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# 'Dentinogenesis Imperfecta' – A Review

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## Abstract

A genetic dental condition called Dentinogenesis Imperfecta (DI) alters the mineralization, structure, and formation of dentin. It causes teeth that are discolored, brittle, and vulnerable to wear, fracture, and early loss. DI is frequently linked to mutations in the dentin sialophosphoprotein (DSPP) gene and can occur with or without systemic involvement. Three types of DI have been identified: Type I is linked to osteogenesis imperfecta, Type II is non-syndromic and also referred to as hereditary opalescent dentin, and Type III is the uncommon Brandywine isolate that exhibits pulp exposures and shell tooth characteristics. Patients usually exhibit pulp obliteration, translucency, rapid attrition, amber or blue-gray tooth discoloration, and bulbous crowns with cervical constrictions. On radiography, Type III teeth have shell-like appearances, short roots, and obliterated pulp chambers. Clinical and radiographic evidence, family history, and genetic testing are used to confirm the diagnosis. Amelogenesis imperfecta, dental fluorosis, and dentin dysplasia are examples of differential diagnoses.

***Keywords:*** Dentinogenesis Imperfecta, Hereditary Opalescent Dentin, Capdepont Teeth, Dysplastic Dentin

## Introduction

Both primary and permanent teeth can develop structural and cosmetic abnormalities as a result of Dentinogenesis Imperfecta (DI), a hereditary dentin defect that affects the formation and mineralization of dentin, the tooth's middle layer. Changes in the DSPP gene lead to dentinogenesis imperfecta, a type of genetic disorder that is passed down and affects how dentin is made, resulting in teeth that are discolored, see-through, and easily damaged. [1]

Affected Part of the Tooth:

- Primarily affects the dentin, the layer beneath the enamel and above the pulp.
- Indirectly affects enamel due to poor dentin-enamel junction (DEJ) support, leading to enamel fracturing and loss.
- Pulp chambers may be obliterated due to abnormal dentin deposition.
- Roots may be short or malformed.
- Radiographically, teeth show "shell teeth" appearance (thin dentin with large pulp chambers) in some

types.

Problems Faced by Patients with Dentinogenesis Imperfecta (DI)

Dentinogenesis Imperfecta (DI) can significantly impact a patient's oral health, function, appearance, and psychological well-being. The problems vary by age and the severity of the genetic defect, and they often require lifelong management.

1. Structural Tooth Weakness & Attrition

- Defective dentin leads to poor support for the overlying enamel, causing it to chip or fracture easily.
- This results in rapid wear, especially in the posterior teeth, often leading to loss of vertical dimension and bite collapse. [2]

2. Dental Hypersensitivity and Pain

- As enamel breaks and dentin becomes exposed, patients often experience tooth sensitivity, especially to thermal and mechanical stimuli.
- In advanced stages, pulpal inflammation or necrosis may occur due to cracks or wear. [3]

3. Discoloration and Esthetic Concerns

- Teeth appear opalescent, bluish-gray, or amber in color.
- This discoloration, along with enamel loss, significantly affects facial esthetics, especially in anterior teeth. [4]

4. Difficulty in Chewing and Eating

- Due to tooth breakdown and occlusal instability, patients may experience difficulty in chewing, affecting nutrition and digestion.
- In severe cases, patients may lose their masticatory efficiency entirely.

5. Early Tooth Loss in Children

- Deciduous teeth often undergo rapid wear and exfoliation, affecting occlusal development and requiring early prosthetic intervention. [5]

6. Psychological and Social Impact

- Children and adolescents may suffer from low self-esteem, social anxiety, and bullying due to discolored or missing teeth.
- Adults may feel embarrassed during social or professional interactions. [6]

7. Bone-Related Complications (in DI Type I)

- In patients with Osteogenesis Imperfecta, skeletal fragility and deformities may complicate oral rehabilitation, especially with implants or surgical procedures. [7]

8. Difficulty in Endodontic Treatment

- Teeth often show pulpal obliteration, making root canal therapy difficult or impossible.
- This limits restorative options and may lead to early extraction in infected teeth. [8]

