Options for Treating Teeth Affected with Developmental Defects of Enamel
A survey of dentists and dental hygienists in Ohio

THESIS

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By

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Abstract

**Purpose:** The purpose of this study was to determine whether dentists and dental hygienists in Ohio observe developmental defects of enamel (DDE) in patients in their practices. This study also determined what treatment options are most frequently recommended by dentists for teeth with minor, moderate and severe DDE, and what treatment options and oral hygiene recommendations are discussed by dental hygienists for patients with DDE.

**Methods:** Researchers developed a survey instrument investigating whether dentists and dental hygienists observe DDE in patients in their practices. The survey included questions about what treatment options dentists utilized for teeth with minor, moderate and severe DDE, and what treatment options and oral hygiene recommendations are discussed by the dental hygienist. An email was sent to 1,468 dentists and dental hygienists across the state of Ohio asking them to complete the survey. Potential respondents were provided five weeks to complete the survey and two reminder emails were sent.

**Results:** A total of 76 responses were received, a 7.2% response rate. Seventy percent of dentists and 66% of dental hygienists observe one to five patients per week with DDE. Sixty-five percent of the dentists treat minor DDE with composite fillings, 82% treat moderate DDE with composite fillings, and 88% treat severe DDE with crowns. Eighty-
nine percent of the dental hygienists discuss composite fillings as treatment options for teeth affected with DDE, and 88% recommend fluoride therapy as oral hygiene care.

**Conclusion:** The results of this study indicate that there are no consistent treatment options for teeth affected with DDE. However, the study does suggest dentists and dental hygienists are observing DDE in patients in their practices in Ohio. Future research might build upon the results by analyzing and developing a guideline on restorative dental treatment and clinical management for teeth with DDE.
This document is dedicated to my husband John and my family, for their continuous support and encouragement throughout my graduate program.
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Fields of Study

Major Field: Dental Hygiene
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Chapter 1
Introduction

Background of the Problem

Developmental defects of enamel (DDE) include amelogenesis imperfecta, dentinogenesis imperfecta, dentin dysplasia, enamel hypoplasia, enamel hypocalcification, and molar incisal hypomineralization.

Amelogenesis imperfecta occurs from a developmental disturbance that interferes with normal enamel formation in the absence of a systemic disorder.\(^1\) Dentinogenesis imperfecta is a hereditary developmental disturbance of the dentin that originates during the histodifferentiation stage of tooth development.\(^2\) Dentin dysplasia, which is a rarer DDE, represents another group of inherited dentin disorders resulting in characteristic features involving the dentin and root morphology.\(^2\) Enamel hypoplasia is a defect in the enamel due to disturbance of ameloblastic function during amelogenesis, and may be either genetic or environmental in nature.\(^3\) Enamel hypocalcification, which is a DDE within the enamel of the teeth, is soft, undercalcified and opaque in appearance but normal in quantity. Enamel hypocalcification is caused by a defective maturation of ameloblasts. Molar incisal hypomineralization (MIH), is a term used for a DDE to describe the clinical appearance of enamel hypomineralization of a systemic origin that affects one or more first permanent molars and is commonly associated with permanent incisors.\(^4\)
Developmental defects of enamel can be described in two types, hereditary and environmental. Hereditary DDE are caused when there is an ectodermal disturbance of formation, while environmental DDE are caused by environmental factors that damage the enamel cells. These factors include: nutritional deficiencies, skin diseases like chicken pox or measles, congenital syphilis, injury, local infection, trauma, and antibiotic use.\(^5\)

A single tooth or multiple teeth can be involved and may vary by several degrees depending on what stage of maturation the tooth was affected. In some cases one to four permanent first molars are affected by DDE and frequently associated are the permanent incisors.\(^6\)

 Teeth that are affected by DDE have various appearances. These variations consist of brown, yellow, porous, soft and chalky white. Teeth affected with DDE are described as an abnormality and change in the translucency of the enamel. Some have clearly defined margins while others have irregular margins.\(^7\)

**Significance of the Problem**

Developmental defects of enamel can appear very unaesthetic, especially on the anterior dentition. These defects can have many negative effects on an individual’s overall appearance and self-esteem.\(^8\) This negative self-esteem seems to not only affect adults with DDE, but younger children as well. As a dentist or dental hygienist working with this younger population, it is vital to understand the social stigmas that can result due to DDE.\(^8\)
In addition to incisors, first molars with idiopathic DDE are a common finding in dental practices. These teeth are recognized as creating severe problems for the patients as well as for the dentists treating them due to loss of substance, hypersensitivity and problems in performing adequate filling therapy. Other issues include masticatory difficulties, tooth sensitivity, complex dental treatment, emotional and physical strains, and financial burdens.

Failure to address developmental defects and their related problems can lead to dental caries and further destruction of tooth structure. This can result in periodontal issues, infections and tooth loss. Developmental defects of enamel, if not properly restored, can exhibit tooth sensitivity, cause more destruction to the coronal form creating unusual function of the teeth, and incorrect occlusion and proximal contacts.

Of major concern is the prevalence of DDE that is being seen in dental practices. The prevalence of these defects is high in modern populations, ranging from 63-68% in Caucasians in New Zealand, Ireland, and England, and 95-99% in Hong Kong Chinese. MIH appears to occur in most European countries and a population of pediatric dentists in Europe consider MIH to be a clinical problem.

