©Operative Dentistry, 2019, **44-2,** 109-113

Clinical Technique/Case Report

Restoration of a Mandibular Incisor With a Computer-aided Design/ Computer-aided Manufacturing Fabricated Anterior Onlay

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Clinical Relevance

The author proposes a new treatment option for nonsurgical root canal treated mandibular anterior teeth using a computer-aided design/computer-aided manufacturing system without conventional post and core.

SUMMARY

The use of computer-aided design/computer-aided manufacturing (CAD/CAM) dentistry has triggered novel approaches to restoring teeth in ways that increase efficiency, improve esthetics, and conserve tooth structure. Endodontically treated mandibular incisors offer a challenging restorative opportunity due to the small amount of natural tooth structure and the required amount of reduction needed for restorative material. The case presented demonstrates how to leverage chairside CAD/CAM technology to restore a discolored and fractured endodontically treated mandibular incisor without the use of a post and core and completing the restoration in a single visit.

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DOI: http://doi.org/10.2341/18-217-S

INTRODUCTION

Digital and adhesive dentistry procedures have provided conservative alternatives to full coverage crown restoration, which can lead to unnecessary tooth reduction.[1,2] Due to the relative new nature of our modern computer-aided design/computer-aided manufacturing (CAD/CAM) fabricated adhesively applied glass ceramics, there are still discoveries to be made on how to apply these advancements.

Similar to the posterior onlay, the anterior onlay is a concept used to restore esthetic situations where a veneer is no longer the best option but a crown may be unnecessarily destructive.[4] This restorative strategy does not rely on purely adhesive bonding as a veneer does, nor does it rely entirely on traditional mechanical resistance and retention form. A full coverage crown can be bonded, but traditionally significant amounts of dependable bonding substrate, enamel, is removed during tooth preparation, and long-term bonding to dentin has not been shown to be dependable.[5,6] The proposed anterior onlay concept tries to use both ideas to maximize the potential for long-term retention of a restoration. This is accomplished by trying to conserve enamel wherever possible, and additionally trying to maxi-

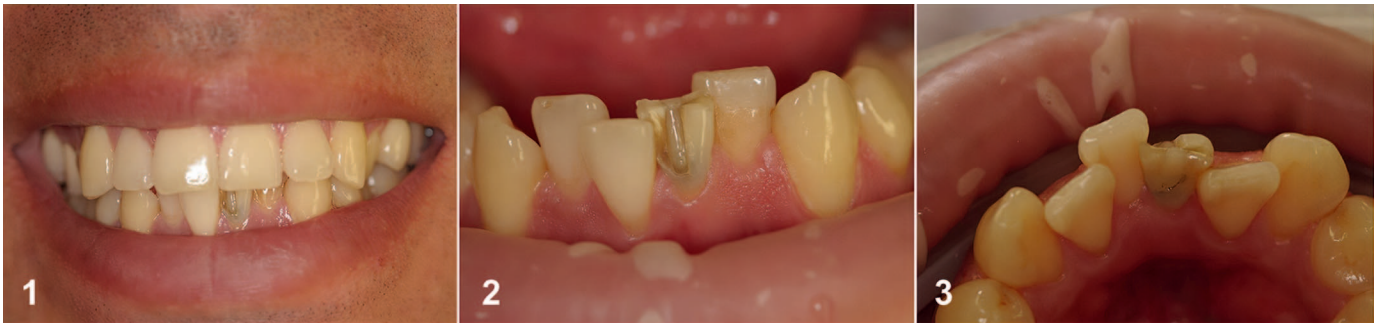

Figure 1. *Initial smile.*

Figure 2. *Existing composite resin core and facially fractured tooth structure.*

Figure 3. *Leaking composite and endodontic access from lingual; the craze line is evident at the distal facial line angle that fractured upon initiation of preparation.*

mize any surface that can provide mechanical resistance and retention.

In the authors' opinion, this restoration design tends to be more ideal in situations where incisal coverage is needed or desired. Whereas a full crown preparation leads to a situation where remaining sound tooth structure is removed and artificial core restorative materials are heavily relied upon to retain the crown. We know that remaining natural tooth structure, and the ferrule effect it provides, is strongly related to the potential longevity of a crown restoration.[7] In addition, the anterior onlay often does not remove more than a minimal amount of tooth structure. Frequently, it can capitalize on the retentive pulp chamber provided after nonsurgical root canal therapy (NSRCT) has been performed, similar to an endocrown where the pulp chamber retained core and crown are a single monolithic restoration.

Fabricating a high-strength glass ceramic restoration using a chairside designed and milled system can be highly efficient, fast, and accurate. In a single one- to two-hour visit, a definitive, highly esthetic, and conservative restoration can be provided to the patient. Additionally, the dentist can maintain control of all aspects of esthetics by controlling the shape and custom staining.