Common Synonyms / Other Names:

1. Hereditary Opalescent Dentin

- Due to the characteristic bluish-gray to amber tooth discoloration [9]

2. Capdepont Teeth
   - A historical eponym referring to opalescent teeth observed in inherited dentin disorders [10]
3. Dysplastic Dentin
   - Occasionally used to describe the malformed dentin structure in DI [11]
4. Type I Collagen-related Dental Defect
   - Specifically refers to DI Type I, which is associated with osteogenesis imperfecta [12]

Classification-Based Terminology: [13]

| ***Name*** | ***Equivalent*** |
|---|---|
| Dentinogenesis Imperfecta Type I | DI with Osteogenesis Imperfecta |
| Dentinogenesis Imperfecta Type II | Hereditary Opalescent Dentin (non-syndromic) |
| Dentinogenesis Imperfecta Type III | Brandywine Type DI |

Classification:

According to Shields' classification: [9]

- Type I: Associated with osteogenesis imperfecta.
- Type II: Not associated with skeletal abnormalities.
- Type III: Rare, also called Brandywine type.

Clinical Signs/Features of Dentinogenesis Imperfecta (DI)

Dentinogenesis imperfecta shows unique signs in both baby teeth and adult teeth that can be seen in clinical exams and X-rays. Depending on the type (Type I, II, or III), the severity can vary, but several hallmark features consistently appear:

Key Clinical Features:

1. Tooth Discoloration:
   - Teeth appear opalescent, bluish-gray, amber, or brownish.
   - The discoloration is due to abnormal dentin shining through translucent enamel.
2. Tooth Wear and Attrition:
   - Enamel fractures easily due to defective dentin-enamel junction (DEJ).
   - Exposed dentin wears rapidly, leading to shortened crowns and severe attrition, especially in deciduous teeth.
3. Pulpal Changes:
   - Pulpal obliteration is common in early life.
   - In Type III DI (Brandywine type), "shell teeth" with large pulp chambers are observed.
4. Tooth Fractures:

- Teeth may fracture spontaneously or during mastication.
- This can cause pain and lead to secondary infections.

5. Delayed Eruption or Malposition:
   - Abnormal eruption patterns or tooth impactions may occur.
6. Increased Caries Risk:
   - Rapid wear exposes dentin, increasing susceptibility to caries and sensitivity.
7. No or Minimal Enamel Defect:
   - Enamel is typically normal histologically, but unsupported and thus readily lost.

Radiographic Features:

- Bulbous crowns
- Cervical constriction
- Short, slender roots
- Pulp chamber obliteration (ghost-like appearance)
- "Shell teeth" (in Type III) with large pulp chambers and thin dentin

Histopathological Features of Dentinogenesis Imperfecta (DI)

Under both light and electron microscopy, abnormal dentin mineralization and structure are indicative of Dentinogenesis Imperfecta (DI). These characteristics show the genetic flaw that prevents dentin matrix and tubular structure from forming normally, which is typically in the DSPP gene.

Histopathological Features:

1. Disorganized Dentin Tubules:
   - Scattered or irregular dentinal tubules
   - Loss of the normal tubular pattern, especially in circumpulpal dentin
2. Interglobular Dentin:
   - Presence of hypomineralized areas known as interglobular dentin, especially in deeper layers.
   - Reflects incomplete fusion of calcospherites during mineralization.
3. Thin Mantle Dentin:
   - Mantle dentin (the first-formed dentin) may be normal or slightly affected, but the bulk of circumpulpal dentin is abnormal.
4. Pulpal Obliteration:
   - Early and progressive deposition of abnormal dentin leads to obliteration of pulp chambers and root canals.
   - In Type III, enlarged pulp chambers ("shell teeth") may be seen.
5. Abnormal Dentinoenamel Junction (DEJ):
   - The DEJ is often smooth instead of scalloped, leading to poor enamel bonding and enamel delamination.
6. Globular or Amorphous Dentin Masses:

- Dentin may appear globular, amorphous, or atubular, indicating defective odontoblast activity.