**Purpose of the Study**

The purpose of this study was to determine whether dentists and dental hygienists in Ohio observe DDE in patients in their practices. This study also determined what treatment options are most frequently recommended by dentists for teeth with minor, moderate, and severe DDE, and what treatment options and oral hygiene recommendations are discussed by dental hygienists for patients with DDE.
Research Questions

How many patients do dentists and dental hygienists in Ohio observe per week with DDE?

What restorative options are most utilized by dentists in Ohio for treating and managing teeth with DDE?

What treatments options and oral hygiene recommendations are discussed by dental hygienists for patients with DDE?

Definition of Terms

1. Developmental defects of enamel (DDE): DDE have been defined as disturbances in the hard tissue matrices and their mineralization that arise during odontogenesis.

2. Amelogenesis Imperfecta: developmental disturbance that interferes with normal enamel formation such as: hypoplasia, hypomaturation, hypocalcification.

3. Dentinogenesis Imperfecta: hereditary developmental disturbance of the dentin during histodifferentiation stage of tooth development.


5. Enamel hypoplasia: defect in the enamel characterized by lack of tooth contact, yellowish brown stain where dentin is exposed.

6. Enamel hypocalcification: soft and under calcified enamel that is opaque in appearance but normal in quantity.
7. Molar incisal hypomineralization (MIH): dental defects that involve the four permanent molars and permanent incisors. These defects are noted as demarcated enamel opacities of different colors due to post breakdown and the enamel is soft and porous, resulting in atypical cavities.
Chapter 2
Review of Literature

The review of literature aims to broaden the understanding of DDE, different risk factors, etiological factors and dental treatment/options to clinically manage affected teeth. General information, case studies and articles regarding the background of DDE, risk factors, prevalence and management of these teeth will be discussed.

Types of Developmental Defects of Enamel

There are several categories of DDE which include amelogenesis imperfecta (AI), dentinogenesis imperfecta (DI), dentin dysplasia (DD), enamel hypoplasia (EH), enamel hypocalcification, and molar incisal hypomineralization (MIH). Amelogenesis imperfecta is a developmental disturbance that interferes with normal enamel formation in the absence of a systemic disorder.¹ Amelogenesis imperfecta can affect all or nearly all teeth in both the primary and permanent dentitions, and includes four types: hypoplastic, hypomaturation, hypocalcified, and hypomaturation-hypoplastic. Hypoplastic teeth with AI exhibit a pitted surface with normal thickness and hardness; hypomaturation teeth have normal thickness, a chipped surface, less hardness and opaque white coloration; hypocalcified teeth have a normal thickness and smooth surface but less hardness, and hypomaturation-hypoplastic teeth have normal thickness, less hardness and an unusual pitted surface.²
Dentinogenesis imperfecta is a hereditary developmental disturbance of the dentin originating during the histodifferentiation stage of tooth development. This disorder can stand alone but can be seen with a hereditary bone disorder such as osteogenesis imperfecta. Teeth diagnosed with DI appear to have an opalescent hue, abnormally discolored dentin, and translucent enamel. Due to the lack of support and poorly mineralized dentin, these teeth have frequent enamel fractures and rapid wear.

Dentin dysplasia represents a group of rarer inherited disorders resulting in characteristic features involving dentin and root morphology. Type 1 DD appears to have a normal crown formation in both primary and permanent teeth, but the roots are short, sharply constricted, and have a loss of dentin. The primary and permanent dentition can demonstrate multiple radiolucencies, which can represent chronic abscesses, granulomas, or cysts. Type II DD demonstrates differences in the clinical crown and root formation. The primary teeth have bulbous crowns, thin roots, and early pulp obliteration, while permanent teeth are normal in coloration, but radiographically exhibit thistle tube shaped pulp chambers with pulp stones present.

Enamel hypoplasia is defined as a deficiency of enamel formation. These defects result from hereditary or environmental factors. It clinically exhibits as pitted, groovy, generalized lack of surface enamel. It is seen as yellow or brown porous lesions, and while the enamel is hard it can be deficient in quantity. It is important EH is clinically detected because of the high risk of dental decay, increased tooth wear, sensitivity and poor esthetics.

Enamel hypocalcification is characterized by soft and undercalcified enamel that is opaque in appearance but normal in quantity. Teeth with enamel hypocalcification are
caused by a defective maturation of ameloblasts, appear chalky in consistency, and because the tooth surface can wear down quickly, are more susceptible to caries.\textsuperscript{7}

Molar incisor hypomineralization is defined as the DDE that involves hypomineralization of one to four permanent first molars and frequently associated with the permanent incisors. Teeth that demonstrate MIH present as demarcated enamel opacities of different color in the affected teeth, which can cause post breakdown of the enamel because of the soft porous texture.\textsuperscript{9}

**Risk Factors for Developmental Defects of Enamel**

Teeth both in the primary and permanent dentition are at risk for developmental defects of enamel, as disruptions can take place any time during development. Hong et al conducted a cohort study where newborn infants were recruited at birth from March of 1992 to February of 1995. A questionnaire was used at 3-6 month intervals, which included a series of items concerning children’s fluoride exposures and ingestion from various sources during the preceding time period or weeks. Information regarding the children’s beverage intakes, breast-feeding patterns, general health/illnesses, and oral health behaviors were obtained. Teeth were evaluated for presence of DDE. After controlling for other potential factors, multivariable regression models suggested that enamel hypoplasia seemed to be a good predictor for childhood infection.\textsuperscript{15}