CASE STUDY

A 32-year-old healthy male patient presented with a nonsymptomatic, coronal facial fracture and previous NSRCT of No. 24 (Figures 1 through 3). Due to mandibular anterior crowding, the tooth was not in occlusion. The reason for the previous restoration was trauma when the patient was an adolescent. The patient's chief concern was the unesthetic dark appearance of his tooth.

Mandibular anterior teeth can be difficult to treat due to their relatively small size. In the case presented here, the size of the fractured fragment and need for cuspal coverage made the use of a direct bonded composite resin less than ideal. Often a post and core are necessary to retain a crown after a minimum 1-mm recommended shoulder for most all-ceramic restorations.[8] Nearly all of the remaining tooth structure would have to be included in the preparation. An alternative outcome is to underprepare the tooth, but this leads to a restoration that is overcontoured to maintain minimal thickness for the glass ceramic strength. This results in an unesthetic appearance, and an overcontoured restoration can lead to plaque retention and periodontal disease.[9]

The patient chose the minimally invasive CAD/CAM anterior onlay, which would preserve all tooth structure except for incisal reduction. No anesthesia was necessary because the tooth was already nonvital and all margins would remain supragingival. Isolation was obtained (Optragate, Ivoclar Vivadent, Amherst, NY, USA; Isodry, Isolite Systems, Santa Barbara, CA, USA). The remaining composite was removed. Staining extended 1 mm into the pulp chamber. A fracture line was seen at the distal line angle of the facial surface (Figure 3). When initiating tooth preparation (fine diamond, flat-end taper, Neodiamond Microcopy Kennesaw, GA, USA), the distofacial fragment fractured. The final onlay preparation margin was determined by the fracture on the facial and the endodontic access on the lingual. The interproximal finish lines were the result of the incisal 2-mm reduction. All margins were smoothed with the same fine diamond, and internal corners were rounded. A shade A1 glass ionomer (GC Fuji IX GP, GC Corporation, Tokyo, Japan) orifice barrier

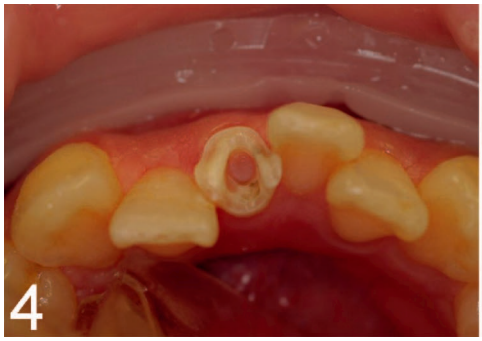

Figure 4. *Glass ionomer core placed, and final preparation showing pulp chamber and lateral wings for retention, and 360° of enamel for resin bonding.*

Figure 5. *Preparation from the facial view.*

was placed to seal the NSRCT-treated tooth, block out undercuts, and flatten the floor of the pulp chamber (Figure 4). Rather than fill the whole pulp chamber with a core, we elected to use the pulp chamber as an endocrown to increase the mechanical resistance and retention without having to remove any additional tooth structure (Figure 5). Interproximal contacts were not broken, and since the process would be all digital rather than analog, there was no need to separate the teeth with a finishing strip as we would for traditionally prepared veneers.

Preparation design was very conservative. The only tooth structure removed was the incisal reduction, much of which was already compromised. Resistance and retention form were maximized with the remaining 2-mm-high proximal tooth structure conserving natural contacts. This, in combination with the 3-mm internal retention gained from the pulp chamber, resulted in a 5-mm depth of resistance and retention form. In addition, the preparation had 360° of substantial enamel remaining along all of the margins. Being supragingival there was no need for gingival retraction.

An impression was digitally captured (CEREC Bluecam, Sirona, Charlotte, NC, USA), and a proposal was created with CAD software. A lithium disilicate block (A1-LT-12) was selected (IPS e.max CAD, Ivoclar Vivadent, Amherst, NY, USA), and the restoration was milled (Cerec MCXL mill, Sirona). The precrystallized restoration was tried in intraorally so any adjustments could be made easily at this stage before crystallization and custom staining was done. Although the tooth was not in function, the author (JM) elected to polish the incisal 1 mm of the restoration (Dialite LD, Brasseler USA, Savannah, GA, USA), as glaze can wear away in function, and when it does, it is essential that occlusal contacts only touch polished porcelain/ceramic to avoid excessive wear.[10] The restoration was then custom stained, glazed (IPS Empress Universal Shade/Stains, Ivoclar Vivadent), and crystallized in a ceramic oven.

