IEJ Iranian Endodontic Journal

Endodontic Management of Dentinogenesis Imperfecta Using Guided Endodontics: A Case Report

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Article Type: **Case Report**

Received: 06 Aug 2024
Revised: 24 Aug 2024
Accepted: 02 Sep 2024
Doi: *10.22037/iej.v19i4.45902*

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Pulp canal calcification (PCC) is common in patients with dentinogenesis imperfecta (DGI). We present endodontic management of multiple anterior and posterior teeth with PCCs in a patient with DGI type II using guided endodontics. A 26-year-old female patient was diagnosed with DGI type II. Clinical examination revealed palatal cusp fracture in tooth #13, microcracks in tooth #14, and a sinus tract in the maxillary right buccal vestibule related to tooth #13. Periapical radiographs revealed PCCs in all teeth, and periapical radiolucencies in several teeth. Due to difficult negotiation of canal orifices, guided endodontic approach was planned. Cone-beam computed tomography (CBCT) was requested and obtained. Intraoral scanning was performed, and CBCT and intraoral scanning data were superimposed. A template was designed and 3D printed. The root canal orifices were successfully negotiated and endodontic treatments were successfully accomplished. At the 1-year follow-up, the endodontically treated teeth were asymptomatic, and periapical lesions were healing.

Keywords: Case Reports; Dentinogenesis Imperfecta; Endodontics; Pulp Calcification; Root Canal Therapy

Introduction

Pulp canal calcification (PCC), also known as calcific metamorphosis, is a common finding in endodontic practice that complicates root canal therapy. PCCs may occur due to a number of reasons, including local and systemic factors [1]. Traumatic dental injuries such as subluxation and concussion are among the main causes of PCC [2, 3]. Moreover, PCCs are more commonly found in cases with genetic connective tissue disorders such as the Ehlers-Danlos type I syndrome [4], type II dentin dysplasia [5], tumoral calcinosis, Marfan's syndrome [6], type 1 osteogenesis imperfecta (OI), and otodental syndrome [7]. PCCs may also occur due to prolonged stimulation, as in dental caries, abrasion, attrition, erosion, orthodontic treatment, and surgical procedures. In such cases, obliteration of the root canal system may occur by pulp stones and dystrophic calcifications [8]. In the elderly, PCC may occur due to high rate of physiological dentin apposition [9].

Dentinogenesis imperfecta (DGI) is an autosomal dominant hereditary disorder of dentin formation, which affects dentin formation and dentin mineralization in both primary and permanent teeth, and may be accompanied by OI. DGI has a prevalence rate of 1/6000-8000 individuals [10, 11], with no gender predilection.

The most commonly used classification for DGI was proposed by Shields *et al*, [12] who divided DGI into three basic types: (i) the type associated with OI, which is due to defective biosynthesis of type I collagen; (ii) the type not associated with OI, which is the most common form of DGI, and is also known as hereditary opalescent dentin, and (iii) the Brandywine type discovered in a tri-racial population [10, 11, 13]. The latter type is characterized by multiple pulp exposures in both primary and permanent teeth [14].

DGI is characterized by opalescent, translucent, and discolored teeth, that often range in color from gray to yellow, blue, or brown [10]. Approximately 30% of DGI patients have an enamel layer thinner than normal, which is also hypo-calcified or hypoplastic, and is poorly supported by dentin [15]. As a result, high masticatory forces may lead to enamel fracture or cracking, and expose dentin. The exposed dentin is highly

Figure 1. Panoramic radiograph of the patient with DGI type II. Note obliterated pulp chambers and root canals with reduced size in all teeth, and presence of periapical lesions in teeth #13, 14, 24, and 25

Figure 2. *A*) Periapical radiolucency in teeth #24 and 25; *B*) Periapical radiolucency in teeth #13 and 14. The sinus tract of tooth #13 was traced with gutta-percha

susceptible to fast severe attrition [16, 17]. Wear of exposed dentin decreases the vertical dimension of occlusion, and can eventually result in exposure of the pulp. Also, such teeth are more susceptible to fracture under heavy masticatory forces due to having narrow and insufficiently mineralized roots [17].

Teeth with DGI have bulbous crowns and noticeable cervical constriction. Radiographically, such teeth are characterized by constricted short roots. Dentinal hypertrophy may be present as well, which can lead to obliteration of the pulp before or right after eruption [10]. Periapical lesions are a common finding in such teeth, which develop following pulpal exposure as the result of dentin attrition [13]. Moreover, dentin attrition enhances bacterial invasion and subsequent necrosis of the pulp, and development of apical periodontitis.

Detection of root canals with PCC is a challenge in root canal treatment [18]. Also, such teeth are at higher risk of root canal treatment failure (20%) [19].

