PROA concept: prosthetic restoration with orthodontic appliance

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This paper describes an alternative computer-aided design/computer-aided manufacturing (CAD/CAM) technique for the creation of a combined prosthetic restoration with orthodontic appliance (PROA). This concept allows the use of orthodontic appliances such as brackets, attachments, or any other type of appliance over different types of prosthetic restorations. The PROA concept aims to mitigate problems associated with performing restorative treatment when orthodontic treatment is necessary. This proposed concept provides the clinicians with proper control and planning of the interdisciplinary treatment that will lead to the final tooth shape, form, and proportions while performing orthodontic tooth movements. *(Quintessence Int 2020;51:304–308; doi: 10.3290/j.qi.a44148)*

Key words: 3D printing, aligners, attachment, bracket, CAD/CAM, digital, orthodontics, PROA, restorative, treatment plan

Dental interdisciplinary treatment is the ideal solution for the rehabilitation of complex cases in order to achieve a predictable result.[1,2] When a restorative/orthodontic approach is indicated, it is preferable that the patient's dentition has the appropriate dental morphology, proportions, and size before initiating any orthodontic treatment.[2] However, dental restorations might be indicated for patients exhibiting defective tooth size, shape, or structure prior to orthodontic treatment.[1-3]

Regardless of the orthodontic approach selected, brackets or attachments are bonded to teeth or to existing dental restorations.[4,5] Some of the bonding agents used are caustic and toxic, having the potential to damage oral tissues, teeth, and restorations.[6-8] Moreover, bonded orthodontic auxiliaries have to be precisely located to produce the desired tooth movement.[2] When performed intraorally, these procedures can present a challenge, especially in areas of reduced access.[6] All the above-mentioned shortcomings can significantly affect the treatment and may lead to additional costs for the patient.

Computer-aided design/computer-assisted manufacture (CAD/CAM)-produced restorations have been widely adopted with the aim of making patient's treatment simpler and more efficient.[9] Although it is common to have milled and printed restorations and orthodontic appliances fabricated separately,[9-11] to the present authors' knowledge no previous attempts to create a prosthetic restoration combined with an orthodontic appliance have been reported. This paper proposes the utilization of digital technology to integrate an orthodontic appliance with a prosthetic restoration to improve the efficacy of planning and prognosis for patients requiring an interdisciplinary approach involving restorative and orthodontic treatment.

The prosthetic restoration with orthodontic appliance (PROA) concept

The prosthetic restoration with orthodontic appliance (PROA) concept was developed to overcome limitations associated with ortho-restorative treatments by incorporating an orthodontic appliance onto a single prosthetic restoration. The rationale consists of fabricating a prosthetic restoration with the appropriate width/length ratio, final proximal contour, and esthetics, and includes an orthodontic appliance digitally designed onto the restoration structure. The resulting restoration is then fabricated using CAD/CAM technologies (milled, printed, laser-sintered, or other combination), constituting the PROA.

Fig 1 Preoperative view of patient exhibiting defective partial fixed dental prosthesis.

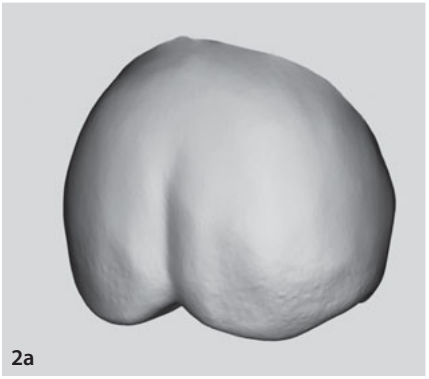

Fig 2a STL file depicting buccal view digital design of maxillary right second molar crown.

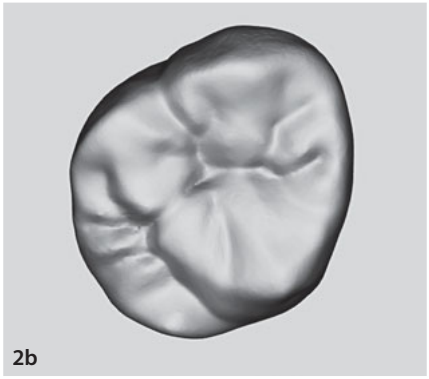

Fig 2b STL file depicting occlusal view of digital design of maxillary right second molar crown.

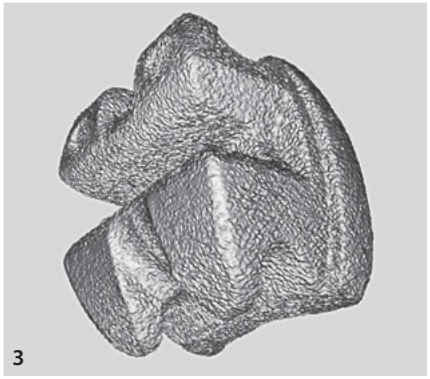

Fig 3 Orthodontic bracket scanned and converted into STL file.