The final restoration was then prepared for bonding following manufacturer's recommendations for lithium disilicate using 5% hydrofluoric acid for 20 seconds (IPS Ceramic Etching Gel, Ivoclar Vivadent) and silane (Monobond Plus, Ivoclar Vivadent). The tooth was prepared for resin cement by selective enamel etching for 15 seconds and resin bonding agent application (Total Etch 37% phosphoric acid, Adhese Universal resin bonding agent, Variolink II resin cement, Ivoclar Vivadent). The dual-cure resin cement was syringed into the tooth pulp chamber and then onto the intaglio surface of the restoration and delivered. Excess cement was removed, and the restoration was light cured (ESPE Elipar S10, 3M, St Paul, MN, USA) following manufacturer's instructions. Margins were polished and final occlusion and interproximal contacts checked (Figures 6 and 7). There was no need for

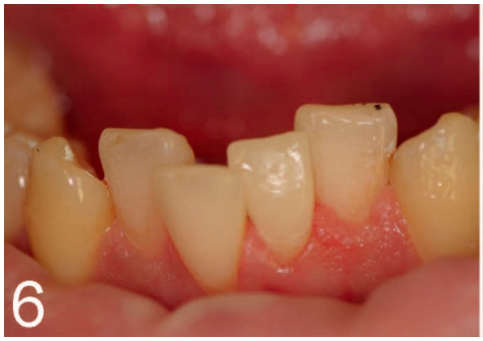

Figure 6. *Final custom-stained lithium disilicate restoration delivered and margins polished.*

Figure 7. *Final restoration from the occlusal view.*

anesthesia or retraction cord; in addition, the simplicity of the preparation and the use of limited restorative materials led to a total treatment time under two hours.

DISCUSSION

Sometimes restorative needs move past reliable use of a direct restorative material due to quality and quantity of remaining enamel and dentin.[11] In posterior teeth, typically when cuspal coverage is required, the next minimally invasive restorative options are onlays. It is not until damage is severe that the conservative recommendation becomes a full crown. Historically, anterior teeth have not had a similar intermediate restorative option between veneers and full-coverage crowns. With the ability to create chairside restorations using CAD/CAM systems, the authors suggest an anterior onlay concept in an effort to conserve tooth structure before removing most of the tooth required for full crown preparation. This can be especially advantageous after endodontic therapy and when more dentin is exposed than is ideal for laminate veneers. These may be especially useful when enamel is still found 360° around the preparation, and mechanical resistance and retention can still be incorporated into the preparation without removing additional tooth structure. When onlays fail, crowns can often still be restorative options. Conversely, when a crown fails, another crown may not be possible.

When laminate veneers are prepared that do not fully break, interproximal contact finishing strips are used to very lightly open the contact. This allows separation of the die stone without having to risk snapping or breaking the stone after sectioning. With digital technology this is no longer necessary because instead of stone a digital model is used, which cannot fracture. However, when a margin ends in an interproximal contact, it can be difficult to prepare a margin at this location and clearly capture the margin in the digital impression. The authors have found that a small amount of local anesthetic infiltration just below the gingival papilla allows the placement of a wedge for separation. This can aid the safe placement of the margin preparation with less risk of damage to the adjacent tooth, and the slight amount of separation makes it easier to capture the margin in a digital impression. In the authors' experience. pre-wedge placement does not affect the software's ability to create a proposal for the restoration. To account for the separation of the wedge, the interproximal contact on that side of the proposed restoration can be lightened. After milling, the restoration can be tried in and adjusted before being bonded into place with a resin luting cement.

Another concern is the ability of the software to understand what is desired from this type of unconventional preparation. The authors' experience has shown that the software has no difficulty proposing appropriate restorations to accommodate anterior onlay preparations. The chairside CAD software readily proposed a clinically desired restoration and only requires minimal operator design modifications.

An endocrown is a monolithic pulp chamber retained core and crown restoration. Research has generally shown that endocrowns seem to have similar, if not better, survival rates in comparison to a composite core or post and core systems under a crown.[12] Information gained from the testing of novel restorative designs, such as endocrowns, are what the authors use to justify this preparation.[12] This restoration design can be more efficient than completing an additional core placement procedure.

CONCLUSION

Anterior onlays avoid unnecessary tooth reduction compared with full crown preparations. The anterior onlay concept offers an intermediate restorative option in cases of anterior teeth that need incisal coverage but lack the ideal parameters for a laminate veneer. This is especially advantageous when restoring an endodontically treated tooth where the pulp chamber can offer additional retention. This technique allows preparations to be guided by remaining tooth structure and previous existing restorations to maximize utilization of existing internal and external retentive features. The use of modern in-office CAD/CAM systems with this type of restoration can lead to a very esthetic outcome that results in a minimally invasive treatment in a single appointment.

Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of Indiana University.

Disclaimer

The views expressed in this article reflect those of the author and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, nor the United States Government.
The author states: "I am a military service member or federal/contracted employee of the United States government. This work was prepared as part of my official duties. Title 17 USC

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.

(Accepted 20 September 2018)

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