Arrow studied the risk factors in the occurrence of enamel defects among Western Australia schoolchildren. The aim of the study was to examine possible risk factors for enamel defects in the first permanent molars. Parents of children that were born during 1999-2000 were invited to participate in the study when they had enrolled their child into
pre-primary schools in 2005. Parents completed a questionnaire about the health status of the mother during pregnancy such as smoking habits, birthing processes and the child’s health for the first three years. Parents who completed the questionnaire were asked to keep track of the child’s growth development and health events by using a booklet issued by the Health Department of Western Australia.\textsuperscript{16}

Information was kept in the booklet on the child’s place of residence for the first 3 years, age when toothpaste use started, family history of relatives with enamel defects, history of facial/dental trauma in the last three years, breastfeeding and length of breastfeeding, socioeconomic information relating to mothers education level and employment status, and place of residence for air quality. The study found that a specific type of health event during the neonatal period was a risk factor for different types of enamel defects and suggests that ameloblasts may respond differentially to different insults.\textsuperscript{16} In addition the researchers found diffuse defects were more likely if a child was premature or had other health events requiring medical care and demarcated defects were more likely to occur if the child experienced infections, independently of the type of medication given.\textsuperscript{16}

Ford et al, looked at risk factors for enamel hypoplasia in the permanent dentition of school-aged children. Several medical conditions that are significantly associated with enamel hypoplasia and enamel opacities were studied and included respiratory infections, chickenpox, exposure to tobacco smoke, otitis media, urinary tract infections (UTI) and asthma.\textsuperscript{17} The results suggested that children who have low socioeconomic status, history of respiratory infections, exposure to cigarette smoke, UTI, otitis and who used adult
toothpaste in early childhood were predisposed to enamel hypoplasia of the permanent dentition.\textsuperscript{17}

Masumo et al conducted a study to assess the frequency of enamel defects in the primary dentition and identify influences of early life course factors in children with low birth weight. A caregiver completed face to face interviews and children underwent oral clinical exams where DDE was recorded. They concluded that children with a history of low birth weight were more likely than their normal birth weight counterparts to present with enamel hypoplasia.\textsuperscript{18}

\textbf{Etiological Factors in Developmental Defects of Enamel}

Suckling et al studied the etiological factors that may contribute to DDE. They evaluated over 1,000 children in New Zealand with information on their health and development available from detailed perinatal data and assessments, which included questions on health matters and medical examinations of the children at ages 3, 5, 7, and 9. A relevant medical history was important as several illnesses, accidents and other experiences were selected on the basis of their possible association with DDE of the permanent teeth.\textsuperscript{19} The authors were able to establish that two strong associations of etiological factors were evident. The prevalence of hypoplasia present in 15% of all children was higher in those with a history of chicken pox before age three, and in those children with a history of trauma to the deciduous incisors.\textsuperscript{19}

Suckling and Pearce conducted a study that assessed 243 children aged 12-14 years in New Zealand evaluating possible etiological factors that contribute to DDE.\textsuperscript{20} They found that an etiological component of DDE was continuous exposure to fluoride in
early forming teeth of children before age 5 and in the late forming teeth between 5 and 10 years of age. They also concluded that other etiological factors such as childhood illnesses in combination with injury showed a higher significance of DDE in children.

Mihaela et al conducted a study in Romania based on the etiological factor of antibiotic use in the first few years of life and the correlation to DDE. They monitored DDE in permanent teeth in urban pediatric children of Iasi, and determined that children who use antibiotics in the first year of life are at a higher risk of developing DDE. Children were twice as likely to develop DDE when antibiotics were used during the first four years of life. The risk ranged from 2.14 to 24.98 when antibiotic administration was associated with personal medical history of asthma or neurological disorders.

Prevalence of Developmental Defects of Enamel

Condo et al studied the incidence and prevalence of MIH distribution in 1,500 pediatric patients. The results of the 15 year study showed that 110 pairs of teeth, or 7.3% of the subject’s teeth were affected with MIH. The incidence was 39% greater in the permanent series of teeth that included the six year molars and permanent incisors. Of the total children noted with MIH, 56% had hypoplastic areas in the molars, while 44% were noted in the incisors. Condo concluded MIH is frequent in the pediatric population.

