



ROLE OF VOLUMETRIC IMAGING IN DEVELOPMENTAL DISTURBANCES IN STRUCTURE OF TEETH

Dentistry

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ABSTRACT

Developmental disturbances such as amelogenesis imperfecta, dentinogenesis imperfecta, dentin dysplasia, and regional odontodysplasia are rare conditions affecting tooth structure. Cone Beam Computed Tomography (CBCT) offers advanced three-dimensional imaging and superior diagnostic accuracy compared to traditional radiographs. **Objective:** To describe and evaluate detailed structural changes in teeth and associated structures using CBCT in patients with developmental disturbances in the structure of teeth. **Materials and Methods:** The study included 24 patients clinically and radiographically diagnosed with developmental disturbances affecting tooth structure, including 14 cases of amelogenesis imperfecta, 5 cases of dentinogenesis imperfecta, 1 case of dentin dysplasia, and 4 cases of regional odontodysplasia. Volumetric imaging was performed using the Newtom GiANO HR Cone Beam CT machine, and images were analyzed with NNT version 12.01 software to assess enamel, dentin, pulpal, and surrounding bone characteristics. **Results:** CBCT provided detailed insights into enamel and dentin thickness, density, pulp chamber alterations, and associated anomalies, including impacted teeth, apical pathology, and altered bone morphology. Specific findings included reduced enamel density in amelogenesis imperfecta, bulbous crowns and pulpal obliteration in dentinogenesis imperfecta, thistle-tube pulp chamber appearance in dentin dysplasia, and ghost teeth with altered bone radiopacity in regional odontodysplasia. **Conclusion:** CBCT proved invaluable in the precise evaluation of rare developmental disturbances affecting tooth structure. Its ability to provide accurate three-dimensional imaging and assess morphological changes in hard and soft tissues underscores its importance in diagnosis, treatment planning, and improving clinical outcomes.

KEYWORDS

DVT(Dental Volumetric Tomography), AI(Amelogenesis Imperfecta), DI(Dentinogenesis Imperfecta), DD(Dentin Dysplasia), RO(Regional Odontodysplasia)

INTRODUCTION

Dental Volumetric Tomography (DVT), also known as Cone Beam CT scanning, is a diagnostic X-ray methodology that produces three-dimensional anatomical images of skeletal tissues, including the teeth. It heralded a new era in three-dimensional (axial, sagittal, coronal) maxillofacial imaging by providing high-quality images that can be obtained with a relatively compact device and lower cost compared to conventional computed tomography (CT).^{1,2} Cross-sectional image sets obtained in different planes with a single scan, and the multiplanar reconstruction ability resulted in more accurate diagnosis which has increased the popularity of CBCT in all fields of dentistry.²

This imaging modality primarily focuses on the osseous and dental components of the maxillofacial complex. It is utilized in various cases, such as severe dentoalveolar trauma, root resorption, patients with cleft lip and palate, developmental disorders (e.g., amelogenesis imperfecta), cysts, and benign tumours. Additionally, it is valuable for assessing dental anomalies like dens invaginatus, dilaceration, as well as for procedures such as auto transplantation and managing unerupted, impacted, and ectopic teeth.³

The tooth structure comprises enamel, dentin, cementum, and pulpal tissue, serving functions of protection, support, anchorage, and sensory nourishment, respectively. Disturbance in any of these tooth structures is a rare entity which includes amelogenesis imperfecta, dentinogenesis imperfecta, dentin dysplasia, and regional odontodysplasia.⁴ Diagnosis of these conditions mainly relies on clinical and radiographic findings, supported by histological features.⁵

Conventional radiographs possess limitations in terms of imaging details and three-dimensional evaluation.⁶ In developmental disturbances in the structure of teeth, CBCT is a useful exam to provide tri-dimensional tooth morphology, and the main advantage of this system is that it eliminates the superimposition of structures.¹ However, there are only a few published cases in which developmental disturbances affecting the structure of teeth have been evaluated using CBCT to date.

The present study aims to describe and examine the detailed structural changes of teeth and associated structures using DVT in patients with developmental disturbances in structure of teeth.

MATERIALS AND METHODS

The study included 24 patients clinically and radiographically diagnosed with developmental disturbances affecting tooth structure, including amelogenesis imperfecta, dentinogenesis imperfecta, dentin dysplasia, and regional odontodysplasia, who were visited the oral medicine and radiology department between 2023 and 2024. Institutional Ethical Committee approval was obtained, and all ethical guidelines were adhered to. Written informed consent was acquired from participating patients, while those uninterested in investigations were excluded.