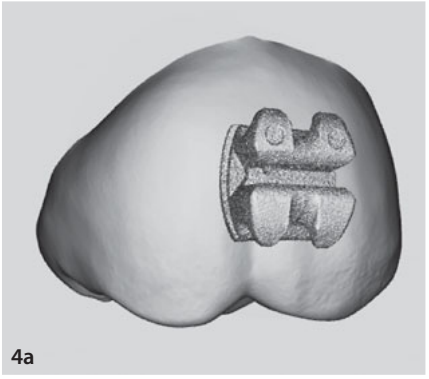

Fig 4a Buccal view of digital design of PROA restoration.

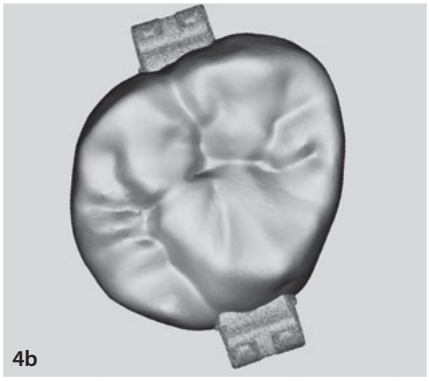

Fig 4b Occlusal view of digital design of PROA restoration.

Fig 5 3D-printed polymethyl methacrylate PROA crown.

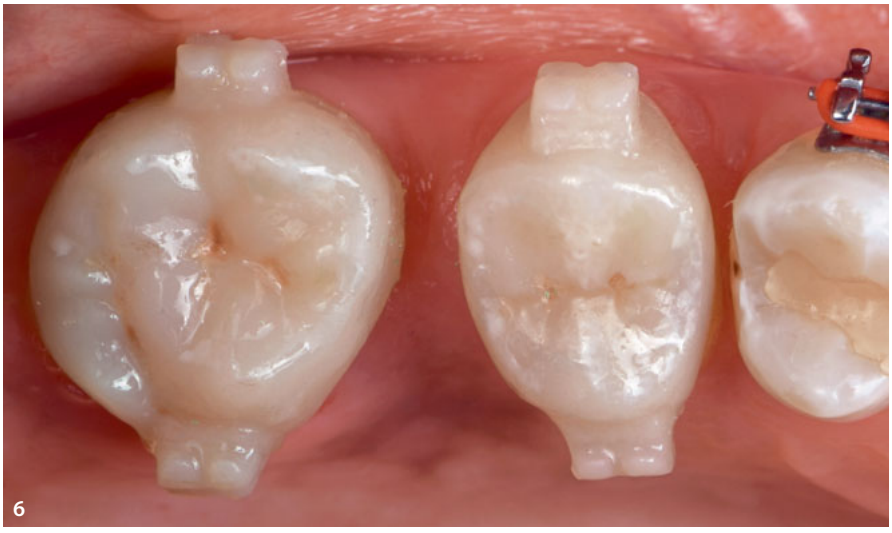

Fig 6 PROA crowns immediately after luting. A self-adhesive resin cement was used as a long-term temporary cement to prevent possible debonding of the polymethyl methacrylate during the whole orthodontic treatment.

The clinical case depicts the steps used for PROA. A 36-year-old patient presented to the Advanced Operative and Adhesive Dentistry Clinic at the University of Southern California requesting replacement of the defective fixed partial denture. Upon review of the patient, a multidisciplinary treatment was indicated, including replacement of the existing partial fixed dental prosthesis, orthodontic movement of the maxillary right second molar and second premolar to close the space between them, and individual full coverage crown restorations (Fig 1).

The defective restoration was removed, provisionally restored with bis-acryl crowns, and the sequence to produce the PROA proceeded as follows:

- Tooth preparations were digitally scanned using an intraoral scanner (Planmeca PlanScan, Planmeca Oy). The prosthetic restorations (full coverage crowns in this case) were designed using open platform dental software (Planmeca PlanCAD, Planmeca Oy) and the designed crowns were exported as STL files (Fig 2).
- The orthodontic appliance (bracket in this case) was scanned using micro-computed tomography (micro-CT; SkyScan 1174, Bruker) to obtain a DICOM file, and the resulting DICOM file was converted into an STL file (Fig 3).
- The two resulting STL files (designed crown and orthodontic appliance) were uploaded to an engineering software (Geomagic Studio 10, 3D Systems). The files were then aligned with spatial positioning via triangulation of three independent reference points (1, 2, and 3). The spatial reference points (1, 2, and 3) were placed on the external surface of the crown where the bracket needed to be positioned. Also, three spatial reference points (1, 2, and 3) were located in the internal area of the bracket. Reference 1 from the bracket matched with reference 1 from the external area of the crown, and similarly with reference points 2 and 3. This alignment produced a precise location of the bracket within the crown, thus facilitating the orthodontic movements of the teeth.
- The files were merged, creating one STL file with the final design of PROA that combined the orthodontic appliance (orthodontic bracket) and the prosthetic restoration (crown) (Fig 4).
- The restorations were fabricated (3D printed in polymethyl methacrylate) (Fig 5) and adhesively luted using self-adhesive resin cement (RelyX Unicem 2, 3M) (Fig 6).
- Orthodontic movements were initiated (Figs 7 and 8).