7. Odontoblast Layer Disruption:
   - Odontoblasts appear disoriented, and sometimes absent, contributing to defective matrix formation.

Ultrastructural (Electron Microscopy) Features:[ 9,12, 14-17]

- Scalloped tubule walls with poor peritubular dentin
- Wide tubules with irregular branching
- Increased collagen spacing, reflecting defective collagen fiber organization

Physical and Chemical Features of Dentinogenesis Imperfecta (DI)

Defective dentin matrix formation and mineralization cause Dentinogenesis Imperfecta (DI), which impacts dentin's composition and structure. Physical (mechanical, optical) and chemical (composition, bonding) analyses clearly show the changes. [17- 21]

Physical Features of DI Dentin:

1. Reduced Hardness and Elastic Modulus:
   - DI dentin is softer and less resilient than normal dentin.
   - Vickers hardness values are significantly lower.
   - Leads to easy wear, fractures, and collapse under occlusal loads.
2. Reduced Tensile and Compressive Strength:
   - Poor mechanical integrity results in brittle teeth.
   - Abnormal collagen and mineral interaction leads to poor dentin toughness.
3. Abnormal Opacity and Translucency:
   - Teeth appear opalescent due to altered light transmission in irregular dentin.
4. Enamel Delamination:
   - Weak DEJ (dentinoenamel junction) causes easy detachment of enamel due to inadequate bonding.
5. Radiographic Appearance:
   - Bulbous crowns, cervical constriction, short roots, and pulpal obliteration.
   - In DI Type III: “shell teeth” with very thin dentin walls.

Chemical Features of DI Dentin:

1. Altered Mineral Composition:
   - Lower calcium and phosphorus content than normal dentin.
   - Abnormal ratio of inorganic to organic matrix.
   - Decreased mineral density confirmed by energy-dispersive X-ray spectroscopy (EDX) and micro-CT.
2. Defective Collagen Structure:
   - Abnormal type I collagen fibrils or arrangement due to DSPP gene mutations.
   - Poor collagen–mineral interaction contributes to mechanical weakness.
3. Increased Water Content:

- DI dentin shows higher porosity and more loosely bound water.
- Indicates hypomineralization and increased intertubular space.

4. Decreased Phosphate and Carbonate Ratios:

- Raman and FTIR spectroscopy show altered carbonate-to-phosphate ratios, suggesting poor crystal quality in hydroxyapatite.

Etiology of Dentinogenesis Imperfecta (DI)

A genetic condition called Dentinogenesis Imperfecta (DI) mainly affects the mineralization and development of dentin. It is caused by mutations in genes, particularly DSPP (Dentin Sialo phosphoprotein), that are essential for the production of the dentin matrix. Although there may be variation in phenotype and severity even within the same family, the condition is autosomal dominant in inheritance.

Primary Etiological Factors:

1. Genetic Mutation in DSPP Gene:

- The DSPP gene, located on chromosome 4q21.3, encodes dentin sialoprotein (DSP) and dentin phosphoprotein (DPP).
- Mutations in DSPP disrupt the processing or secretion of these proteins, leading to defective dentin matrix formation and mineralization. [18]

2. Autosomal Dominant Inheritance:

- DI is commonly inherited in an autosomal dominant pattern, with high penetrance and variable expressivity.
- Family history is often positive for similar dental abnormalities. [9]

3. Association with Osteogenesis Imperfecta (in Type I DI):

- In DI Type I, the dentin defect is secondary to collagen-related mutations, especially in the COL1A1 or COL1A2 genes.
- These mutations also cause osteogenesis imperfecta, affecting both bone and dentin. [17]

4. Molecular Pathophysiology:

- Mutated DSPP proteins may be misfolded or trapped in the endoplasmic reticulum, inducing cellular stress and impairing odontoblast function.
- Leads to irregular dentin tubule formation and defective mineral deposition. [22]

5. Other Proposed Molecular Mechanisms (less common):

- Disruption in matrix metalloproteinase activity
- Disturbed signaling in TGF-β pathway, indirectly affecting matrix mineralization [23]

Interdisciplinary Management

Dentinogenesis Imperfecta requires interdisciplinary management to effectively address the functional, esthetic, psychological, and genetic aspects of the disorder.

