Biomimetic CAD/CAM restoration made of human enamel and dentin: case report at 4th year of clinical service

Pascal Magne, DMD, PhD
Associate Professor, The Don and Sybil Harrington Professor of Esthetic Dentistry, Division of Restorative Sciences, Ostrow School of Dentistry of USC, Los Angeles, California, USA

Luís Henrique Schlichting, DDS, MS, PhD
Clinical Assistant Professor, Department of General Dentistry, School of Dental Medicine, East Carolina University, Greenville, North Carolina, USA.

Correspondence to: Pascal Magne, DMD, PhD
The Don and Sybil Harrington Professor of Esthetic Dentistry, Herman Ostrow School of Dentistry of USC, Division of Restorative Sciences, 925 West 34th Street, Room 4382, Los Angeles, CA 90089, USA; Tel: +1 213 740 4239; Email: magne@usc.edu

Abstract

Currently, no dental material can exactly match the unique properties of dentin and enamel. Recently, a revolutionary approach was introduced in which a real tooth was utilized in combination with computer-aided design/computer-aided manufacturing (CAD/CAM) technology to obtain a natural CAD/CAM restoration. After 4 years of clinical service, the case was reevaluated and revealed an optimal condition of the biomimetic restoration.

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Introduction

Three disciplines in restorative dentistry can currently be identified as undergoing major developments and contributing to significant improvements in quality of care: adhesive dentistry; computer-aided design/computer-aided manufacturing (CAD/CAM) and digital dentistry; and biomimetic/bio-emulation dentistry. First, adhesive dentistry is now widely recognized for its ability to combine the well-established enamel bonding technique with optimized techniques for dentin bonding such as immediate dentin sealing.[1] The major benefit of adhesive dentistry is that it allows for non-retentive and minimally invasive tooth preparations. Second, CAD/CAM and digital dentistry in general is experiencing exponential advances due to the significant progress of computer processing power and manufacturing devices. As a result, extremely sophisticated and user-friendly CAD/CAM chairside systems are now available to the clinician to fabricate restorations made of various polymer and ceramic materials. It is therefore unavoidable that restorative dentistry is increasingly driven by biomimetics and bio-emulation approaches aimed at studying the structure, function, and biology of the natural tooth organ,[2,3] and using it as a model for the design and engineering of materials, techniques, and equipment to restore or replace teeth. While a significant amount of resources are dedicated to bio-engineering approaches using stem cell research to try to fabricate a real tooth (enamel and dentin) "in a petri dish," it is often forgotten that countless intact natural molars (wisdom teeth)[4] and premolars (for orthodontic reasons) are being extracted daily and discarded.

Case report

The application presented in this article finds itself at the crossroads of the three aforementioned major trends of modern restorative dentistry. It features the follow-up (4th year of clinical service) of a restoration of an extremely damaged tooth using an unprecedented approach: a bonded biomimetic CAD/CAM restoration made of real human enamel and dentin harvested from a donor patient (wisdom tooth) and used in a recipient patient of the same family.[5]

Both recipient patient (41 years old at the time of treatment) and donor patient (the recipient's daughter) were informed that this type of CAD/CAM natural restoration had not been used in the past, and consented to the treatment. The treatment planning was arranged in two phases: indirect bonded ceramic restorations on the premolars and second molar (Fig 1a and b, and Fig 2a to d – not presented in detail), and a bonded CAD/CAM natural restoration on the first molar.

Following removal of an old infiltrated restoration on a right first mandibular molar, only sound tooth structure was preserved (Fig 3a). A nonretentive onlay preparation was completed (Fig 3b), followed by immediate dentin sealing[1] using a three-step etch-and-rinse dentin bonding agent (Optibond FL, Kerr) (Fig 3c and d).

One of three donated wisdom teeth was chosen for best compatibility with the anatomy and dimensions of the tooth

