International Journal of
Oral and Dental Health

Pita et al. Int J Oral Dent Health 2016, 2:034
Volume 2 | Issue 4
ISSN: 2469-5734

Case Report: Open Access

Case Report: Ultraconservative CAD/CAM Ceramic Restorations for the Treatment of Developmental Enamel Defects

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Abstract

Objective: Developmental enamel defects can cause a number of problems to patients. Tooth sensitivity, loss of aesthetics and functionality of the involved teeth are some of the many problems reported by patients. This clinical report aims to present a treatment modality for developmental enamel defects following a very conservative approach to restore functionality and aesthetics.

Materials and methods: Treatment planning was done after considering primarily the conservation of the remaining tooth tissues, but also aesthetics, occlusion and the advances of new restorative modalities. Teeth preparations were done according to an ultra-conservative design to accept ceramic onlay restorations fabricated using a CAD/CAM system.

Results: The patient was reviewed in 6, 12 and 18 months. The United States Public Health Service (USPHS) Criteria were used to evaluate the restorations, which scored As in all of the criteria except the criterion of surface texture.

Conclusions: The use of CAD/CAM technology in patients with developmental enamel defects is very promising, as it can provide high quality minimal invasive restorations.

Keywords

Minimal invasive dentistry, Enamel defects, CEREC, CAD/CAM, Ceramic, Onlay, Amelogenesis imperfecta, Minimal preparation design

Introduction

During the development of dental tissues many disorders have been identified and researched. One of these disorders is amelogenesis imperfecta (AI). The term amelogenesis imperfecta includes a variety of defects regarding the enamel of the tooth and is the result of decreased attachment between the enamel and the dentin [1]. There are many clinical and genetic factors that influence the development of the enamel, but no relation to systematic diseases has been found [2,3]. AI can be located both in primary and permanent dentition [3] and can be divided in four different types, which are the hypoplastic, hypocalcified, hypomaturation and hypomaturation-hypoplastic types. The classification described above is Witkop's classification which is most frequently used in the existing literature and is summarized in table 1 [4,5].

Developmental enamel defects, such as amelogenesis imperfecta can cause several problems. These conditions can undermine the occlusal surfaces of permanent teeth, producing pain and leading to dental decay [6]. It can also predispose the dentition to excessive wear and even loss of vertical dimension. Patients diagnosed with AI can face problems such as; esthetic problems, tooth sensitivity, difficulties during mastication, loss of dental tissues, high caries prevalence, anterior open bite and decreased vertical dimension.

Traditional rehabilitation techniques can include preventative measures in early stages and direct restorations. However, the location and extent of these defects can sometimes contraindicate treatment with direct restorations. Another approach could then be the restoration of these defects with cast metal, metal ceramic or ceramic/composite bonded restoration such as inlay/onlay restorations, full porcelain and lately zirconium crowns. In more severe cases partial dentures, over-dentures and complete dentures may be the best approach [2,4].

A major concern for the restoration of teeth with developmental defects is that a substantial amount of tooth tissue has already been lost due to these defects. Traditional indirect restorations require a certain amount of tooth tissue reduction, which can weaken a tooth with AI even more. Lately the principles of Minimal Invasive Dentistry are becoming more and more popular for indirect restorations as well. This is due to the evolution of restorative materials that can now be adhesively bonded to the tooth, as well as the introduction of new restorative techniques, such as CAD/CAM, that has been demonstrated in the past that can be used along with the principles of Minimal Invasive Dentistry [7].

Table 1: Witkop's classification of amelogenesis imperfecta

Type	Features of the enamel
Hypoplastic	• Reduced crystal size • Insufficient amount • Normal composition
Hypocalcified	• Soft and fragile • Sufficient amount
Hypomaturation	• Mottled • Opaque white to red brown coloration • Soft • Loose connection to the dentin
Hypomaturation-hypoplastic	• Taurodontism

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Citation: Pita A, Marinou G, Tsitrou E (2016) Case Report: Ultraconservative CAD/CAM Ceramic Restorations for the Treatment of Developmental Enamel Defects. Int J Oral Dent Health 2:034

Received: August 28, 2016: **Accepted:** November 01, 2016: **Published:** November 03, 2016

