CAD/CAM Endocrown Fabrication from a Polymer-Infiltrated Ceramic Network Block for Primary Molar: A Case Report

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Objective: *The aim of this case report is to describe the treatment of a primary molar with a deep carious lesion by pulpotomy and placement of a ceramic endocrown.* ***Clinical case:*** *A 7-year-old male patient with profound caries in tooth number 85 was referred to our clinic and underwent a pulpotomy. As the final treatment in tooth restoration, placement of an endocrown was planned, because little more than half of the tooth structure remained. After an additional request from the patient's parents for an advanced and prompt restoration, a computer-aided design/computer-aided manufacturing (CAD/CAM) polymer-infiltrated ceramic network (PICN) block was chosen. A three-dimensional model of the arch was obtained after scanning the dental cast, and the endocrown was designed digitally according to the model. When the design was complete, the endocrown was fabricated with a milling machine. Finally, the endocrown was cemented with self-adhesive resin cement.* ***Results:*** *Over the 9-month follow-up period, no pulpal or periradicular pathology was observed on radiographs. Regarding the crown, the marginal fit was excellent, the anatomical form was protected, and no discoloration occurred.* ***Conclusion:*** *During follow-up, the CAD/CAM PICN block endocrown proved to be a good material for the short- to long-term treatment of a primary tooth. However, more clinical cases and follow-up are required to investigate the long-term effects of antagonistic tooth wear.*

Key words: *Digital dentistry, Restorations, Crown, Digital design*

INTRODUCTION

Dental caries and periodontal diseases are the main predictors of tooth loss [1]. Other predictive factors are advanced age, low socioeconomic status, and difficulty accessing dental health care services [2-4]. With developments in the food industry and revolutionary changes in human diet [5], the incidence of early childhood caries and tooth loss is inevitable in young populations and in developing countries, where increased sugar consumption and lack of fluoride are common. As a consequence, dental caries and dental treatment prevalence have been increasing [6].

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Despite the popularity of direct posterior composite resins, these can result in problems such as polymerization shrinkage, which can lead to complications such as microleakage, cuspal distortion, crack formation, and wear [7,8]. Polymerization shrinkage alone can cause marginal defects and gaps despite careful application, and requires the use of adhesive techniques for large cavities [9]. To counteract these problems, approaches such as indirect composite and ceramic restorations have been developed [10-12].

Fixed partial dental prostheses (FPDs) have become the treatment of choice for patients with esthetic and functional losses. Determining which restorative material to use depends on several parameters such as esthetics, opacity, adhesion to tooth structures, wear, biocompatibility, and thermal, chemical, and physical properties [13]. With rapidly developing technology, several types of materials including different metal alloys and high-strength ceramics have been developed. Metal-supported ceramic crowns continue to be popular, but have esthetic disadvantages including lack of transparency, opacity, and reflection from the metal beneath the ceramic at the cervical zone where the opaque and ceramic layers are thinner [14]. For these reasons, complete ceramic restorations are usually preferred (Table 1).

Over the past decade, computer-aided design (CAD) and computer-aided manufacturing (CAM) technologies have become very popular in the development of removable and fixed partial prostheses, ranging from crowns and long-term fixed partial dentures to

Table 1 Advantages and disadvantages of crown and endocrown restorative materials in pediatric dentistry

Material	Advantages	Disadvantages
Stainless Steel	-High strength and reliability -Minimal tooth preparation -Economic; low manufacturing costs result in low treatment costs for patients -Crimping can be performed	-Esthetic -Antagonistic wear
Zirconia	-Highest strength of any pediatric crown type -Esthetic -Biocompatible -Regular fit -No need for crimping because of CAD/CAM -Because of the CAD/CAM technique, the marginal fit is better than with conventional techniques	-Bonding -Greater tooth preparation (2 mm) is required, which may increase the risk of pulpotomy -No change in shape is permitted after cementation -Antagonistic tooth wear -Cost
PICN	-Esthetic -Similar physical properties to dentin -Bonding -No need to adjust occlusion directly due to digital arrangement -CAD/CAM -Composite restorative material can be added for modification after cementation -No need for crimping because of CAD/CAM -Because of the CAD/CAM technique, the marginal fit is better than with conventional techniques -Patient chair time is less than with other techniques -No risk of pulpotomy due to preparation	-A long-term color change may occur if glaze is not applied -Cost
Polymer/ acrylic strip crowns	-Crimping is possible -Minimal tooth reduction is required, resulting in decreased pulpotomy risk -Cost	-Decreased strength -Pre-polymerized polymers will not bond to subsequently applied resins -Extended chair time may be required to adapt the crowns

removable partial dentures [15]. Developments in ceramic technology, and especially CAD/CAM systems, have led to the production of single all-ceramic crowns and endocrowns with high biocompatibility, esthetics, and optimal mechanical properties [10].

