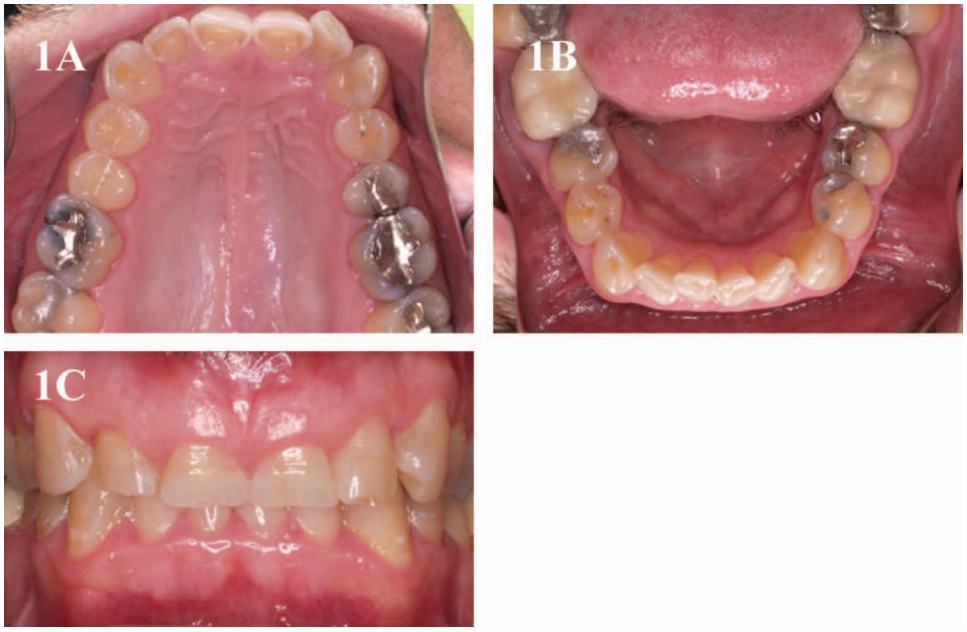

Figure 1. *Preorthodontic treatment. (A): Maxillary occlusal view. (B): Mandibular occlusal view. (C): Frontal view.*

ceramic crowns along with long-term provisional restorations fabricated using a digital impression technique and computer-aided design/computer-aided manufacturing (CAD/CAM) technology. This novel approach bypassed conventional PVS master impression techniques and the need for solid casts and semiadjustable articulation. The creation of a digital impression, occlusal record, and prosthetic fabrication of all-ceramic crowns were performed through the acquisition of digital CAD/CAM files.

CLINICAL TECHNIQUE REPORT

A healthy 45-year-old man presented to the department of orthodontics for consultation (Figure 1A through C). Initial examination revealed mild maxillary and mandibular anterior crowding as well as excessive anterior overbite/overjet. The patient had moderate to severe lingual wear on his maxillary anterior teeth and moderate wear on the incisal edges of his mandibular anterior teeth due to nocturnal bruxism and daytime clenching. He was wearing a self-prescribed, over-the-counter occlusal splint to slow the wear rate of his teeth. His treatment plan was for comprehensive orthodontic therapy and full-banded fixed orthodontic appliance. He was treated for one year to correct his malocclusion and to achieve sufficient restorative space for indirect prostheses. Of particular importance was reestablishing bilateral canine rise to protect his dentition from excursive interferences during functional movements.

After the conclusion of orthodontic treatment (Figure 2A through C), the patient was referred to the department of oral health and rehabilitation for restorative evaluation and treatment planning. His maxillary and mandibular anterior dentition exhibited moderate to severe wear due to parafunction. His posterior maxillary and mandibular teeth showed no signs of wear, although he had multiple amalgam and direct composite restorations. Although interocclusal space became available after orthodontic treatment, crown-lengthening surgery was indicated to increase abutment height and improve the esthetics of the final restorations.