However, except for the above concern another very important issue in the rehabilitation of an AI patient is the adhesion of materials to tooth structures. AI affected teeth present a bond strength with adhesive materials less powerful than the one detected in healthy structured teeth. This problem originates from the fact that the enamel of AI affected teeth has lower mineral content which can undermine the bond with adhesive materials [8]. Also because of the enamel deficiency in AI patients, the dentine is consequently affected as it is exposed to the oral environment. This exposure leads to alterations in its composition and in its morphology, which result also in lower bond strength with adhesive materials [9]. On the other hand it has been reported that in less severe cases of AI, normal enamel can be detected in the preparation site near the affected enamel, which can lead to successful adhesion of materials [10].

This report presents the case of two successfully restored second upper premolars with AI. Teeth preparations were done according to an ultra-conservative design to accept ceramic onlay restorations fabricated using a CEREC CAD/CAM system.

Materials and Methods

A 22-year-old female patient was presented to the post-graduate clinic of the Restorative Department in Aristotle University of Thessaloniki, with symptoms of hypersensitivity in both maxillary second premolars (#15 and #25). Her medical history was clear and no medication was received in the past year.

Clinical examination revealed hypoplasia of the buccal cusps in both premolars and brown to grey discolorations of the interproximal surfaces, which were identified as dental caries. Enamel cracks were spotted in the remaining tooth structure and previous composite restorations, as well as the intra-coronal metal pin in #15, were compromised (Figure 1). Tests to inform about pulp vitality were performed and both teeth were vital and free of endodontic complications. Intra-oral radiographic examination was performed, which confirmed the clinical findings. Various treatment options were discussed with the patient from direct composite restorations to full-coverage crowns. However, the large pulpal size, due to the young age of the patient and the fact that the remaining dental structure was already compromised, due to enamel defects and previous restorations, it was decided that in this case what was most important was to maintain as much tooth tissue as possible. The patient's request had to be taken into consideration, which was to decide on a treatment plan that would be more long-lasting compared to her previous composite restorations. Thus a minimal invasive approach with immediate porcelain restorations and the use of CAD/CAM technology was decided.

The preparation was performed under local anesthesia and rubber dam isolation. The previous restorations and dental caries were carefully removed in order to preserve as much healthy dental tissue as possible and the remaining cavities were conservatively prepared for an onlay restoration (Figure 2). The CEREC 3D CAD/CAM system was used for optical impression of the preparations, designing and manufacturing of the restorations (Figure 3 and Figure 4). IPS Empress CAD HT (A3/I12) blocks were used for the restorations. The chosen color was in reference to the color of the first premolars. After milling the restorations were tried in and subsequently characterized with staining and glazing. A resin cement (RelyX Unicem, 3M ESPE) was used for the cementation of the onlays. Specifically the onlays were etched with hydrofluoric acid (HF) then rinsed for 15(s), dried with air free of oil and then treated with silane. The teeth were cleaned thoroughly from any remnants, a pumice slurry was used and the teeth were rinsed and lightly dried. Afterwards the resin cement was applied on the surface of the onlays and the prepared teeth and the restorations were seated into place. Excess cement was removed and light-curing was performed for 20(s). The occlusion was checked and the restorations were finished and polished (Figure 5). Post cementation instructions were given to the patient. The patient was scheduled for follow up examinations in 6, 12 and 18 months. During the follow-up examinations the restorations where evaluated using the modified United States Public Health Service (USPHS) criteria (Table 2) [11-13]. Post-operative sensitivity was determined by asking the patient. The grading scale used in the USPHS criteria is given in table 3.