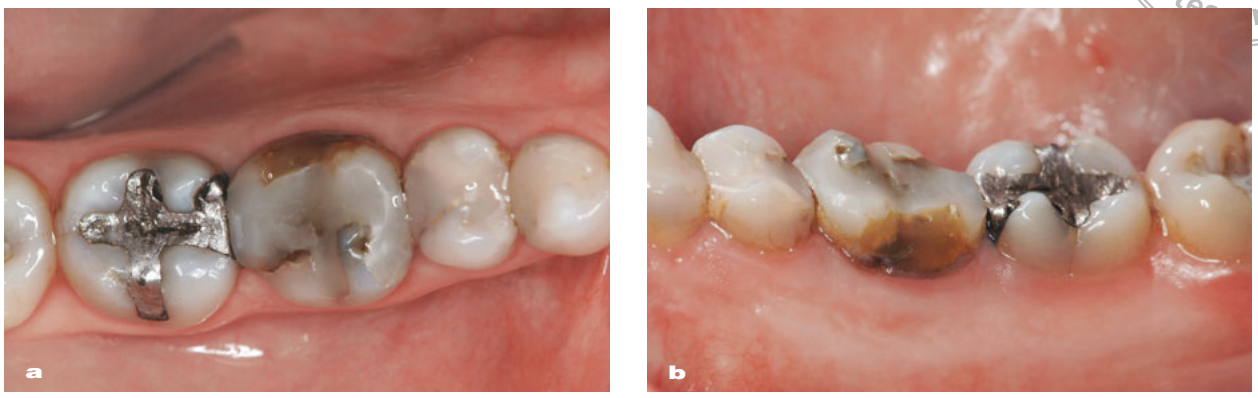

Fig 1 Preoperative views featuring heavily restored vital tooth in mandibular right sextant **(a and b)**.

Fig 2 Conventional lithium disilicate full-contour partial onlays (IPS e.max Press, Ivoclar Vivadent) for premolars and second molar. Pressed restorations **(a)**. Stained and glazed restorations **(b)**. Try-in (lingual view) **(c)**. Premolars and second molar completed with ceramic restorations, and first molar to be treated with natural restoration **(d)**.

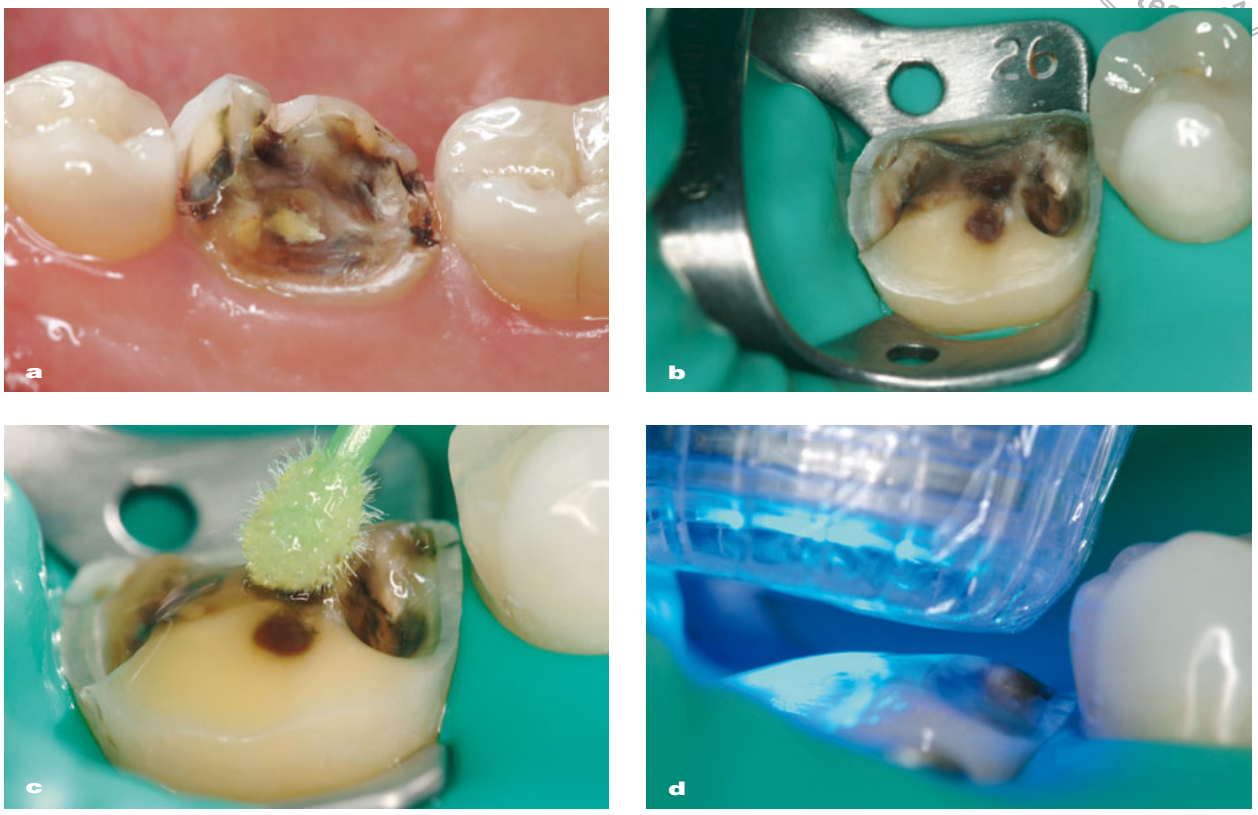

Fig 3 Severely damaged but vital right first mandibular molar (old restoration removed) **(a)**. Tooth preparation **(b)**. Immediate dentin sealing (Optibond FL) **(c and d)**.