A recently presented polymer-infiltrated ceramic network (PICN) with a Young's modulus similar to that of dentin appears to be an ideal restorative material with long-lasting esthetics [16]. PICN structures were shown to have properties similar to those of tooth structures [17].

Here, we present the case of a primary second molar with profound caries treated first with pulpotomy, followed by restoration with a CAD/CAM PICN endocrown and 6 months of successful follow-up.

CLINICAL REPORT

A 7-year-old male patient visited Sifa University Clinics in Izmir/Turkey for dental treatment. Affected teeth involved the lower second primary molar (Fig. 1). On clinical examination, tooth number 85 was found to be carious, including the pulp chamber, with insufficient axial wall support. The cavity was prepared with a round diamond bur (021 code: 146990186; Medin, Vlachovická, Czech Republic), and then the caries were cleaned with a round steel bur (tungsten round carbide bur; 023 code: 142511093; Medin, Vlachovická, Czech Republic). Then, a pulpotomy was performed on tooth 85. Zinc oxide eugenol (ZnOE) (Cavex, Haarlem, the Netherlands) was placed on top of the pulpotomy area and covered with a layer of glass ionomer cement (GIC) (Ketac Molar Easymix; 3M ESPE, Cuxhaven, Germany). A flowable composite (Nexcomp Flow; MetaBiomed, Chungbuk, Korea) was applied over the GIC to provide a smoother base (Fig. 2). After the pulpotomy, the cavity walls were covered with a flowable composite to avoid undercuts and obtain a path for insertion. Then, the cavity walls were prepared according to the onlay restoration technique with a fissure diamond bur (018 code: 146990193, Medin; Vlachovická, Czech Republic). As the final treatment option for the tooth restoration, an endocrown was planned, because barely more than half of the residual tooth structure remained. To facilitate an advanced and prompt restoration, a CAD/CAM PICN block (VITA ENAMIC; VITA Zahnfabrik H. Rauter GmbH & Co. KG, Bern, Switzerland) was chosen. An impression (Elite HD; Zhermack SPA, Badia Polesine, Italy) was taken and transferred to a laboratory where it was filled with dental stone (SHERA Werkstoff-Technologie; Hanover, Germany) to obtain a positive cast. A three-dimensional (3D) image of the dental stone arch, was scanned with a digital scanner (D810; 3Shape, Copenhagen, Denmark). After obtaining the data, the endocrown was designed digitally using software (DWOS software, Dental Wings Inc., Montreal, QC, Canada) (Fig. 3). After the design was completed, the endocrown was fabricated with a milling machine (CEREC MC XL; Sirona Dental GmbH, Salzburg, Austria). The endocrown was finalized with polishing and disinfection before the try-in. Occlusal interference was checked with articulating paper. Finally, the endocrown was cemented with self-adhesive resin cement (RelyX U200; 3M ESPE, Cuxhaven, Germany) (Fig. 4).

Figure 1: A radiographic image of the primary mandibular right second molar before treatment.

Figure 2: An oral image of the primary mandibular right second molar after tooth preparation.

Figure 3: An image from the digital restoration design.

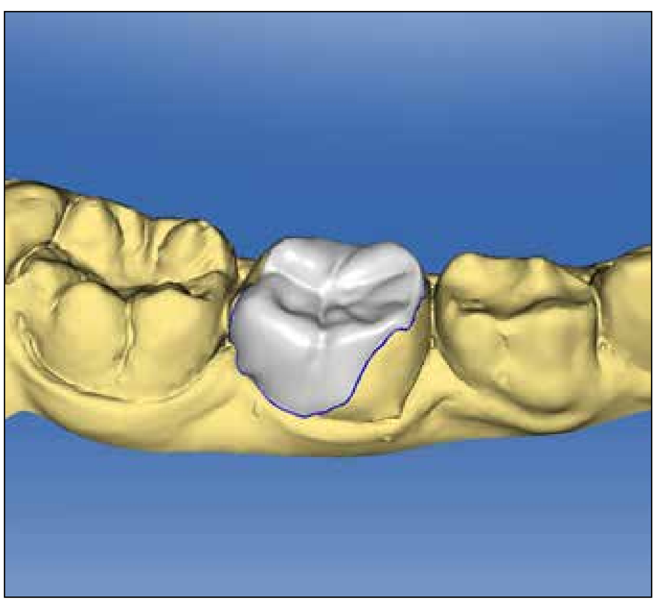

Figure 4: An occlusal image of the primary mandibular right second molar after cementation.

RESULTS

Over the 9-month follow-up, no pulpal or periradicular pathology was observed on the radiographs. When the crown was taken into consideration, the marginal fit was excellent, the anatomical form was protected, and no discoloration occurred (Figs. 5–7).