Recently, a computer-assisted treatment approach has been introduced for minimally invasive detection of root canals with PCC, known as "Guided Endodontics" aiming to decrease the risk of procedural errors and accelerate the treatment process [20].

Access cavity preparation by guided endodontics can be performed in two ways: (I) by static guidance and using a template, and (II) by dynamic navigation and positioning of markers in the oral cavity and a camera system.

Accordingly, three dimentional (3D) data can be collected by cone-beam computed tomography (CBCT), superimposed on the surface scan data, and used to fabricate a 3D drill guide. The drill paths are virtually planned, and then the templates are fabricated to safely negotiate the canal orifices. However, endodontic treatment of teeth with DGI reportedly has a very poor prognosis, and most of such teeth are eventually extracted [21, 22].

Herein, we describe endodontic treatment of multiple anterior and posterior teeth with PCCs in a patient with DGI type II using guided endodontics with a 1-year follow-up.

Case Presentation

A 26-year-old Iranian female patient presented to the Cosmetic and Restorative Dentistry Department of School of Dentistry, Shahed University of Medical Sciences with a chief complaint of unesthetic appearance of her teeth. This case report has been written according to Preferred Reporting Items for Case reports in Endodontics (PRICE) 2020 guidelines [23]. Intra-oral examination revealed translucent teeth exhibiting significant wear, characterized by bulbous crowns. Radiographs of the patient displayed teeth with constricted, short roots and obliterated pulp chambers. Given these distinctive clinical and radiological features, no additional diagnostic procedures were deemed necessary to confirm the diagnosis of DGI type II. The diagnosis of DGI type II was made after thorough clinical and radiographic examinations and taking a family history (Figures 1, 2).

The patient's medical history did not indicate any issues, and she had no dental pain or symptoms. Clinical dental examination revealed fracture of palatal cusp of tooth #13 and microcracks in tooth #14 (Figure 3A). Also, a sinus tract was detected in the maxillary left buccal vestibule, which was traced and found to be related to tooth #13. Due to the presence of PCC, the teeth did not respond to cold pulp sensibility tests and electric pulp testing. Teeth #13, #14, #24, and #25 exhibited different sensations during palpation and percussion tests. The probing depth of all teeth was within normal limits.

Periapical radiographs revealed PCCs in all teeth, and periapical radiolucencies in teeth #13, #14, #24, and #25 (Figure 2). The diagnosis and the intended treatment plan were explained to the patient and the informed consent was obtained from the patient.

Due to difficult identification of root canal orifices in an initial attempt, guided endodontic was planned and rendered. A CBCT scan was obtained (NewTom, Verona, Italy). Intraoral scanning of the teeth was also performed (Carestream Dental, Atlanta, GA, USA), and the CBCT and intraoral scanning data were

Figure 3. *A*) Palatal cusp fracture in tooth #13 and microcracks in tooth #14; *B*) appearance of the teeth after final restoration

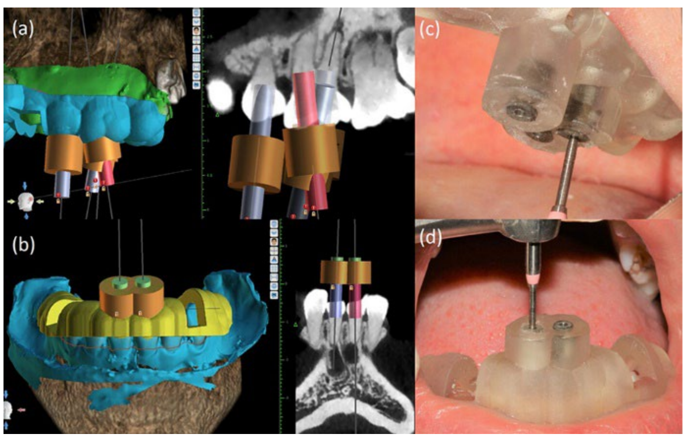

Figure 4. *A, B)* Direction of drill insertion into the root canal system was virtually designed by Blue Sky software; *C, D*) Intraoral view of the mounted template and drill sleeves


Figure 5. One-year follow-up radiograph revealing a reduction in size of apical lesions in all teeth

using Blue Sky Plan 4 software (Blue Sky Bio, Libertyville, IL, USA). The direction of the drill to safely enter the root canal through the orifice was determined accordingly, and a template was designed (Figure 4). Next, the standard tessellation language (STL) files were exported to a 3D printer (Digident Quick, Mobtakeran Mechatronics Ark, Iran) for template fabrication and printout.