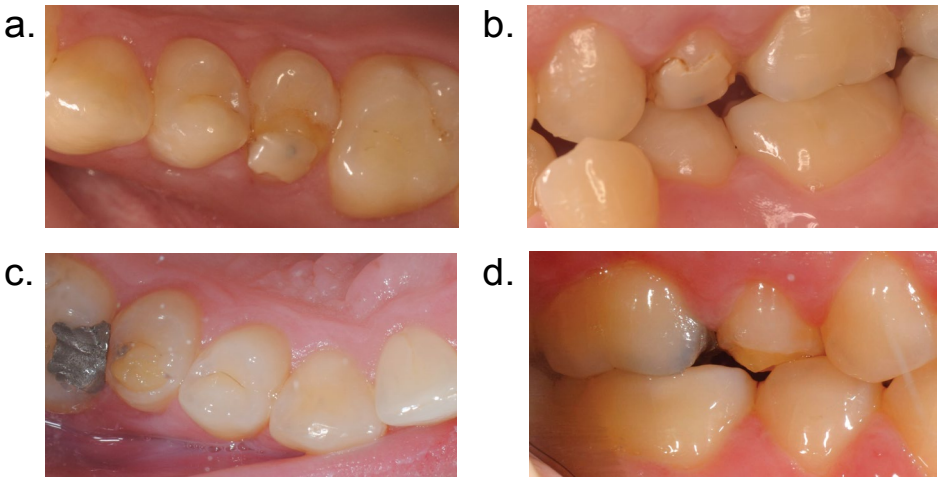

Figure 1: (a,b) Occlusal and lateral views of teeth #15; (c,d) teeth #25 at initial examination.

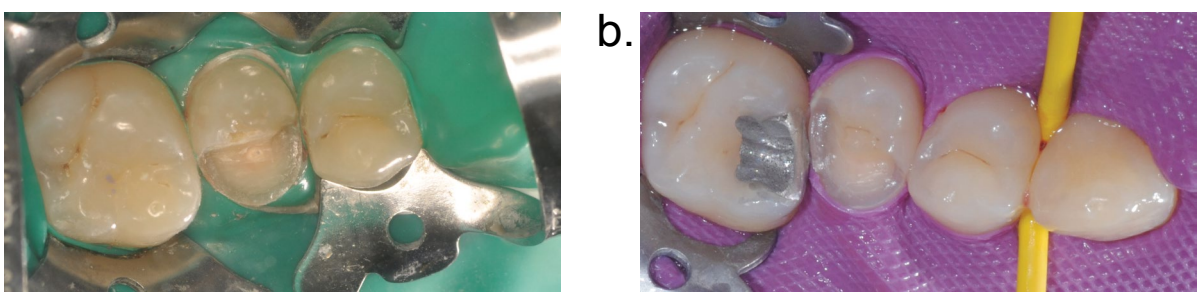

Figure 2: (a) Preparation of teeth #15; (b) #25 the preparations were minimal removing only the previous restorations without extending intracoronally to prepare a typical onlay preparation.

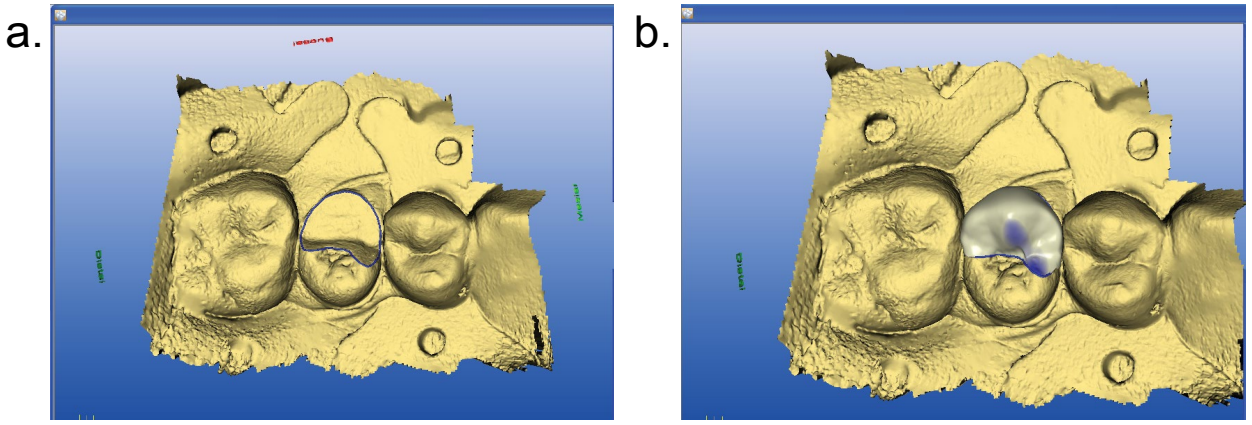

Figure 3: (a,b) Digital impression and CAD design of the restoration on tooth #15.