Figure 5: A radiographic image of the restored primary mandibular right second molar after 6 months.

Figure 6: The restored primary mandibular right second molar in occlusion with the antagonist tooth after 6 months.

Figure 7: An occlusal image of the restored primary mandibular right second molar after 6 months.

DISCUSSION

To our knowledge, this case report is the first to describe the application of a CAD/CAM-manufactured PICN endocrown for a primary molar. The decision to treat the patient with a CAD/CAM-fabricated PICN material was based on several mechanical studies showing that PICN material is a good imitation of natural tooth material, with physical and mechanical properties similar to those of enamel and dentin [16,17].

However, an important parameter for deciding on restorative materials to treat primary teeth is antagonist tooth wear from occlusion formation during the eruption sequence. Surface wear is of multifactorial etiology [18], including attrition and abrasion [19], which is induced by surface roughness, the hardness of the restorative material and antagonist tooth, the anatomical structure of the antagonist tooth's enamel rods, and abrasive chemicals and tools such as a toothbrush and toothpaste. The average expected vertical loss of permanent tooth enamel from wear is 20–38 µm *per* year [20]. However, in this case, the treatment of a primary tooth is presented. Another study that compared the wear amounts of primary and permanent tooth enamel found that primary tooth enamel wore down by 26.42 ± 1.94 µm after 5000 cycles under 20 N of force [21]. A detailed, up to date study evaluated several restorative materials in a two-body wear analysis after 1.2 million chewing cycles and found enamel-to-enamel wear of 54.5 µm; while PICN material (VITA ENAMIC) showed 46.1 µm of wear, and caused 27.6 µm of wear on the antagonist tooth [22]. Additionally, in terms of the attrition of enamel and compomer materials, it was reported that there was a correlation between the wear on materials and wear on enamel cusps ($r = 0.85$), but not between wear on enamel not involved in the restoration and wear on enamel cusps ($r = 0.53$) [23]. Moreover, the glossiness of PICN material has been shown to be greater than that of enamel, which is important for the retention of plaque [22] and esthetics. A study has shown that the Vickers hardness of PICN material is 2.5 GPa, which is less than that of permanent tooth enamel (5.3 GPa). The same study showed that the Vickers hardness of dentin is < 1 GPa [24]. Additionally, results from a study that investigated primary molar enamel hardness found a mean hardness value of 4.88 GPa [25]. For all the reasons mentioned above, the treatment was planned with CAD/CAM and PICN block material was used to fabricate the custom endocrown. At the 6-month follow-up, there was no increase in periodontal gap width and no visible wear on the antagonist tooth, which can affect occlusion.

RelyX U200 has been reported to bond sufficiently to both dentin and enamel [26]. Moreover, in another study, self-adhering cements such as RelyX U200 cement were compared with a glass ionomer self-etching adhesive system, composite luting cement, etch-and-rinse adhesive system, self-adhesive cement, and composite luting cement and showed that the microshear bond strength of RelyX U200 was significantly stronger compared with other materials [27].

In a case report, Vita Enamic was recommended for its restorative properties and satisfactory esthetics [28].

In this study, a positive cast scan was used because we did not have an intraoral optical scanner at the time. However, the digital impression technique requires a learning process until efficiency is achieved. The digital impression technique is less time consuming, and has advantages such as digital transfer of the model to the laboratory, no dimensional change occurs over time, a more accurate fit, no need to store dental working models, and a more comfortable experience for the patient compared with conventional impression techniques [29]. To ensure the clinical success of restorations, the minimum thickness should be 1.5 mm in functional zones such as the incisal edge and occlusal cusps, and an additional 0.8–1.5 mm thickness is suggested for the circumferential zone in the cervical third, while a 1.0-mm thickness is suggested for occlusal surfaces at the bottom of the fissure. For laminate veneers, the PICN material can be as thin as 0.2–0.3 mm [30]. Because of these values, PICN preparation is safe for young children with large pulps.

An indirect restoration has the advantage of resin thickness in the cementation process, which avoids shrinkage and microleakage between the cavity walls and restorative material. Indirect restorations permit practitioners to minimize patient chair time and errors that can occur during direct restorations. With the required chairside devices, treatment with endocrowns fabricated from PICN material is a single-visit treatment, which also can be achieved with conventional restorative materials, but with extended chair time.

CONCLUSIONS

PICN is a suitable material for fabricating dental restorations for children. Using the CAD/CAM technology, PICN endocrowns can be fabricated that are likely to show good results in terms of wear, dental properties, and postoperative dental health. However, a greater number of clinical follow-up cases are required to investigate the effects on antagonist teeth from long-term wear.

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