Weerheijm and Mejare sought to determine whether MIH is prevalent throughout Europe and if it is a clinical problem. A questionnaire was sent to 59 members of the European Academy of Paediatric Dentistry (EAPD) encompassing 31 countries. Ninety-seven percent of the respondents stated they were familiar with the clinical appearance of
MIH, and 90% of the respondents considered it as a clinical problem and further exploration of MIH prevalence data worthwhile.\textsuperscript{7}

Basha et al conducted a study to determine prevalence of DDE and associated etiological factors. A questionnaire was given to parents of school aged children in India to obtain demographic data, collect information about maternal health during pregnancy, and overall pre and postnatal health. They found the overall prevalence of DDE was 42.19\% and there was a significant association of DDE with age, gender, low socioeconomic status and obesity.\textsuperscript{23} A demarcated opacity was the most frequent type of DDE in primary and permanent dentition, and prevalence of DDE was more frequent in the permanent dentition compared to the primary.\textsuperscript{23}

Hall investigated the prevalence of hypoplastic surface and severe opacity DDE in children and adolescents with major medical disorders. Dental records of 8,411 children who were discharged from the Department of Dentistry at the Royal Children’s Hospital in Melbourne, Australia between 1960 and 1987 were divided into an experimental group of 7,518 patients compromising of 25 medical conditions, and a control group of 893 children with dental disorders only. The findings from this study indicated children with compounding medical conditions had a higher prevalence of DDE.\textsuperscript{24} The most frequent compounding conditions were rubella and premature births.\textsuperscript{24}

Dental Treatments and Treatment Options for Clinical Management

The American Academy of Pediatric Dentistry (AAPD) has developed guidelines to assist practitioners in the management of DDE. Restorative care for these dental defects includes assessing the appearance, quality and amount of enamel and dentin
affected which will dictate the type of restorations necessary to achieve esthetic, masticatory, and functional health.\textsuperscript{2} If the enamel is discolored but intact, it is suggested that bleaching combined with microabrasion can help enhance the color of the tooth. If enamel is more hypoplastic with pitting, a composite or veneer could be an option.\textsuperscript{2} If enamel defects are both affecting the enamel and dentin and cannot be bonded, a full coverage restoration can be placed, such as a crown.\textsuperscript{2} Periodontal therapy may need to be provided to help clean around the tooth, and in some cases if the enamel defect is so severe compromising adequate oral health, extractions may need to be an option.\textsuperscript{2}

Feierabend et al studied the potential benefits of laboratory made composite resin restorations in children and adults with hypoplasia and hypomineralization of teeth. The aim of the study was to develop a suitable treatment strategy that required little chair time and was applicable to several conditions. The case study followed children between the ages of 6 to 15. Restorations were completed and followed for 2-48 months after placement. The outcome of the study was favorable, with good patient compliance, brief chair time, and functional and esthetic restorations.\textsuperscript{25}

A widely discussed topic in regards to severely involved enamel defects is extraction of affected teeth. Jalevik and Moller evaluated spontaneous space closure and development of permanent dentition after extraction of hypomineralized permanent first molars and the need for orthodontic treatment. During their research, they followed 27 children from the ages of 5 to 12 who had their first permanent molars extracted due to severe enamel defects. The eruption of the permanent dentition and space closure was documented by orthopantomograms, casts, photographs, and/or bitewings. Fifteen children showed development of their permanent dentition without any orthodontic
intervention. Seven children needed to have consults due to other reasons such as crowding and/or missing teeth, and five were judged to have treatment due to inadequate space closure as a result of the extraction of the first permanent molars. Results from this study showed extraction of permanent first molars severely affected by DDE is an acceptable treatment alternative as favorable spontaneous space reduction and development of the permanent dentition positioning can be expected without any orthodontic intervention in the majority of cases. ²⁶

William et al reviewed the recommendations for clinical management of DDE. From this review it was found that adequate anesthesia, suitable cavity design and choice of restorative materials should be determined for optimal clinical management of DDE. ⁴ This study concluded restorations completed on teeth with developmental defects of enamel appear to have an increased failure rate. ⁴ A six step approach was developed to manage teeth with DDE, including: 1. Risk identification, 2. Early diagnosis, 3. Remineralization and desensitization, 4. Prevention of caries and post-eruption breakdown, 5. Restorations and extractions, 6. Maintenance. ⁴

Research has been conducted on understanding how different risk factors, etiological factors and dental treatments/options are used to clinically manage teeth with DDE. Yet minimal studies on prevalence and consensus for the treatment of developmental defects have been completed. The purpose of this study was to determine whether dentists and dental hygienists in Ohio observe DDE in patients in their practices. This study also determined what treatment options are most frequently recommended by dentists for teeth with minor, moderate and severe DDE, and what treatment options and oral hygiene recommendations are discussed by dental hygienists for patients with DDE.
Chapter 3
Methodology

This chapter outlines the specific steps utilized to gather and analyze data to determine the observation of DDE and the most utilized treatment options of teeth with DDE. The research investigates treatment options most utilized by dentists for teeth with minor, moderate, and severe DDE, and the treatment options and oral hygiene recommendations discussed by dental hygienists.

Research Design

A descriptive survey research design was employed with a 13 question dentist-specific survey containing one open-ended question and 12 multiple choice questions. Questions were related to the numbers of patients observed per week with DDE in dental practices and the most utilized treatment options for teeth affected with minor, moderate, and severe DDE. A six question dental hygiene-specific survey contained multiple choice questions related to the number of patients observed per week with DDE in dental practices, and the restorative treatment options and oral hygiene recommendations discussed to the patient with DDE. The survey was reviewed for content and clarity by a group of three dental hygiene faculty and revised accordingly prior to distribution. A follow up mailing was sent after seven days and again after fourteen days via email to non-respondents. Respondents had five weeks to respond to the survey. The research
protocol was submitted to the Institutional Review Board at The Ohio State University and approved with exempt status.

Research Questions

How many patients do dentists and dental hygienists in Ohio observe per week with DDE?