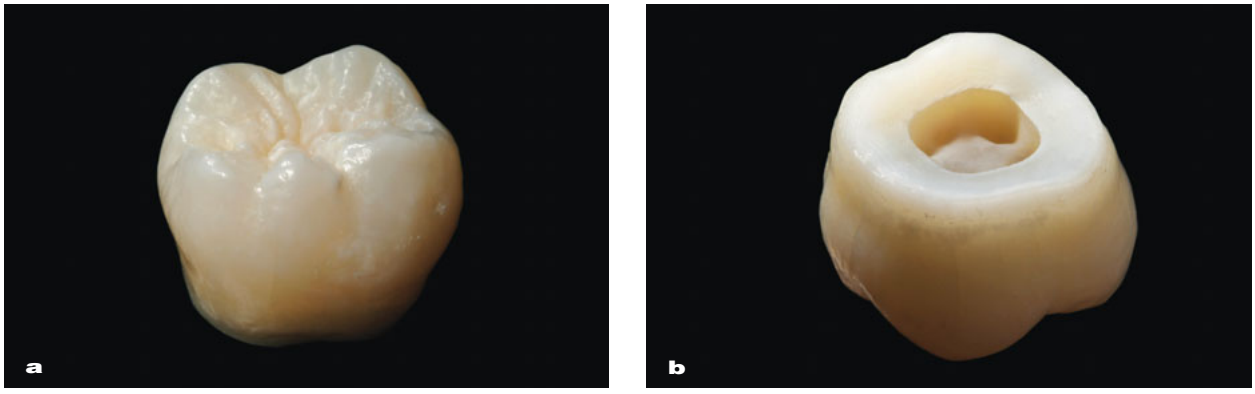

Fig 4 It is recommended that the root be removed (1 mm below the cementoenamel junction) **(a)** as well as the pulp, and to store the specimen in isotonic saline solution at a low temperature (around 4°C) **(b)**.

Fig 5 A duplicate stone cast was trimmed to remove the prepared tooth and some of the extent of the neighboring teeth to accommodate the crown of the extracted molar in the ideal position within the dental arch **(a)**. The occlusal contacts were checked with the articulated opposing stone casts **(b)**. The extracted tooth was powdered with titanium dioxide to allow anatomy acquisition by CEREC software version 3.65 (Sirona Dental Systems) set in correlation mode **(c)**. Screenshot of the digital impression of the preparation (first stone cast) **(d)**. Screenshot of the proposed design of the natural restoration based on the anatomy of the extracted tooth by means of correlation **(e)**.

to be restored (Fig 4a and b). A technique was developed and is presented elsewhere in detail (Schlichting et al, 2014)[5] to ideally position the natural tooth crown within a customized milling block to be used in the CEREC system (Sirona Dental Systems). For this purpose, the crown of the extracted tooth was ideally positioned within the patient's modified cast (Fig 5a to c), and scanned as a reference to be correlated with the scan of the tooth preparations, with the intact neighboring teeth serving as fitting surfaces between the two scans (Fig 5d and e).

A first block was milled without separating the onlay from the block (Fig 6a). A silicon index including the occlusal surface was then used to assemble the natural tooth crown with a new "L-shaped" block (Fig 6b and c). The new customized milling block (Fig 6d) was milled again using the previously designed restoration. This allowed the occlusal surface of the natural tooth not to be affected or damaged by the milling instruments. Milling was limited to the fitting surface with the preparation and neighboring teeth. Therefore, important occlusal anatomical landmarks were fully preserved (Fig 6e), and the adaptation of margins was deemed acceptable (Fig 6f).