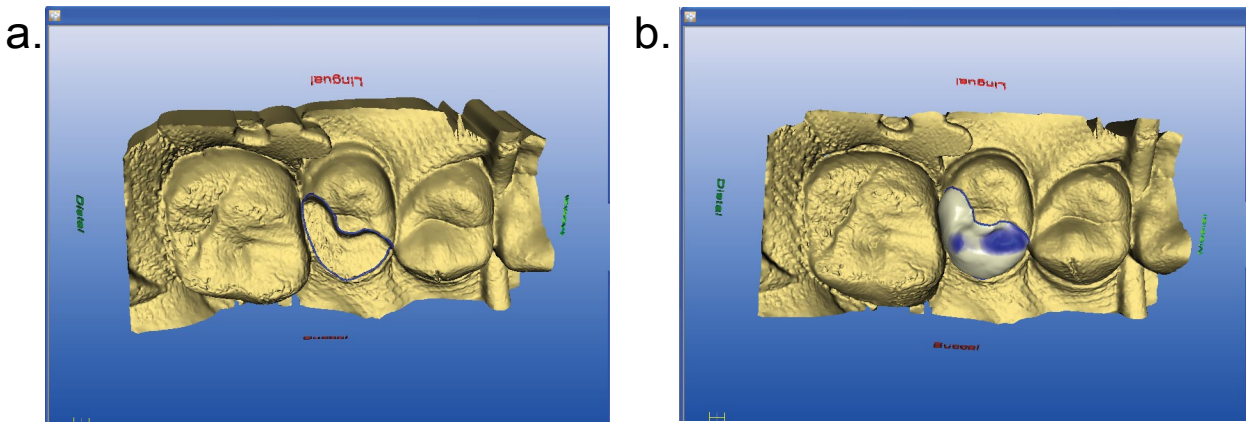

Figure 4: (a,b) Digital impression and CAD design of the restorations on tooth #25.

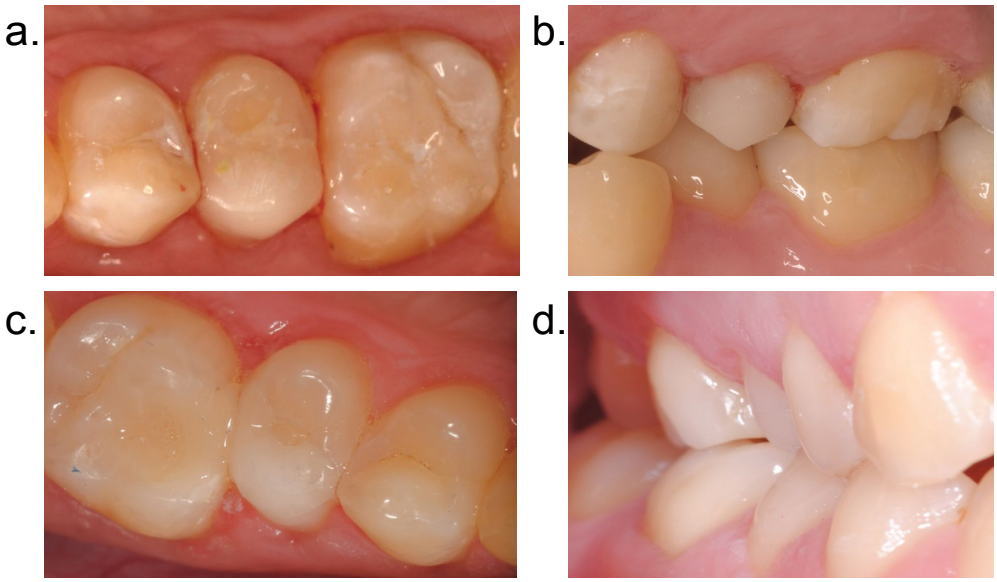

Figure 5: (a,b) Occlusal and lateral views of ceramic restorations on teeth #15; (c,d) #25 immediately after cementation.

Table 2: United States Public Health Service (USPHS) criteria.