What restorative options are most utilized by dentists in Ohio for treating and managing teeth with DDE?

What treatments options and oral hygiene recommendations are discussed by dental hygienists with patient’s with DDE?

Subject Selection

The sample population included dentists and dental hygienists across the state of Ohio. A total of 1,468 email addresses were used. Email addresses were purchased from Exact Data (Chicago, Illinois). Researchers sent an initial email to dentists and dental hygienists with a cover letter and link to the electronic survey. Qualtrics software (Provo, Utah) was used to administer the survey.

Data Collection

Data was de-identified prior to analysis. The data was compiled on individual data collection, as each dentist’s and dental hygienist’s responses were assigned with an identification number.
Statistical Analysis

Data was analyzed using descriptive statistics and total responses.
Chapter 4

Results and Discussion

The purpose of this study was to determine whether dentists and dental hygienists in Ohio observe DDE in patients in their practices. This study also determined what treatment options are most frequently recommended by dentists for teeth with minor, moderate, and severe DDE, and what treatment options and oral hygiene recommendations are discussed by dental hygienists for patients with DDE.

Eighty-four emails were undeliverable for a total of 1,468 sent surveys. Nineteen dentists and 76 dental hygienists completed the survey. From the master list it was unknown how many subjects surveyed were dentists and how many were dental hygienists, but the combined response rate was 7.2%. Of the participating dentists 76% did not accept any type of government health insurance, 89% practice general dentistry, 89% have been practicing over 20 years, 50% practice in Northeast Ohio, and 70% have over 2,000 active patients in their practices(Table 1).

Responses from the survey indicated that 70% of dentists see between one and five patients with DDE per week(Table 2).

The most common treatment for teeth with minor DDE limited to the occlusal surface was composite fillings followed by sealants. Eighty-two percent of the dentists responded that composite fillings would be the best treatment for teeth with moderate DDE with softness/discholoration limited to two or three tooth surfaces. Six percent
responded that amalgam fillings would be the best treatment while 12% responded with crowns (Table 3).

Eighty-eight percent of dentists responded that crowns would be the best treatment option for teeth with severe DDE with softness/discoloration involving three or more tooth surfaces. The other 12% responded that composite fillings are the best treatment for these teeth (Table 3).

Forty-one percent of dentists responded that composite fillings are the most utilized treatment option for newly erupted primary teeth with moderately to severe DDE. Thirty-five percent responded they would treat with stainless steel crowns and 24% with sealants (Table 4).

According to the surveyed dentists, the most common type of crown utilized on permanent teeth with DDE was cast crowns. Thirteen percent of dentists chose partial onlays, 13% full coverage onlays, and 6% utilized stainless steel crowns (Table 5).

Many dentists consider multiple factors when making treatment recommendations for patients with developmental defects. All of the respondents considered patients’ immediate and long term prognosis, 53% considered cooperation, and 41% considered treatment cost.

Seventy-six dental hygienists completed the survey. Eighty percent of responding hygienists work in a general practice, and 71% have been working over 20 years (Table 6).

Of responding dental hygienists 66% observe 1-5 patients per week with DDE. Fifty-eight percent of dental hygienists observe minor DDE, 63% observe moderate DDE, and 39% observe severe DDE (Table 7).
Eighty-nine percent of the dental hygienists responded that composite fillings would be the treatment of choice to discuss with a patient after a tooth has been diagnosed with DDE, while 62% responded with sealants, and 43% with crowns (Table 8).

Dental hygienists most frequently recommended fluoride therapy and limiting sugar intake to patients with DDE (Table 9).

Although the study shows there are no consistent treatment options for DDE, the study does suggest dentists and dental hygienists observe between one and five patients with DDE each week in their practices.

**Discussion**

It is evident that teeth with DDE have clinical problems that are of concern to both dentists and dental hygienists. The dentists and dental hygienists who completed the survey observe DDE on a weekly basis, and yet treatment options are not consistent among dental professionals.

Results from this study show 70% of dentists and 66% of dental hygienists who responded to the survey are seeing one to five patients per week with DDE. The results show the majority of dentists and dental hygienists are observing DDE on a weekly basis, and other studies have shown that prevalence of hypomineralization and hypoplastic defects of enamel are found in 63-68% of Caucasians in New Zealand, Ireland and England.

Sixty-five percent of dentists responding to the survey suggested composite fillings as the best treatment options for teeth with minor DDE and 35% responded with
dental sealants. William et al supports the use of composite fillings for treatment of DDE because they are considered an adequate restorative treatment option for 1 to 2 tooth surfaces areas due to good handling techniques and tensile and flexural strengths.⁴

Eighty-two percent of dentists responded they would treat with teeth affected with moderate DDE with composite fillings while 12% responded they would treat with crowns. Croll’s study supports using composite based materials because they provide advantages such as chemical bonding to dentin and enamel, fluoride release, coefficient of thermal expansion similar to that of tooth structure, biocompatibility, micromechanical bonding and insufficient shrinkage or heat formation during the setting reaction.²⁷

Eighty-eight percent of participating dentists chose crowns as the best treatment option for teeth with severe DDE while the remaining 12% chose composite fillings. The findings of the survey relate to a study completed by Koch and Garcia-Godoy stating gold and ceramic crowns have properties different from those of stainless steel making them ideal restorations for permanent molars with developmental defects.²⁸ The review and recommendations from William et al. also suggest crowns prevent further tooth deterioration and establish correct occlusal relationships.⁴