All patients diagnosed with developmental disturbances affecting tooth structure, including 14 cases of amelogenesis imperfecta, 5 cases of dentinogenesis imperfecta, 1 case of dentin dysplasia, and 4 cases of regional odontodysplasia, underwent clinical and radiographic assessments. Morphological findings were analyzed using 3D imaging, specifically cone-beam computed tomography (CBCT).

Radiographic imaging was performed using the Newtom GiANO HR Cone Beam CT machine, generating volumetric radiographic images for evaluating structural changes in enamel, dentin, and dental pulp. Analysis was conducted using NNT version 12.01 software.

Various morphological findings were observed using CBCT in both erupted and impacted teeth, including Enamel Characteristics (Enamel Thickness, Enamel Density), Crown and Root Characteristics (Bulbous crown, Cervical constriction, Thin roots, Short roots, Altered shape of the teeth), Pulpal Characteristics (Pulpal obliteration, Enlarged pulp chamber, Pulpal calcification), Tooth Appearance (Shell teeth, Thistle tube appearance, Pulpal calcification), Other Characteristics (Taurodontism, Gubernaculum tract, Altered bone morphology, Impacted teeth, Hyperplastic follicle, Expansion of buccal and lingual cortical plate, Apical pathology)

RESULTS

• Demographic distribution of study subjects (patients with developmental disturbances affecting the tooth structure) (Table 1):

A total of 24 patients were included, consisting of 14 cases of amelogenesis imperfecta (AI) (8 hypocalcified, 2 hypomaturation, and 4 hypoplastic), 5 cases of dentinogenesis imperfecta (DI) (2 with osteogenesis imperfecta (OI) and 3 without osteogenesis imperfecta),

1 case of coronal type dentin dysplasia (DD), and 4 cases of regional odontodysplasia (RO). The maximum number of patients were in the age group of 11-20 years, and males were the most commonly affected.

- Radiographic characteristics observed in patients with developmental disturbances affecting the structure of teeth (Table 2):

AI: In the hypocalcified type of AI, for enamel characteristics, 5 cases exhibited normal enamel thickness, while 3 had altered thickness. All 8 cases had altered (reduced) enamel density. Regarding crown and root characteristics, 6 cases had an altered shape of the teeth, and there was 1 case with short roots. In terms of pulpal characteristics, 7 cases exhibited pulpal calcification. Additional characteristics included 3 cases with the presence of a gubernaculum tract, 4 cases with impacted teeth, and 3 cases with apical pathology. In the hypomaturation type of AI, for enamel characteristics, 1 case exhibited normal enamel thickness, while 1 had altered thickness. Regarding enamel density, 1 case had normal enamel density, while 1 had altered (reduced) enamel density. In terms of pulpal characteristics, 1 case had an enlarged pulp chamber. Additional characteristics included 1 case with a gubernaculum tract, 2 cases with impacted teeth, 1 case with a hyperplastic follicle, and 1 case with apical pathology. In the hypoplastic type of AI, for enamel characteristics, 1 case exhibited altered thickness. Regarding enamel density, all 4 cases had altered (reduced) enamel density. In terms of crown and root characteristics, all 4 cases had an altered shape of the teeth. Pulpal characteristics included no cases of pulpal obliteration, but 1 case exhibited pulpal calcification. Additional characteristics included 1 case with a gubernaculum tract, 1 case with impacted teeth, and 3 cases with apical pathology.

DI: In the DI with OI, all cases showed normal enamel thickness and density, bulbous crown, cervical constriction, thin roots, and altered bone morphology. 1 case showed pulpal obliteration, enlarge pulp chamber, and shell tooth appearance. In DI without OI all cases showed normal enamel thickness and density, bulbous crown, cervical constriction, thin roots, pulpal obliteration, and apical pathology.

Dentin Dysplasia: All cases of dentin dysplasia (coronal type) exhibited normal enamel thickness and density, enlarged pulp chambers, thistle tube appearance, presence of gubernaculum tracts, impacted teeth, hyperplastic follicles, expansion of the buccal and lingual cortical plates, and apical pathology.

RO: All cases of RO showed altered enamel thickness and density, altered tooth shape, enlarged pulp chambers, ghost tooth appearance, presence of gubernaculum tracts, altered bone morphology, impacted teeth, hyperplastic follicles, expansion of the buccal and lingual cortical plates, apical pathology, and one case showed pulpal calcification.