Following try-in and field isolation with rubber dam, the restoration was delivered using standardized adhesive procedures. The fitting surface of the tooth preparation was gently air abraded and enamel etched for 30 s with 37.5% phosphoric acid (Ultra-Etch, Ultradent), rinsed, and dried. The biomimetic restoration was etched for 30 s with 37.5% phosphoric acid (Ultra-Etch), rinsed, air dried without desiccation for 3 to 5 s, followed by the application of a primer (Optibond FL, bottle no. 1, Kerr) with a light brushing motion for 15 s, air dried for 3 to 5 s, then followed by an application of adhesive resin (Optibond FL, bottle no. 2) for 20 s (no air thinning). The tooth preparation fitting surface was coated with adhesive resin (Optibond FL, bottle no. 2) and was also left unpolymerized. Filtek Z100/A2 (3M ESPE), preheated to 68°C (Calset, Addent), was used as a luting agent. Following the elimination of excess composite resin, each surface was exposed at 1200 mW/cm^2 for 60 s (20 s per surface, repeated 3 times). The margins were then covered with a glycerin air barrier and light polymerized for an additional 20 s.

Follow-up during the 4th year of clinical service revealed an optimal condition of the organic restoration as well as the neighboring teeth, restored conventionally (Fig 7a). All the teeth remained vital with normal sensitivity and normal periodontal and radiological findings (Fig 7b).

Conclusion

Even though this case only represents a proof of concept and its successful outcome in the medium term, it demonstrates that it is possible to combine a significant biological resource such as extracted third molars and premolars (for orthodontic reasons) from a donor such as a family member (Fig 8) with a modern dental CAD/CAM system and adhesive technology. It is of special interest to note the emotional component of this treatment, somewhat similar to that of a transplant patient, which led the