An endodontic access bur (Munce Discovery Bur #1/4; Hager & Meisinger GmbH, Neuss, Germany) was then used, which had a 0.5 mm tip, 1 mm shank diameter, and 16 mm working length. All the template sleeves were designed with an internal diameter of 1.09 mm.

The root canal orifices were successfully identified. Mechanical root canal preparation was performed with ProTaper nickel-titanium rotary files (Dentsply Maillefer, Baillagues, Switzerland). Sodium hypochlorite (3%) was used as irrigant, and was ultrasonically activated (Varios 970; NSK, Tochigi, Japan). The root canals were then obturated with gutta-percha and AH-26 epoxy resin sealer (Dentsply Sirona, Konstanz, Germany) by cold lateral compaction technique. Finally, the access cavities were restored with composite resin (Figure 3B). The sinus tract of tooth #13 was completely healed two weeks after root canal therapy.

At the 1-year follow-up, the endodontically treated teeth were asymptomatic. Radiographic examination revealed a reduction in size of periapical lesions in all teeth (Figure 5). Further follow-ups were scheduled for the patient to monitor the ultimate outcome of endodontic treatments.

Discussion

Root canal treatment of teeth with short roots and PCC found in patients with DGI may be associated with some complications [17]. Periapical radiolucency [24] and/or abscess may develop in such teeth in absence of any pathology [22]. Extraction is often recommended for teeth with complete obliteration of root canal and periapical radiolucency [22, 25]. Alternatively, periapical curettage and retrograde endodontic treatment may be performed for such teeth; however, this option is not suitable for teeth with short roots [26].

In patients with DGI, the clinicians often recommend endodontic treatment in addition to restorative procedures for teeth with extensive caries, severe attrition, or enamel fracture. Also, such procedures should be preferably accomplished at a young age while the root canals have yet to be fully obliterated [22].

Pettiete *et al.* [22] reported endodontic treatment of a maxillary molar in a patient with DGI type II. The tooth had a bulbous crown and the orifices were hard to identify due to pulp chamber calcification. The pulp chamber had an irregular outline, and the normal landmarks were absent, complicating safe negotiation of root canal orifices. Finally, they had to extract the tooth since they could not perform endodontic treatment for all root canals and consequently, the symptoms were not resolved.

Safe negotiation of root canal orifices in teeth with PCC due to hereditary dentinal defects is more challenging than that in cases with PCC due to extensive caries or trauma [25]. In patients with DGI type II, PCCs have a unique pattern with an unknown pathophysiological mechanism. PCC in such cases occurs before or soon after eruption of teeth [27]. After luxation injuries, calcification starts from the coronal part of the root canal and results in subsequent gradual narrowing of the root canal system. However, the pattern of PCC in DGI is not necessarily the same as that in luxation injuries. Instead, variable expressivity has been reported in teeth with DGI type II, which may range from complete obliteration of the root canal system to calcifications in some specific areas in the apical or coronal third of the root canal [27].

In DGI, dentin hypomineralization compromises its resistance to endodontic instruments, and increases the risk of procedural errors such as ledge formation, canal transportation, or root perforation [22].

In the present case, the root canals in all teeth were successfully negotiated, instrumented, and obturated using the guided endodontics approach. However, despite the favorable results (clear signs of periapical healing) at the 1-year follow-up, longer follow-ups are required to monitor the healing process and possibly detect new endodontic lesions which may occur in other teeth.

In the present case, guided endodontics was proven to be a reliable alternative for endodontic treatment of calcified canals. Many studies have confirmed high accuracy of guided access cavity preparation by comparing conventional cavity preparation with virtual planning [20, 28-31].

Prospectively, advanced guided endodontics based on computer-aided dynamic navigation and augmented reality technology may soon be available for cases where multiple root canal treatments need to be performed in calcified root canals. Nonetheless, further clinical studies are recommended to clinically validate such procedures [32-35].

Conclusion

Guided endodontics is a predictable approach for endodontic treatment of challenging cases such as DGI patients. This approach decreases the risk of procedural errors, increases the accuracy of root canal negotiation, and consequently improves the survival rate of such teeth.

Acknowledgments

None.

Conflict of interest

None.

Funding support

None.

Authors' contributions

MR: Study concept and design, administrative, technical, and material support, Acquisition of data, YS: Analysis and interpretation of data, AK/OD: Statistical analysis, study supervision. All authors contributed and approved the final manuscript.

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Please cite this paper as: Rahmatian M, Kazemi A, Dianat O, Safi Y. Endodontic Management of Dentinogenesis Imperfecta Using Guided Endodontics: A Case Report. Iran Endod J. 2024;19(4): 308-12. Doi: 10.22037/iej.v19i4.45902.