DISCUSSION

Developmental disturbances affecting the structure of the teeth are rare hereditary disorders that primarily impact the quality and/or quantity of tooth structure. These include amelogenesis imperfecta, dentinogenesis imperfecta, dentin dysplasia, and regional odontodysplasia.⁴ The lack of local information in the literature about the radiographic changes associated with these disturbances motivated this study. The technological advancements, increasing functionality, and cost-effective accessibility of CBCT have made its use widespread in contemporary dentistry, allowing for more precise determination of the dimensions and locations of oral structures. This results in better definition of tooth structures, including enamel, dentin, pulp, associated pathology, and surrounding structures.¹ In such cases, CBCT is essential for obtaining greater details and characteristics of the lesions, given the uncommon nature of these conditions.⁷

In the present study, the majority of patients had amelogenesis imperfecta, while the fewest had dentin dysplasia. According to the literature, among these anomalies, amelogenesis imperfecta is the most common, followed by dentinogenesis imperfecta, odontodysplasia, and dentin dysplasia, which is consistent with the findings of this study.^{6,8,9} The patients were mainly young, aged 11-20 years, and males were the most commonly affected, similar to the studies conducted by Daniela Adorno-Farias et al.¹⁰ and D. Ceyhan et al.¹¹

Amelogenesis imperfecta (AI) encompasses hereditary conditions causing structural and compositional alterations in enamel during development, categorized into hypoplastic, hypocalcified, and

hypomaturation types.¹⁰ CBCT provides significant advantages in diagnosing and assessing AI. In hypoplastic AI, which features thin enamel, CBCT's real-time measurement capabilities allow for precise assessment of enamel thickness and continuity, aiding in differentiation from other types. hypocalcified AI, characterized by reduced enamel density, CBCT effectively evaluates enamel density by comparing the lower radiopacity to that of dentin. For hypomaturation AI, where enamel thickness is affected, CBCT facilitates diagnosis by providing detailed observations of enamel characteristics, enabling accurate measurement and density assessment, which is not possible in 2D radiographs.

Developmental disturbances affecting dentin include dentinogenesis imperfecta (DI) and dentin dysplasia. Dentinogenesis imperfecta comprises three types according to Shields's classification: Type I DI with Osteogenesis imperfecta (OI), Type II DI without OI, and Type III, also known as Brandywine type.³ Dentin dysplasia has two types: Type I (radicular) and Type II (coronal). In Type I dysplasia, the roots exhibit short, blunt, conical, or similarly malformed characteristics. Type II presents an abnormally large pulp chamber in the coronal portion of the tooth, often described as a "thistle-tube."^{4,9} In cases assessed by CBCT, it allows for the evaluation of dentin density and measurement similar to enamel, along with assessing the surrounding bone and its morphological characteristics.

Regional odontodysplasia (RO), also known as "localized arrested tooth development" or "ghost teeth," is characterized by abnormal development of dental hard tissues, including enamel, dentin, and cementum, as well as abnormalities in the pulp tissue and supporting bone on the affected side.^{5,6} Conventional radiographs typically depict teeth affected by RO with a hypoplastic morphology, featuring large pulp chambers enclosed by thin layers of enamel and dentin. In the present study, CBCT software allows real-time assessment of all tissues and measurement of the pulpal tissue and morphological alterations of the surrounding bone, similar to cases of developmental disturbances in enamel and dentin. Additionally, with RO, ghost teeth consist of an intraosseous tooth-related eruption pathway containing a fibrous tissue band (gubernaculum cord or tracts (GTs)) that communicates the tooth bud follicle with its overlying oral mucosa, appearing in the lingual alveolar bone of the deciduous related tooth.⁶ The present study underscores the importance of CBCT in accurately detecting ghost teeth and GTs, as panoramic radiography usually does not reveal these findings. Another interesting and rare finding observed in the present study using CBCT was the mandibular bone altered radiopacity adjacent to the RO teeth. In a clinical point of view, this radiographically altered bone should be carefully analyzed when planning osseointegrated implants placement.

Computed tomography (CT), specifically Cone Beam Computed Tomography (CBCT), is invaluable in assessing various dental conditions, particularly those involving apex closure, calcification, in erupted as well as impacted teeth.⁷ CBCT offers precise localization of calcification and increased follicular space, termed hyperplastic dental follicle. It also facilitates the evaluation of apical pathology, enabling measurement and assessment of enamel and dentin density in all directions, even for impacted teeth, which is challenging with 2D imaging. Its superiority over conventional radiographs, which are limited in imaging details and three-dimensional evaluation, makes CBCT, highly recommended in such cases.⁵

CONCLUSION

Dental Volumetric Tomography (DVT) is a crucial diagnostic tool for developmental disturbances in tooth structure. It provides precise three-dimensional imaging, enabling accurate assessment of enamel, dentin, and surrounding tissues. With advanced capabilities to evaluate apex closure, calcifications, and impacted teeth, CBCT enhances diagnosis and treatment planning for rare dental conditions, ultimately improving patient care and outcomes.