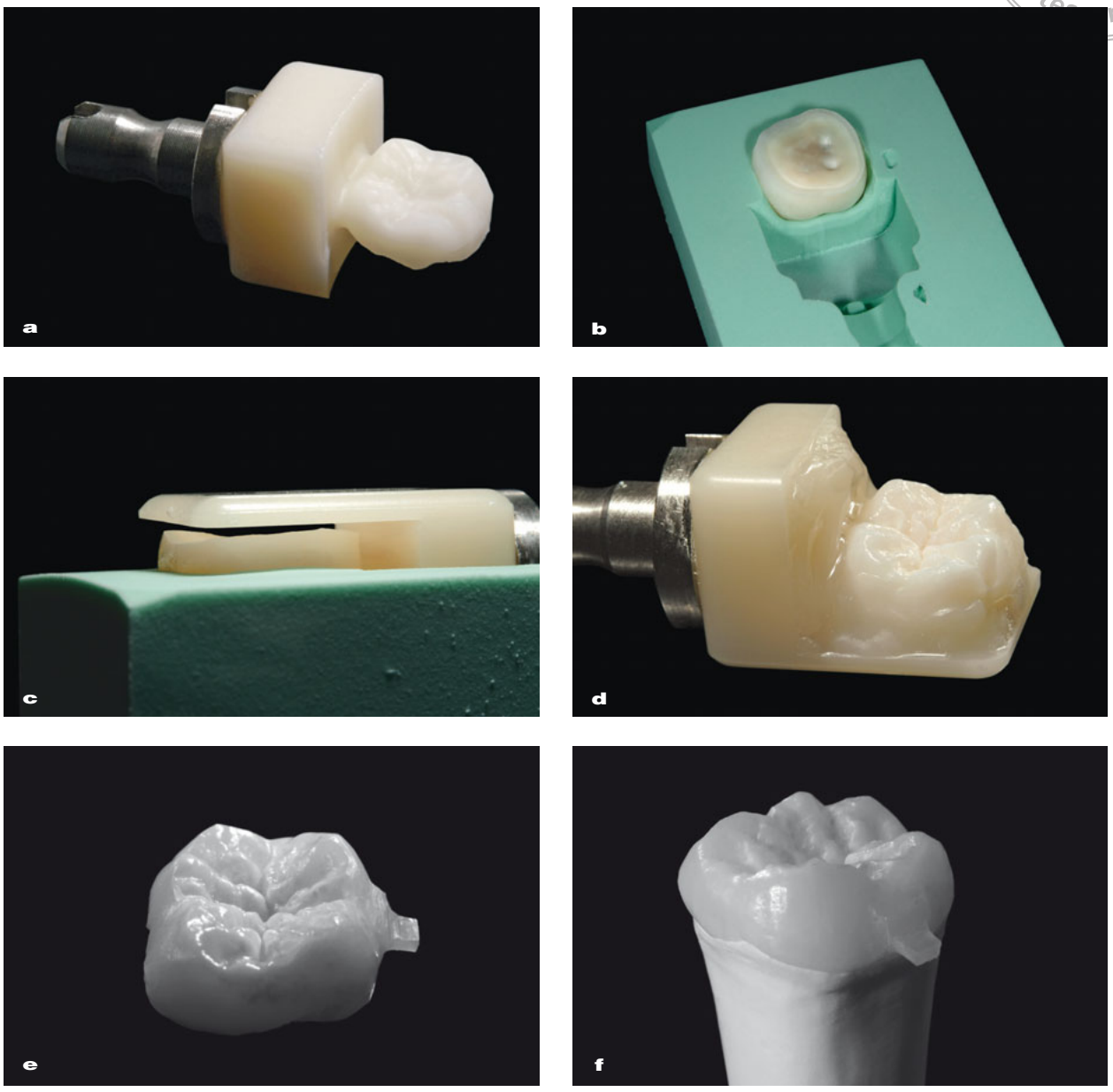

Fig 6 The designed restoration was initially milled with a ceramic block **(a)**. Its coordinates were recorded with a silicon mold, which was used for the positioning of the natural tooth crown **(b)** within a new custom CEREC block **(c and d)**. Milled enamel/dentin biomimetic restoration. Note the intact occlusal anatomy **(e)**. Marginal fit **(f)**.

mother to state: "When I touch or think about that tooth, it makes me think of my daughter." Clinical investigations are now required to evaluate novel biomimetic bonded CAD/CAM restorations in the long term.

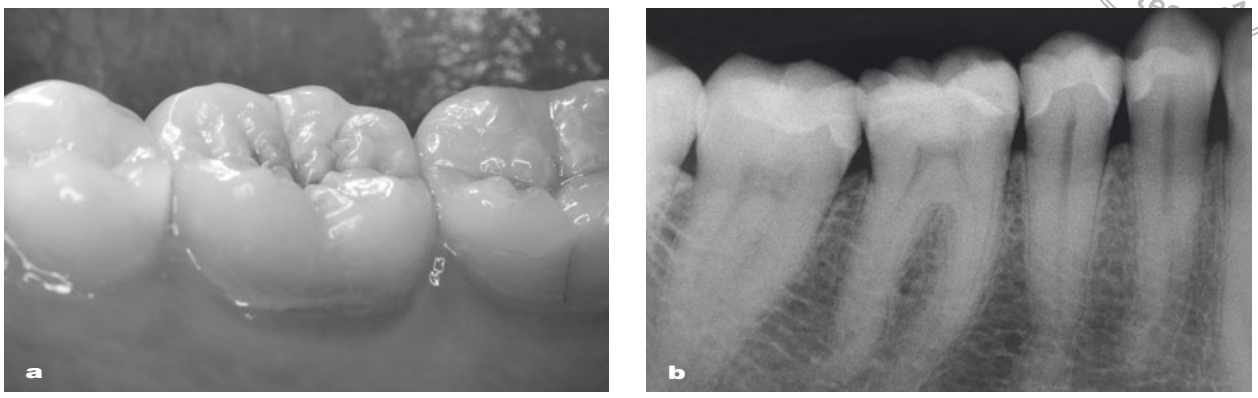

Fig 7 Follow-up of biomimetic onlay during 4th year of clinical service. Clinical **(a)**. Radiological **(b)**.

Fig 8 Mother (recipient) and daughter (donor). "When I touch or think about that tooth, it makes me think of my daughter."

Acknowledgments

"You have approached even the smallest details with excellence; Your works are wonderful; I carry this knowledge deep within my soul." (Psalm 139:14, The Bible).

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References

1. Magne P, So WS, Cascione D. Immediate dentin sealing supports delayed restoration placement. J Prosthet Dent 2007;98:166–174.
2. Nicholson JW. Biological considerations. In: Summitt JB, Robbins JW, Hilton TJ, Schwartz RS, dos Santos J (eds). Fundamentals of Operative Dentistry: A Contemporary Approach, ed 3. Chicago: Quintessence Publishing, 2006:1–36.
3. Marshall SJ, Balooch M, Habelitz S, Balooch G, Gallagher R, Marshall GW. The dentin-enamel junction: a natural, multilevel interface. J Eur Ceram Soc 2003;23:2897–2904.
4. Esposito M, Coulthard P. Impacted wisdom teeth. Clin Evid 2008;5:1302.
5. Schlichting LH, Schlichting KK, Stanley K, Magne M, Magne P. 2014. An approach to biomimetics: The natural CAD/CAM restoration: a clinical report. J Prosthet Dent 2014;111:107–115.