Reasons for Interdisciplinary Approach:

1. Complex Dental Involvement

- Affects both primary and permanent teeth, causing severe wear, fractures, and enamel loss.
- Early intervention by pediatric dentists is essential to preserve occlusion and prevent pain.
- In adulthood, prosthodontic rehabilitation is often necessary due to tooth structure loss. [2]

2. Genetic Counseling and Diagnosis

- DI is a hereditary condition, often due to mutations in the DSPP gene.
- Medical geneticists are involved to confirm diagnosis, identify syndromic associations (e.g., with osteogenesis imperfecta in DI Type I), and provide family counseling. [13]

3. Orthodontic Considerations

- Due to malocclusions, short roots, and premature tooth loss, orthodontic movement is complicated.
- Orthodontists must coordinate with prosthodontists and monitor root resorption risk in DI patients. [12]

4. Restorative and Prosthodontic Rehabilitation

- General and restorative dentists manage early structural defects with crowns, overlays, or composite build-ups.
- Prosthodontists may be needed for full-mouth rehabilitation, including implants, fixed or removable prostheses. [3]

5. Psychosocial Support and Esthetic Counseling

- Patients often suffer from tooth discoloration, early tooth loss, and self-image concerns.
- Involvement of psychologists or counselors helps manage psychosocial impact, especially in children and adolescents. [6]

Management of Dentinogenesis Imperfecta (DI) in Children and Adults

Dentinogenesis Imperfecta is a lifelong condition that requires age-specific, functional, esthetic, and often psychosocial management. Because the clinical presentation differs between primary and permanent dentition, the treatment strategy also differs for children and adults.

Management in Children

Goals:

- Preserve tooth structure and vertical dimension
- Prevent premature tooth loss
- Restore function and esthetics
- Minimize psychological trauma

1. Early Diagnosis and Monitoring

- Conduct thorough clinical and radiographic evaluations.
- Evaluate family history and consider genetic counseling if needed. [3]

2. Full-Coverage Restorations for Primary Teeth

- Use preformed metal crowns (PMCs) or zirconia crowns to protect against attrition and preserve

occlusion.

- Posterior teeth especially need protection due to masticatory forces. [2]

3. Composite or Strip Crowns for Anterior Teeth

- For esthetics, use composite resin restorations or strip crowns.
- These help build confidence and reduce psychosocial effects.

4. Space Maintainers or Partial Dentures

- In cases of early tooth loss, use removable partial dentures or space maintainers.
- This prevents collapse of the dental arch and maintains space for permanent teeth. [4]

5. Behavior Management and Preventive Regimen

- Fluoride varnishes, pit and fissure sealants, and strict oral hygiene are essential.
- Schedule frequent recall visits to monitor wear or restoration failure.

Management in Adults

Goals:

- Rehabilitate function and esthetics
- Restore vertical dimension of occlusion
- Preserve remaining tooth structure
- Manage complications such as TMJ issues or sensitivity

1. Full-Mouth Rehabilitation

- Due to severe attrition and discoloration, adults often require comprehensive prosthodontic rehabilitation.

a. Crown Lengthening + Full-Coverage Crowns

- Use porcelain-fused-to-metal (PFM), zirconia, or E-max crowns after crown lengthening to ensure retention.

b. Overlay Dentures / Onlay Restorations

- For severely worn dentition with minimal crown height. [24]

2. Implant-Supported Prostheses (Selective Use)

- In cases with hopeless dentition, implants can be used after extraction, but bone quality and facial development must be evaluated. [25]

3. Endodontic Management

- Pulp chambers are usually obliterated, making root canal therapy difficult.
- Early periapical lesions may require surgical endodontics or extractions.

4. Occlusal Adjustment and Splint Therapy

- Necessary for TMJ management and to stabilize occlusion if there is bruxism or severe wear.