Table 1: Demographic Distribution of Study Subjects (Patients with Developmental Disturbances Affecting the Tooth Structure):

Variable	AI (n=14)			DI (n=5)		Dentin Dysplasia (Coronal type) (n=1)	RO (n=4)
	Hypo-calcified (n=8)	Hypo-maturation (n=2)	Hypo-plastic (n=4)	DI with OI (n=2)	DI with OI (n=3)		
Age							
1-10	0	1	0	0	0	0	0

11-20	5	1	3	2	0	1	2
21-30	3		1	0	3		1
Gender							
Male	7	1	4	2	3	0	1
Female	1	1	1	0	0	1	2

Table 2: Characteristic Features Observed in Patients with Developmental Disturbances Affecting the Structure of Teeth in Digital Volumetric Tomograph (CBCT)

Characteristics	AI (n=14)			DI (n=5)		Dentin Dysplasia (Coronal type) (n= 1)	RO (n= 3)
	Hypocalcified (n=8)	Hypomaturation (n=2)	Hypoplastic (n=4)	DI with OI (n=2)	DI without OI (n=3)		
Enamel Characteristics:							
Enamel Thickness:							
Normal	5	1	0	2	3	1	0
Altered	3	1	1	0	0	0	3
Enamel Density:							
Normal	0	1	3	2	3	1	0
Altered (Reduced)	8	1	1	0	0	0	3
Crown and Root Characteristics:							
Bulbous crown	0	0	0	2	3	0	0
Cervical constriction	0	0	0	2	3	0	0
Thin roots	0	0	0	2	3	0	0
Short roots	0	0	1	0	0	0	0
Altered shape of the teeth	6	0	2	0	0	0	3
Pulpal Characteristics:							
Pulpal obliteration	0	0	0	1	3	0	0
Enlarged pulp chamber	0	1	1	1	0	1	3
Pulpal calcification	7	0	3	0	0	0	1
Tooth Appearance:							
Shell teeth	0	0	0	1	0	0	0
Thistle tube appearance	0	0	0	0	0	1	0
Ghost tooth appearance	0	0	0	0	0	0	3
Other Characteristics							
Taurodontism	0	0	1	0	0	0	0
Gubernaculum tract	3	1	2	0	0	1	3
Altered bone morphology	0	0	0	2	0	0	3
Impacted teeth	4	2	4	0	0	1	3
Hyperplastic follicle	0	0	2	0	0	1	3
Expansion of buccal and lingual cortical plate	0	0	1	0	0	1	3
Apical pathology	3	1	3	0	3	1	3

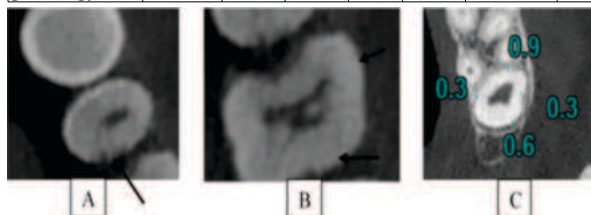


Figure 1: CBCT sections (axial) shows AI ((A) Hypomaturation, (B) Hypocalcification, (C) Hypoplastic)

(A) Discontinuation of the enamel on the distal surface of the left maxillary second premolar. (B) Density of the enamel, which is the same as the dentin suggests a decrease in enamel density. (C) Measurements of the enamel are obtained, with dimensions of 0.9 mm mesially, 0.6 mm distally, 0.3 mm lingual, and 0.3 mm buccally, which are less than the normal thickness of enamel.

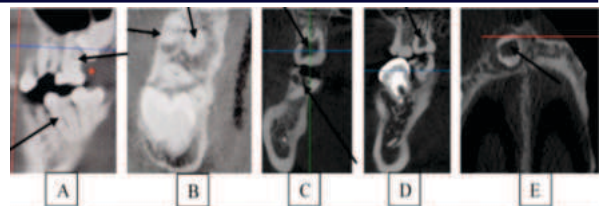


Figure 2: CBCT sections (transaxial and axial) shows DI (A and B), DD (C and D) and Regional odontodysplasia (E)

(A) Cervical constriction of the crown of the teeth as well as obliteration of the pulp chamber due to abnormal deposition of dentin in 26, 27, impacted 28, 37, and 38, (B) narrowing of the pulp chamber is observed in the root portion of 17 and 18. (C) Enlarged pulp chambers in the crown portion of teeth 16 and 47. A widened coronal pulp chamber in 28 (D), and in 11 (E) with an open apex in tooth 28 (D). The density of the dentin is altered (A, B, C, D, and E)