The treatment plan, which was discussed with and accepted by the patient, was to restore the maxillary and mandibular teeth from the first premolar to the contralateral first premolar with single-unit all-ceramic full coverage restorations preceded by a crown-lengthening procedure of the aforementioned teeth. He understood the benefits and risks associated with the proposed treatment options, and treatment consent was obtained.

Diagnostic impressions were made with irreversible hydrocolloid impression material (Jeltrate Fast Set, Dentsply Caulk, Milford, DE, USA), and solid casts were made from type III dental stone (Orthodontic Stone, Whip Mix Corp, Louisville, KY, USA). Face-bow transfer and maxillomandibular relationship were obtained and used to articulate the diagnostic casts on a semiadjustable articulator (Hanau 2240, Whip Mix Corp). A diagnostic wax-up was completed by a dental laboratory with white-

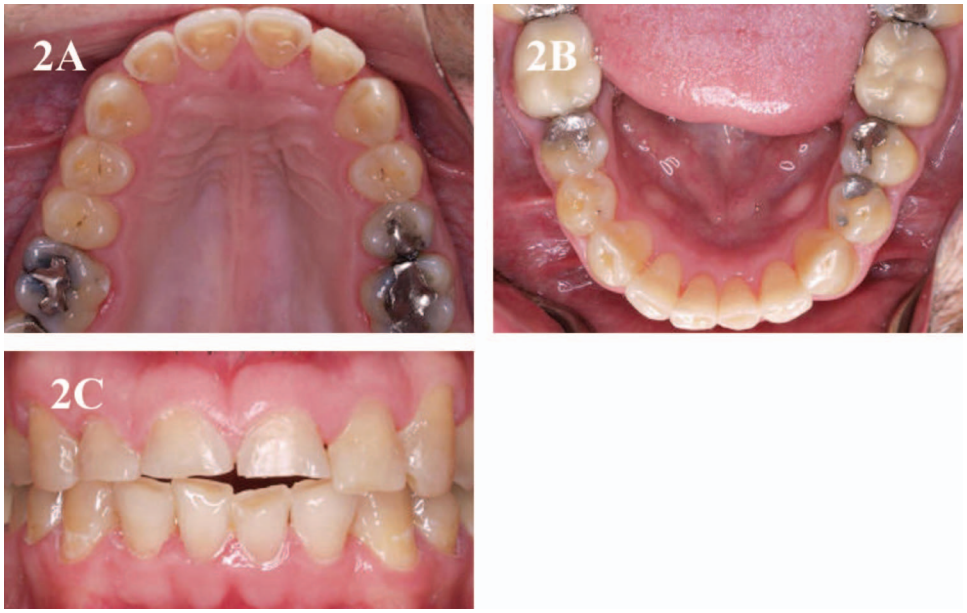

Figure 2. *Postorthodontic treatment. (A): Maxillary occlusal view. (B): Mandibular occlusal view. (C): Frontal view.*

colored wax (Life-like presentation wax, Whip Mix Corp) (Figure 3) and then duplicated. Vacuum-formed material (0.030" Coping Material, Keystone Industries, Cherry Hill, NJ, USA) was used to fabricate a surgical template for crown lengthening, a preparation guide, and a provisional stent.

The crown-lengthening procedure was performed on the facial and palatal/lingual aspects of the abutment teeth using a disposable surgical scalpel blade No. 15 (MDS15215, Medline Industries, Inc, Mundelein, IL, USA) according to the previously mentioned surgical template (Figure 4A,B). Osseous recontouring was accomplished using a surgical handpiece (WS-56E, W & H Dentalwerk, Bürmoos, Austria) and a surgical round bur (Brasseler USA, Savannah, GA, USA). The gingival tissues were sutured using 4(0) interrupted black silk suture (Ethicon, Sommerville, NJ, USA).