5. Esthetic Veneers or Direct Bonding (Mild Cases)

- If tooth structure is adequate, composite bonding or ceramic veneers can be placed for esthetic correction.

Multidisciplinary Approach

Team involvement includes:

- Pediatric dentist (for early care)
- Prosthodontist (for full-mouth rehab)
- Orthodontist (malocclusion management)
- Endodontist (complex RCTs)
- Oral surgeon (implants, extractions)
- Geneticist (DSPP mutation diagnosis and counseling)
- Psychologist (patient confidence and quality of life) [13]

Role of a Prosthodontist in the Management of Dentinogenesis Imperfecta (DI)

The Prosthodontist plays a central role in the functional and esthetic rehabilitation of patients with Dentinogenesis Imperfecta, especially in the permanent dentition and adult stages. DI affects dentin structure, leading to rapid tooth wear, enamel fracture, loss of vertical dimension, and aesthetic concerns — all of which fall under the domain of prosthodontic expertise.

Key Roles of the Prosthodontist:

1. Comprehensive Evaluation and Treatment Planning

- Perform detailed occlusal and esthetic analysis, vertical dimension assessment, and radiographic examination.
- Formulate individualized treatment plans considering the severity of structural loss, age, esthetics, and patient expectations. [13]

2. Restoration of Occlusion and Function

a. Full-Coverage Crowns:

- Zirconia, E-max, or PFM crowns are used to restore structural integrity and prevent further wear.
- Crowns restore lost vertical dimension and improve mastication.

b. Onlays/Overlays:

- In less severe cases or where some coronal tooth structure remains.

c. Occlusal Splints:

- Fabricated to protect restorations from parafunctional habits such as bruxism. [24]

3. Esthetic Rehabilitation

- Address discoloration and malformed anterior teeth with:
  - Ceramic veneers
  - Lab-fabricated composite restorations

- Full esthetic crowns [3]

4. Removable Prosthodontics (When Teeth Are Non-Restorable)

- Design removable partial dentures or complete dentures in cases with:
  - Multiple extractions
  - Collapsed occlusion
  - Loss of posterior support

Implant-Supported Overdentures:

- In adults, if bone quality allows, prosthodontists may coordinate implant-retained prostheses. [25]

5. Multidisciplinary Coordination

- Prosthodontists work with:
  - Pediatric dentists (for early intervention)
  - Endodontists (for root canal treatment of fragile teeth)
  - Oral surgeons (for extractions and implants)
  - Orthodontists (for spacing and alignment)
  - Geneticists and psychologists (for syndromic forms and emotional support) [4]

6. Long-Term Maintenance and Follow-Up

- Regular evaluation of restorations, occlusion, and prosthesis fit.
- Address restoration failure, chipping, or wear as needed.

Recent Advancements in the Treatment of Dentinogenesis Imperfecta (DI)

Recent developments in biomaterials, digital dentistry, genetics, and minimally invasive approaches have significantly improved the management of Dentinogenesis Imperfecta (DI), especially regarding tooth preservation, esthetic outcomes, and long-term functional rehabilitation.

1. Genetic Testing & Molecular Diagnosis

- Next-Generation Sequencing (NGS) now allows accurate identification of mutations in the DSPP gene and associated syndromes (e.g., osteogenesis imperfecta).
- Early diagnosis enables pre-symptomatic counseling, customized treatment planning, and family screening. [13]

2. Biomimetic and Adhesive Restorative Materials

- Use of bioactive composites (e.g., Giomers, calcium silicate-based materials) to promote dentin remineralization and better bonding.
- Self-etching adhesives with improved dentin penetration enhance retention in hypomineralized dentin. [19]

3. CAD/CAM & Digital Dentistry

- CAD/CAM-fabricated crowns and overlays provide precise marginal adaptation, better esthetics, and minimal invasiveness, which is critical for fragile teeth.
- Digital smile design helps in esthetic planning for anterior teeth affected by discoloration and wear. [26]

4. Pediatric Zirconia Crowns

- Introduction of prefabricated esthetic zirconia crowns for children with DI offers better durability and esthetics than stainless steel crowns.
- Excellent soft-tissue compatibility and color stability. [27]