Modified USPHS criteria	
1. Retention	6. Contact surfaces
2. Marginal adaptation (Marginal Integrity)	7. Recurrent caries
	8. Tooth integrity
3. Marginal discoloration	9. Post-Operative sensitivity
4. Loss of anatomical form	10. Patient complaints
5. Surface texture	11. Patient satisfaction

Table 3: Grading scale of USPHS criteria.

Rating	
A (Alpha)	Excellent result
B (Bravo)	Acceptable result
C (Charlie)	Unacceptable, replacement of the restoration necessary
D (Delta)	Loss or fracture of the restoration

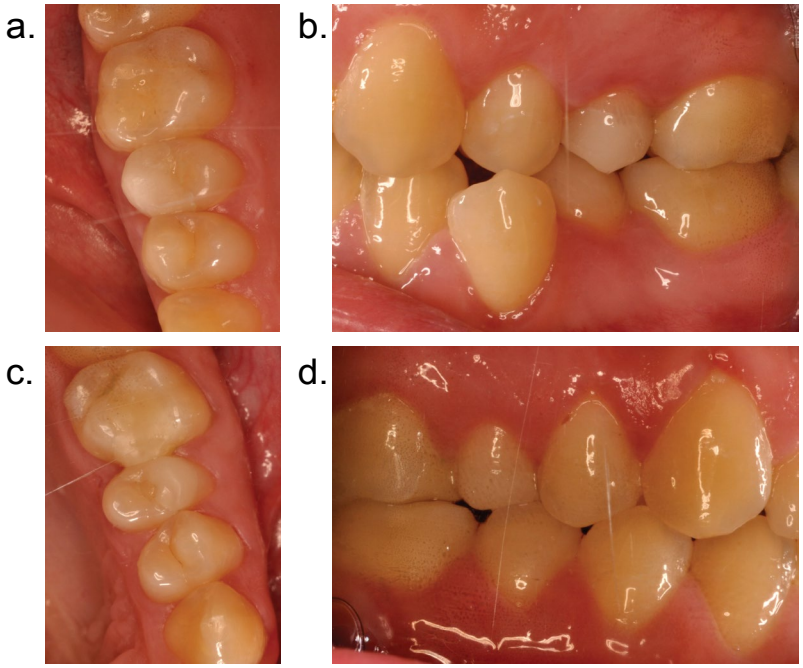

Figure 6: Occlusal and lateral views of the restorations at the 18 months review. (a,b) Tooth 15; (c,d) Tooth 25.

Table 4: Scores after 6 months United States Public Health Service (USPHS) criteria and results.

Modified USPHS criteria			
Criteria	**Score**	**Criteria**	**Score**
Retention	A	Contact surfaces	A
Marginal adaptation (Marginal integrity)	A	Recurrent caries	A
		Tooth integrity	A
Marginal discoloration	A	Post-Operative sensitivity	A
Loss of anatomical form	A	Patient complaints	A
Surface texture	A	Patient satisfaction	A

Table 5: Scores after 12 and 18 months United States Public Health Service (USPHS) criteria and results.

Modified USPHS criteria			
Criteria	**Score**	**Criteria**	**Score**
Retention	A	Contact surfaces	A
Marginal adaptation (Marginal integrity)	A	Recurrent caries	A
		Tooth integrity	A
Marginal discoloration	A	Post-Operative sensitivity	A
Loss of anatomical form	A	Patient complaints	A
Surface texture	B	Patient satisfaction	A

Results

In order to evaluate every criterion for each restoration in the consequent clinical follow-ups a clinical expert, different from the one who delivered the restorations, was employed to ensure reliability of the result in the follow-ups.

The criteria examined in the follow-ups and the scores are summarized in table 4. Both restorations scored As in every follow-up examination and in every criteria, with the exception of the criterion: surface texture, where both restorations scored B at the 12 and 18 months review (Table 5). The restorations and remaining tooth structure were intact and no marginal discoloration or recurrent caries was noted after 18 months of performance (Figure 6). The patient herself was very pleased with the treatment outcome, since she was relieved of her sensitivity symptoms immediately after the cementation of the restorations. She was asked to continue her follow- up visits once a year.