After a healing period of eight weeks, maxillary and mandibular abutment teeth preparations were completed according to the vacuum-formed preparation guide under local anesthesia (Septocaine [Articaine HCl 4%], Septodont, Lancaster, PA, USA) with a diamond rotary cutting instrument (Fine Diamonds, Round End; Brasseler USA, Savannah, GA) (Fig. 5). The provisional restorations were fabricated using the vacuum-formed provisional stent and autopolymerizing bis-acryl composite resin Vita shade A1 provisional material (Integrity, Dentsply Caulk, Milford, DE, USA) and cemented with a resin-based temporary cement (TempBond Clear,

Figure 3. *Pretreatment wax-up (front view).*

Figure 4. *Periodontal crown lengthening. (A): Crown-lengthening surgery with surgical template. (B): Gingival tissue six weeks after surgery.*

Figure 5. *Abutment teeth preparations (front view).*

Kerr Corp, Orange, CA, USA). The temporary restorations were placed in function for four weeks to allow the patient to evaluate the esthetics, form, and function.

Soft tissue management during the definitive impression was accomplished using a retraction paste (3M ESPE retraction capsule, 3M ESPE, St Paul, MN, USA). The definitive impressions and occlusal record registrations were made using a chairside intraoral digital scanner (iTero, Cadent Ltd, Carlstadt, NJ, USA). The clinician was prompted by the scanner software to capture the prepared abutment teeth and the remaining dentition in a series of occlusal, facial, lingual, and interproximal scans. A virtual interocclusal record was captured with the posterior teeth in maximum intercuspation. The completed scan data were then transmitted to the manufacturer (Cadent, Carlstadt, NJ, USA) for refinement. The data files were subsequently transmitted electronically to a commercial dental laboratory to mark the crown margins and to perform virtual trimming of the margins on the digital image. The digital images of maxillary and mandibular casts were virtually articulated according to the interocclusal record captured during the definitive impression.

The digital file with identified margins and virtual trimming (Figure 6) was approved by the clinician and transmitted to the dental laboratory, which then downloaded the file to the laboratory-based CAD/CAM system (Straumann CARES, Straumann USA, Andover, MA, USA) for design of the definitive restoration.

Individually milled provisional crowns were fabricated to confirm the impression accuracy, the maxillomandibular relationship, and patient satisfaction with the proposed esthetics. The provisional restoration design (Figure 7A) was transmitted to a remote milling center for fabrication (Straumann

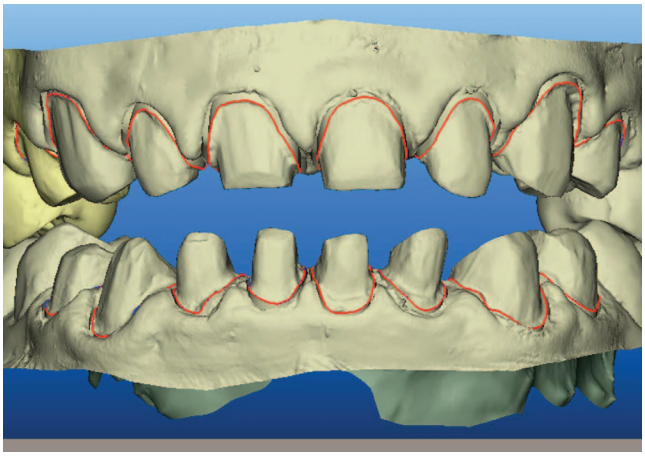

Figure 6. *iTero scans with margins identified (frontal view).*

USA, Arlington, TX, USA). The individually milled provisional crowns were fabricated with polymethyl methacrylate–-based acrylate resin using Vita shade A1 (Polycon ae; Straumann USA). Canine-guided occlusion was designed for the provisional restorations. The proximal and occlusal surfaces were evaluated using articulating paper (AccuFilm, Parkell Inc, Edgewood, NY, USA), all necessary adjustments were made with a low-speed dental handpiece, and the restorations were cemented with resin-based temporary cement (TempBond Clear; Kerr Corp) (Figure 7B,C). No marginal discrepancies were noted with the provisional restorations, which verified the accuracy of the proposed marginal fit. The patient followed the prescribed oral hygiene regimen for home care and was scheduled for a follow-up appointment three weeks after insertion. At the follow-up appointment, the patient was satisfied with the proposed esthetic color and contours of the provisional restorations and reported no functional interferences.