Forty-one percent of dentists responded composite fillings would be the utilized treatment on newly erupted primary teeth that is moderately or severely diagnosed with DDE. Thirty-five percent of dentists responded they would treat these affected teeth with stainless steel crowns. The findings from the survey are not supported by the AAPD recommendations and guidelines that suggest it is important to restore teeth for adequate function and maintain arch parameter and to do so primary teeth may require veneered anterior crowns with posterior full coverage steel or veneered crowns.² The findings also
are not supported by the review and recommendations from William et al that stainless steel crowns prevent further deterioration, establish proper occlusal relationships, are not as technique sensitive or costly, and requires little time to prepare and insert.\textsuperscript{4}

Sixty-five percent of the responding dentists recommend an orthodontic consultation when an extraction was needed for a severely involved tooth with DDE. Penchas et al and Sandler et al reported that when the permanent first molar is so severely malformed, either with or without caries, the best treatment is extraction with the goal of the adjacent permanent second molar migrating mesially to replace the missing tooth, and consultation with an orthodontic specialist is helpful in these cases.\textsuperscript{29,30}

The recommendations and guidelines from William et al and AAPD supports the use of an early orthodontic assessment when permanent first molars are severely hypomineralized that restorations may be impossible and extractions are considered.\textsuperscript{4}

When the permanent dentition involves a complex treatment plan, specialists from multiple disciplines such as periodontics, endodontics, and orthodontics may be necessary for treatment.\textsuperscript{2}

Eighty-eight percent of dental hygienists responded they would discuss composite fillings as a treatment option for teeth diagnosed with DDE, while 60\% would discuss sealants. The review and recommendations by William et al supports dental hygienists are providing adequate information because composite fillings are recommended when restoring molar surfaces with limited involvement DDE.\textsuperscript{4}

Eighty-five percent of dental hygienists recommend fluoride therapy for oral hygiene therapy and retaining healthy tooth structure around the restoration, while 83\% responded limiting high sugar intake. The review and recommendations of William et al
supports limiting high sugar intake because the cariogenicity and erosivity of the child’s diet should be assessed. Fluoride therapy is also supported because it remineralizes enamel, reduce sensitivity, and enhance resistance to further decay by providing a reservoir of fluoride ions.4

The results of this study showed that there are no consistent treatment options for DDE. The results provide evidence that further research and data needs to be completed on treating and managing teeth with DDE. Overall there is a lack of definitive treatment plans for teeth affected with DDE, as it is a case-by-case treatment. However the collected responses from this study did support similar suggestions with those found in the literature.

Limitations

A major limitation of this study was the low response rate and limiting the surveys to Ohio only. Having a low response rate could have damaged the credibility of the survey’s results because the sample size is less likely to represent the overall target population. Distributing the survey to different geographical regions in the United States and within different healthcare systems are some ways to increase the response rate, reach the target population and achieve a more representative response of treatment options.

The survey lacked a clear definition of DDE or specific types of DDE and its severity, and interpretation of DDE can vary from one individual to the next. Also, a visual aid depicting minor, moderate, and severe DDE was not presented to the participating dentists and hygienists, which may have been a limitation to the study.
It was complicated to compare the literature of this study to other studies because much of the literature researched was towards a specific type of DDE, and this study grouped many types of DDEs together.

Responses may have been skewed due to lack of specific questions on the survey because every patient’s restorative treatment and management is different for teeth affected with DDE. It was hard to generalize answers of the survey questions making it a limitation to the study. A more productive way to gather information for restorative treatment options is to ask questions related to case studies.

Conclusion

The results of this study indicate that there are no consistent treatment options for teeth affected with DDE. However, the study does suggest dentists and dental hygienists are observing DDE in patients in their practices in Ohio. Future research might build upon the results by analyzing and developing a guideline on restorative dental treatment and clinical management for teeth with DDE.
References


Appendix A: Consent and Dental Survey

Survey/Consent

Dear Doctor,

I am a graduate student in the Master’s in Dental Hygiene program at The Ohio State University. We are conducting a study on dentists’ thoughts and perceptions on the most common and preferred treatment options of developmental defects of enamel. This study has been determined exempt from Institutional Board review at The Ohio State University. As a dentist who treats developmental defects of enamel, your input is particularly valuable to this study. The 14 question survey will take no longer than 10 minutes to complete.

Participation in the survey is voluntary. All of your answers will remain anonymous, IP addresses will not be collected and data will be encrypted.

If you decide to participate, you are free to not answer any questions or withdraw at any time. Completing and submitting the survey implies your consent to participate in this research study.

In order to access the survey, click on the link below. Thank you for your willingness to complete the survey and contribute to the body of knowledge in dental hygiene.