Discussion

The PROA concept incorporates prosthetic restorations and orthodontic appliances into a single restoration to facilitate treatment of interdisciplinary cases involving restorative dentistry and orthodontics, in comparison with traditional restorative techniques.[1-3] Clinicians can digitally evaluate the preparation and the root position, allowing for proper alignment of the restoration with the appliance, thus improving tooth movement and predictability.[1-3,5] Furthermore, the PROA concept circumvents the intricate intraoral bonding steps required to adhere an orthodontic appliance to a restoration, thus increasing safety and reducing treatment time and costs for both patient and clinician.[6-8]

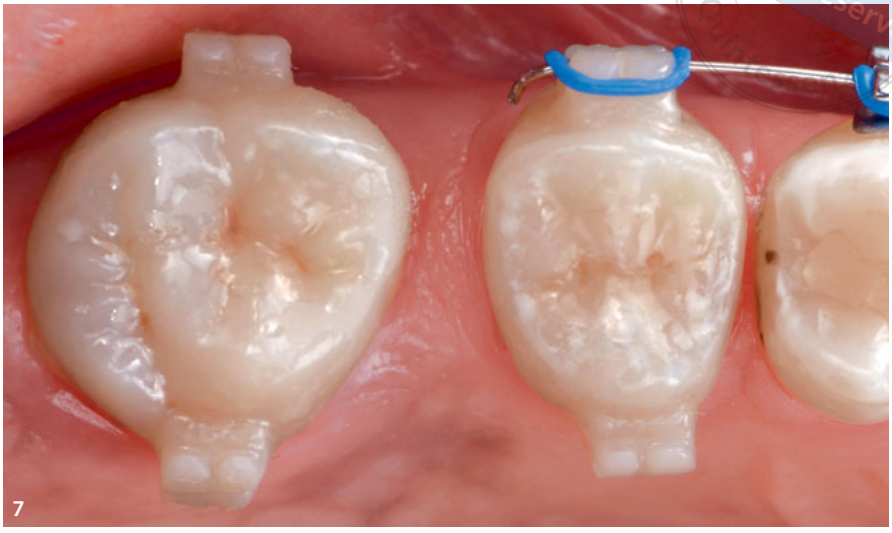

Fig 7 PROA crowns 1 month after delivery.

Fig 8 3D-printed polymethyl methacrylate PROA crowns after 10 months.

Different prosthetic restorations such as inlays, onlays, crowns, veneers, and fixed partial dentures fabricated using digital technology can benefit from the PROA concept. The orthodontic appliance may be customized to the specific type of treatment selected by the orthodontist, such as brackets, conventional attachments (tubes, balls, hooks, bands, buttons, rings, bite blocks), customized attachments, attachments for aligners (tray-based orthodontics), orthopedic appliances (palate expanders or extraoral orthodontic masks that rest on dental restorations), or any other customized appliance with any type of design.

The PROA concept allows the fabrication of a provisional restoration digitally designed with the final desired form and shape considering the ideal dimensions, contour, and proportions before initiating the orthodontic treatment. The PROA provisional restoration can be replaced and reproduced for definitive restoration by digitally excluding the orthodontic appliance.[2,3] The PROA can also be delivered as a definitive restoration before the orthodontic treatment, reducing discomfort during treatment for both the patient and clinician.[9] Thus, once the orthodontic treatment has been completed, the orthodontic appliance present in the PROA can be easily

removed. Situations where no restorative space is available may pose a challenge for the PROA concept. In these cases, creating restorative space through initial orthodontic movements would be of paramount importance, delaying PROA to a later stage.[1]

At this point, to the best of the authors' knowledge, there is no dental software that allows merging prosthetic restorations with orthodontic appliances in a convenient way. Thus, the PROA concept, as described, represents an illustrative method because micro-CT and Geomagic Studio are not always suitable for dental practices. Innovative advances in CAD software with the ability to incorporate both restorative and orthodontic features will facilitate the implementation of this technique to daily digital workflow. Improvements of CAM systems will provide a wider range of restorative and orthodontic treatment options and benefit patients worldwide.

Declaration

The authors have declared that no conflict of interest exists.

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