Screenshots of the completed design of the definitive all-ceramic restorations were sent electronically from the dental laboratory to the patient and clinician for review and subsequent approval. The approved design was then sent to the remote milling center for fabrication (Straumann USA). Individual full-contour lithium disilicate restorations (IPS e.max CAD, Ivoclar-Vivadent, Amherst, NY) were milled using Vita shade A1, high-translucency ceramic blocks. High-translucency blocks were chosen because of their “normal” dentin stump shade to be used for optical properties and natural shading. After assessing occlusion and the contours of the crowns, minimal adjustments were made with rotary cutting instruments using a low-speed dental handpiece. Upon completion of all adjustments, the

Figure 7. *iTero scanned and milled acrylic provisional appliance. (A): iTero CAD of provisional restorations. (B): Frontal view of provisional restorations. (C): Patient's smile after treatment.*

adjusted areas were polished and made ready for final cementation. Canine-guided occlusion was achieved for the definitive crowns.

A high-translucency try-in paste was used to evaluate the dentin stump shade's optical properties and select the final resin luting color. The restorations were verified and luted with a high-translucency, self-adhesive, autopolymerizing resin cement (SpeedCEM, Ivoclar-Vivadent) (Figure 8). The residual cement was removed and postinsertion instructions were given to the patient. The patient was then enrolled in a hygiene program with a six-month recall interval.

DISCUSSION

Tooth wear is difficult to treat. It often presents at an advanced stage and with multiple underlying factors, which complicates its diagnosis and necessitates a multidisciplinary treatment approach. The workflow in this current case report presented a novel method for digital impression capture using a chairside intraoral scanner and electronic data transfer to the dental laboratory. This serves to facilitate the digital design of the restoration between the clinician, dental technician, and restoration manufacturer at a centralized production facility.

The digital design of the provisional and definitive restorations can be advantageous in allowing the CAD software to replace the wax-up procedures for individual teeth that were traditionally done by the dental technician. To remove the waxing and casting/pressing techniques cuts down on human error and the lengthy time required to make simple contour changes. Electronic mail was used to facilitate communication with the patient, which gave him the opportunity to play an active role throughout the critical phases of the CAD design. The process of controlling the soft tissue during the scanning phase is extremely technique sensitive. Therefore, the operator must provide an uncontaminated scanning surface for the iTero scanner to properly identify the preparation margins. Many times the technique sensitivity for the iTero scanner is less forgiving than traditional PVS impression materials. Obtaining clear and visible margins through proper tissue retraction and adequate isolation are paramount for accurate data acquisition by the scanner as no impression material is introduced into the sulcus, unlike the case with conventional impression techniques. Also, operator experience in orienting the scanning module (wand) and the need to capture sufficient data points are essential.

Figure 8. *Frontal view of iTero Milled IPS e.max definitive restorations.*

SUMMARY

This clinical report presented a multidisciplinary treatment protocol for treatment of excessive anterior teeth wear associated with parafunctional habits. It emphasized the collaboration between practitioners in the fields of orthodontics, periodontics, prosthodontics, and dental technology to achieve an optimal esthetic outcome for the patient. Fabrication of the milled provisional and definitive all-ceramic restorations was accomplished through a completely digital approach. Long-term milled provisional restorations were used to confirm esthetics and digital articulation. The use of CAD/CAM definitive restorations that were identical to the approved designs of the provisional restorations ensured a predictable clinical outcome and patient satisfaction, while eliminating dental laboratory errors and additional steps and, thus, maximizing efficiency. This case report presents a novel treatment protocol for CAD/CAM milling of long-term provisional and definitive restorations that did not require the production of physical casts or mounted articulation.

Human Subjects Statement

This work was conducted at the University of Louisville School of Dentistry.

Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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