-Insert Link Here-

If you have any questions about the survey you can contact:

Lauren McMahon BSDH, RDH
Masters in Dental Hygiene Student
College of Dentistry- Division of Dental Hygiene
The Ohio State University
mcmahon.118@buckeyemail.osu.edu

Or
Michele Carr, RDH, MA
Associate Professor and Chair
College of Dentistry- Division of Dental Hygiene
The Ohio State University
Carr.3@osu.edu

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251

1. Choose your specialty or area of dentistry:
A. General Dentistry  
B. Pediatric Dentistry  
C. Oral Surgery  
D. Endodontics  
E. Prosthodontics  
F. Orthodontics  
G. Periodontics  
H. Other  

2. How long have you been in practice?  
A. 0-5 years  
B. 6-10 years  
C. 11-15 years  
D. 20+ years  

3. In what part of the state of Ohio are you practicing?  
A. Northeast Ohio  
B. Northwest Ohio  
C. Central Ohio  
D. Southeast Ohio  
E. Southwest Ohio  
F. Other  

4. How many active patients do you have in your practice at this time?  
A. Less than 1,000  
B. 1,000-1,500  
C. 1,500-2,000  
D. 2,000-2,500  
E. More than 2,500  

5. How many patients per week do you see with development defects of enamel within their dentition?  
A. 0 patients  
B. 1-3 patients  
C. 3-5 patients  
D. 5-7 patients  
E. More than 7 patients  

6. In your professional opinion, what would be the best treatment option for teeth with minor developmental defects of enamel, with discoloration and/or softness limited to the occlusal (1) tooth surface?  
A. Sealants  
B. Amalgam Fillings
C. Composite Fillings  
D. Root Canal Therapy  
E. Crowns  
F. Extractions

7. In your professional opinion, what would be the best treatment option for teeth with moderate developmental defects of enamel, with discoloration and/or softness limited to the mesial/distal and occlusal (2-3) tooth surfaces?
A. Sealants  
B. Amalgam Fillings  
C. Composite Fillings  
D. Root Canal Therapy  
E. Crowns  
F. Extractions

8. In your professional opinion, what would be the best treatment option for teeth with severe developmental defects of enamel, with discoloration and/or softness involving buccal/lingual, mesial/distal and occlusal (more than 3) tooth surfaces?
A. Sealants  
B. Amalgam Fillings  
C. Composite Fillings  
D. Root Canal Therapy  
E. Crowns  
F. Extractions

9. On a newly erupted primary tooth that is moderately or severely involved with a developmental defect of enamel, what treatment option would you most commonly use?
A. Seals  
B. Composite Fillings  
C. Pulpotomy and Stainless Steel Crown

10. As a dental professional, if you chose a crown for a permanent tooth involved with a developmental defect of enamel, what type do you most commonly use?
A. Partial Onlays  
B. Full Coverage Onlays  
C. Cast Crowns  
D. Stainless Steel Crowns

11. As a dental professional, if you chose an extraction for a moderately or severely involved tooth with a developmental defect of enamel, do you recommend an orthodontic consultation?
A. Yes
B. No
   a. If no, why?

12. Which of the following factors do you consider most when making treatment recommendations for this patient with developmental defects of enamel? (check all that apply)
   A. Patients immediate and long term needs
   B. Cooperation
   C. Treatment Cost

13. Does your practice accept state assistance insurances such as:
   - CareSource
   - Medicaid
   - United Health Care Community Plan
   - Molina
   - Buckeye
   - Other

   A. Yes
   B. No

   If yes, what percentage of your practice is covered by Medicaid?

   __________________________
Appendix B: Consent and Dental Hygiene Survey

Survey/Consent

Dear Dental Hygienist,

I am a graduate student in the Master’s in Dental Hygiene program at The Ohio State University. We are conducting a study on dental hygienists’ thoughts and perceptions on the most common and preferred treatment options of developmental defects of enamel. This study has been determined exempt from Institutional Board review at The Ohio State University. As a dental hygienist who treats patients with developmental defects of enamel, your input is particularly valuable to this study. The 6 question survey will take no longer than 5 minutes to complete.

For the purposes of this study, developmental defects of enamel is defined as visible deviations from the normal translucent appearance of tooth enamel resulting from damage of the enamel organ during amelogenesis. Examples include but are not limited to enamel hypoplasia and amelogenesis imperfect.

Participation in the survey is voluntary. All of your answers will remain anonymous, IP addresses will not be collected and data will be encrypted.

If you decide to participate, you are free to not answer any questions or withdraw at any time. Completing and submitting the survey implies your consent to participate in this research study.

In order to access the survey, click on the link below. Thank you for your willingness to complete the survey and contribute to the body of knowledge in dental hygiene.

-Insert Link Here-

If you have any questions about the survey you can contact:

Lauren McMahon BSDH, RDH
Masters in Dental Hygiene Student
College of Dentistry- Division of Dental Hygiene
The Ohio State University mcmahon.118@buckeyemail.osu.edu

Or

Michele Carr, RDH, MA
SURVEY

1. What type of dental setting do you primarily practice in?
   A. General Dentistry
   B. Pediatric Dentistry
   C. Oral Surgery
   D. Endodontics
   E. Prosthodontics
   F. Orthodontics
   G. Periodontics

2. How long have you been practicing?
   A. 0-5 years
   B. 5-10 years
   C. 10-15 years
   D. 15-20 years
   E. More than 20 years

3. On how many patients do you encounter developmental defects of enamel in your practice on a weekly basis?
   A. 0 patients
   B. 1-3 patients
   C. 3-5 patients
   D. 5-7 patients
   E. More than 7 patients