5. Implant-Based Prosthodontics in Adulthood

- Implants are now considered in select adult DI patients after careful evaluation of bone quality and jaw development.
- Recent advances in short and narrow-diameter implants, guided implant placement, and zirconia abutments improve outcomes even in reduced bone conditions. [25]

6. Regenerative Approaches (Experimental/Research Phase)

- Tissue engineering and stem cell therapy using dental pulp stem cells (DPSCs) are being investigated to regenerate dentin in inherited disorders like DI.
- Potential application of recombinant DSPP proteins to enhance dentin formation in gene-deficient models. [25]

7. Interdisciplinary Digital Workflow

- Integration of 3D imaging (CBCT), intraoral scanning, digital wax-up, and guided occlusal rehabilitation is now standard in full-mouth rehab of DI patients.
- Enhances precision, patient education, and treatment predictability.

Some adult patients with DI may benefit from dental implants as part of their prosthetic rehabilitation, especially if they have severely worn dentition, edentulous spaces, or non-restorable teeth. However, because of a number of difficulties that are specific to the condition, implant use needs to be handled carefully.

DI and Its Challenges for Implants

Dentinogenesis Imperfecta is a genetic condition that affects dentin structure, but it does not primarily involve the alveolar bone. Therefore, in principle, osseointegration is possible, but clinical considerations include:

- Poor bone quality in some patients, especially those with DI Type I (associated with Osteogenesis Imperfecta)
- Short roots, tooth loss, or periapical pathology may lead to early edentulism and the need for implants
- Growth considerations in younger patients contraindicate early implant placement

Clinical Indications for Implants in DI:

Suitable Cases:

- Adults with fully developed jaws
- Loss of teeth due to fracture, caries, or restoration failure
- Patients unwilling to wear removable prostheses

- Posterior support restoration in partial edentulism

Precautions and Limitations:

Caution in:

- Patients with DI Type I: Bone fragility from osteogenesis imperfecta increases implant failure risk
- Young patients: Implants are contraindicated until jaw growth is complete
- Compromised alveolar ridge: Bone grafting may be needed before implant placement

Treatment Considerations:

1. Pre-Implant Imaging:
   - CBCT for bone volume and density evaluation
2. Implant Design:
   - Use of narrow diameter implants, short implants, or zirconia abutments to improve esthetics and adapt to limited bone
3. Guided Implant Surgery:
   - Digital planning and surgical guides improve placement precision in difficult cases
4. Prosthetic Protocols:
   - Fixed prostheses (crowns, bridges) or implant-retained overdentures in fully edentulous cases
5. Multidisciplinary Coordination:
   - Prosthodontist, oral surgeon, and periodontist collaboration is essential

Dental implants can be successfully used in adults with DI, especially when:

- Growth is complete
- Bone quality is adequate or augmented
- A multidisciplinary team manages the case
- Risk factors (e.g., OI, bruxism) are controlled

Implants are not typically first-line in children or adolescents with DI but may be critical for long-term rehabilitation in severe adult cases.

## Conclusion

Tooth discoloration, structural weakness, and heightened vulnerability to attrition and fracture are the hallmarks of Dentinogenesis Imperfecta, a genetically inherited dentin disorder. Both primary and permanent dentitions are impacted by the condition, which can manifest with or without systemic associations like osteogenesis imperfecta. Effective management requires an early diagnosis made by clinical, radiographic, and genetic evaluation.

Comprehensive care requires a multidisciplinary approach involving pediatric dentists, geneticists, prosthodontists, endodontists, orthodontists, and oral surgeons. The main goals of management techniques should be to protect tooth structure, restore function and appearance, and avoid psychological effects, particularly in young patients. The long-term outlook for those impacted has improved due to recent developments in biomaterials, adhesive systems, CAD/CAM technologies, and genetic diagnostics. People

with DI can achieve satisfactory functional, aesthetic, and psychosocial outcomes throughout their lives with prompt intervention and individualized treatment planning.

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