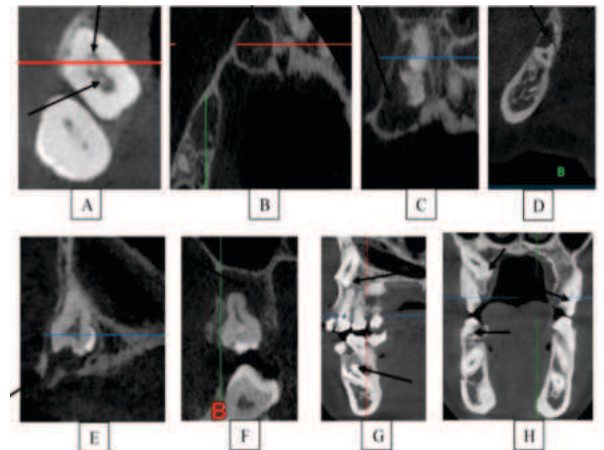


Figure 4: CBCT sections (coronal, transaxial, axial and sagittal) shows AI (A, G and H), RO (B, C, E and F), DD (D).

(A) intra pulpal calcification in tooth 17 at the mesiobuccal and distopalata aspect, (B) buccal and lingual cortical plate expansion, Increased follicular space (hyperplastic follicle) in impacted tooth 14 (C) and tooth 38 (D). (E) Presence of Gubernaculum Tracts (GTs) associated with tooth 11 in transaxial section, (F) Presence of hypodense area below the apex of tooth 17 suggestive of periapical pathology, (G and H) Altered tooth morphology in the impacted teeth

REFERENCES

- Gina Murillo DD, Cob C, Mena N, Valverde A, Barrantes B, Ana Berrocal DDS OM, Sandra Silva MQ. Use of Dental Volumetric Tomography for Dental Phenotyping In Amelogenesis Imperfecta. *OdoVotus-International Journal of Dental Sciences*. 2016 Mar 17;18(1):83-91.
- Ismayilov R, Özgür B. Indications and use of cone beam computed tomography in children and young individuals in a university-based dental hospital. *BMC Oral Health*. 2023 Dec 21;23(1):1033.
- Allareddy V, Vincent SD, Hellstein JW, Qian F, Smoker WR, Ruprecht A. Incidental findings on cone beam computed tomography images. *International journal of dentistry*. 2012;2012.
- Sivapathasundharam B. *Shafer's textbook of oral pathology-E book*. Elsevier Health Sciences; 2016 Jul 25.
- Mabrouk R, Chouchene F, Maatouk F, Masmoudi F, Baaziz A, Ghedira H. Cone-beam computed tomography in the diagnosis of regional odontodysplasia. *Clinical Case Reports*. 2022 May;10(5):e05890.
- de Sá Cavalcante D, Fonteles CS, Ribeiro TR, Kurita LM, Pimenta AV, Carvalho FS, Costa FW. Mandibular regional odontodysplasia in an 8-year-old boy showing teeth disorders, gubernaculum tracts, and altered bone fractal pattern. *International journal of clinical pediatric dentistry*. 2018 Mar;11(2):128.
- Rodrigues LG, da Silva VB, de Carvalho Carmelo J, Khouri MS, Mendes PA, Manzi FR. An Imaging Perspective to Multiple Calcifying Hyperplastic Dental Follicles-A Report of Three Cases. *Annals of Maxillofacial Surgery*. 2022 Jul 1;12(2):227-30.
- Seow WK. Developmental defects of enamel and dentine: challenges for basic science research and clinical management. *Australian dental journal*. 2014 Jun;59:143-54.
- Jose EA, Palathingal P, Baby D, Thachil JM. Dentin dysplasia Type I: A rare case report. *Journal of Oral and Maxillofacial Pathology*. 2019 May 1;23(2):309.
- Adorno-Farias D, Ortega-Pinto A, Gajardo P, Salazar A, Morales-Bozo I, Werlinger F, Rojas-Flores S, Molina-Berrios A, Echeverría-López S, Jara-Sandoval J, Jara L. Diversity of clinical, radiographic and genealogical findings in 41 families with amelogenesis imperfecta. *Journal of Applied Oral Science*. 2019 Apr 1;27:e20180359.
- Ceyhan D, Kirzioglu Z, Emek TO. A long-term clinical study on individuals with amelogenesis imperfecta. *Nigerian journal of clinical practice*. 2019 Aug 1;22(8):115