Discussion

The restorations described in this clinical case report were minimal indirect onlay ceramic restorations. The teeth were prepared according to the principles of minimal invasive dentistry, which included only the parts of the teeth that were compromised due to caries and previous restorations. Traditionally these defects would have been treated either with onlay restorations or full coverage crowns. This would certainly require more extensive preparations that would include either preparing the circumference of the crown of the tooth or an intracoronal preparation to increase mechanical retention in the case of the onlay restoration.

In this case direct resin restorations were not an option as they have already been tried and failed, aesthetically and functionally. Although, resin composite restorations are an excellent cost effective option and are indicated for the conservative treatment of enamel defects, they have certain limitations, such as lack of resistance to last through the years, polymerization shrinkage and inferior aesthetic result in the long term due to stain absorption [14-17]. In contrast, porcelain restorations exhibit a better outcome in terms of adaptation to dentin, marginal adaptation, and cusp stabilization [18-20]. A porcelain restoration has a lower risk of debonding due to better stress distribution [21] and can achieve a more aesthetic result. Layered porcelains offer versatility and they are able to mimic more precisely the chroma, shade, hue, translucency and surface finish of natural teeth [22]. As for the longevity of a ceramic restoration a recent study, where CEREC-3 was used, has shown that partial ceramic crowns survive at a similar rate to cast-gold partial crowns, which are considered to provide the longest service [23]. In this particular case-report study the indirect onlay restorations proved to be a very beneficial type of prosthetic treatment as it conserved a great amount of dental tissue and because of the advantages of porcelain restorations stated above.

In this particular case report study the cement that was used in order to achieve luting of the restorations was a self-adhesive resin cement (RelyX Unicem, 3M ESPE). The types of resin cement that can be used in luting CAD/CAM-ceramic restorations are; 1) “etch-and-rinse” resin cements, 2) “self-etch” resin cements and 3) self-adhesive resin cements [24,25]. The self-adhesive resin cement RelyX was used in this case report, as one of the aims of the study was to simplify the luting process and at the same time achieve a reliable and durable bond. In this AI case the enamel defects were less severe as they were presented in only two premolars and consequently it was considered that normal enamel could be present at the preparation sites among the affected enamel and therefore a successful adhesion could occur [10]. Many studies have claimed that self-adhesive resin cements present varying performances from time to time and that they are less

effective compared to "etch-and-rinse" types of resin cements even though they present an acceptable behaviour [26]. On the other hand there have been many studies which have reached the conclusion that self-adhesive resin cements can achieve a reliable bond and good marginal adaptation with teeth and also a high bond with silica-based ceramics [25,27-30]. Furthermore another advantage of self-adhesive resin cements in AI cases is that they don't require etching of the tooth with phosphoric acid, as the use of this acid is considered to cause more enamel loss [31].

According to the USPHS criteria the outcome of the procedure followed in this study was excellent. The restorations scored As in all the criteria except for the surface texture. The surface texture was evaluated with a B at 12 months review as it was found slightly rough and dull. However, the patient was very satisfied and considered the procedure successful. She was extremely happy specifically about the aesthetic result and the long term prognosis of the restorations. Studies have shown that these types of IPS Empress onlay and inlay restorations have good long term clinical prognosis and are succesfull even in large defects [32]. The restorations she had before were composite resin restorations which did not fulfill at all her expectations. They weren't aesthetic, as part of the pin that used to retain the composite resin was showing, and it didn't stop the sensitivity she was feeling due to the margins being partly broken.

The use of the CAD/CAM technology helped the process even further. This technology requires only one appointment for the whole procedure to take place. The total amount of chair time needed was significantly less, as only one appointment was required for each restoration, which was convenient for the patient regarding her time. There was no need of temporary restorations to be constructed, fewer tools were needed and laboratory fees were absent. Last but not least the restorations were designed by the dentist in charge and were personalized according to the patient's needs and the aesthetic result that was pursued, securing in this way the quality of the prosthetic restoration [33-35].

Conclusion

The use of CAD/CAM technology is a very promising technique when it comes to minimal invasive restorations. The system was able to produce restorations with the correct morphology and marginal quality when a hybrid minimal preparation design was prepared. The "direct" technique of producing indirect onlay restorations was successful in producing aesthetically pleasing and functional restorations, which left both patient and clinician very pleased.

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