4. What severity have you encountered when developmental defects of enamel are detected?
   A. Minor, softness and/or discoloration limited to the occlusal (1) tooth surface
   B. Moderate, softness and/or discoloration on the mesial, distal and/or occlusal (2-3) tooth surfaces
   C. Severe, softness and/or discoloration on buccal/lingual, mesial/ distal and occlusal (more than 3) tooth surfaces

5. After the teeth are diagnosed with having a development defect, what are some of the treatment options you have discussed with the patients and/or guardians? (check all that apply)
A. Sealants
B. Amalgam Fillings
C. Composite Fillings
D. Root Canal Therapy
E. Crowns
F. Extractions

6. What would you most likely recommend to keep the restorations and surrounding tooth surfaces of developmental defects healthy? (check all that apply)
   A. Mouthrinse
   B. Flossing
   C. Limited high sugar intake
   D. Avoided sticky/gummy foods
Appendix C: Tables

Table 1: Dentist Demographics

<table>
<thead>
<tr>
<th>Practice setting</th>
<th>Response (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Dentistry</td>
<td>89% (17)</td>
</tr>
<tr>
<td>Prosthodontics</td>
<td>5% (1)</td>
</tr>
<tr>
<td>Other</td>
<td>5% (1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Practice location</th>
<th>Response (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N.E. Ohio</td>
<td>50% (9)</td>
</tr>
<tr>
<td>N.W. Ohio</td>
<td>22% (4)</td>
</tr>
<tr>
<td>S.W. Ohio</td>
<td>22% (4)</td>
</tr>
<tr>
<td>Other</td>
<td>6% (1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Years in Practice</th>
<th>Response (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-10 Years</td>
<td>6% (1)</td>
</tr>
<tr>
<td>11-15 Years</td>
<td>6% (1)</td>
</tr>
<tr>
<td>Over 20 Years</td>
<td>89% (16)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of active patients</th>
<th>Response (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1,500</td>
<td>12% (2)</td>
</tr>
<tr>
<td>1,500-2,000</td>
<td>18% (3)</td>
</tr>
<tr>
<td>2,000-2,500</td>
<td>35% (6)</td>
</tr>
<tr>
<td>&gt; 2,500</td>
<td>35% (6)</td>
</tr>
</tbody>
</table>

Table 2: Patients per week seen with DDE by Dentists

<table>
<thead>
<tr>
<th>Number of Patients</th>
<th>Response (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Patients</td>
<td>12% (2)</td>
</tr>
<tr>
<td>1-3 Patients</td>
<td>35% (6)</td>
</tr>
<tr>
<td>3-5 Patients</td>
<td>35% (6)</td>
</tr>
<tr>
<td>5-7 Patients</td>
<td>18% (3)</td>
</tr>
<tr>
<td>More than 7 Patients</td>
<td>0% (0)</td>
</tr>
</tbody>
</table>
Table 3: Comparison of treatment options by dentist for level of DDE severity

<table>
<thead>
<tr>
<th>DDE Treatment Options</th>
<th>Minor DDE</th>
<th>Moderate DDE</th>
<th>Severe DDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sealants</td>
<td>35% (6)</td>
<td>0% (0)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>Amalgam Fillings</td>
<td>0% (0)</td>
<td>6% (1)</td>
<td>12% (2)</td>
</tr>
<tr>
<td>Composite Fillings</td>
<td>65% (11)</td>
<td>82% (14)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>Root Canal Therapy</td>
<td>0% (0)</td>
<td>0% (0)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>Crowns</td>
<td>0% (0)</td>
<td>0% (0)</td>
<td>88% (15)</td>
</tr>
<tr>
<td>Extractions</td>
<td>0% (0)</td>
<td>0% (0)</td>
<td>0% (0)</td>
</tr>
</tbody>
</table>

Table 4: Treatment options on a newly erupted primary tooth with DDE

<table>
<thead>
<tr>
<th>Treatment Option</th>
<th>Response (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sealants</td>
<td>24% (4)</td>
</tr>
<tr>
<td>Composite Fillings</td>
<td>41% (7)</td>
</tr>
<tr>
<td>Stainless Crown</td>
<td>35% (6)</td>
</tr>
</tbody>
</table>

Table 5: Crown options for permanent teeth with DDE

<table>
<thead>
<tr>
<th>Treatment Option</th>
<th>Response (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial Onlays</td>
<td>13% (2)</td>
</tr>
<tr>
<td>Full Coverage Onlays</td>
<td>13% (2)</td>
</tr>
<tr>
<td>Cast Crowns</td>
<td>69% (11)</td>
</tr>
<tr>
<td>Stainless Steel Crowns</td>
<td>6% (1)</td>
</tr>
</tbody>
</table>
Table 6: Dental Hygiene Demographics

<table>
<thead>
<tr>
<th>Practice setting</th>
<th>Response (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Dentistry</td>
<td>80% (47)</td>
</tr>
<tr>
<td>Other</td>
<td>8% (5)</td>
</tr>
<tr>
<td>Periodontics</td>
<td>7% (4)</td>
</tr>
<tr>
<td>Pediatric</td>
<td>5% (3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Years in Practice</th>
<th>Response (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 20 Years</td>
<td>71% (42)</td>
</tr>
<tr>
<td>15-20 Years</td>
<td>14% (8)</td>
</tr>
<tr>
<td>10-15 Years</td>
<td>14% (8)</td>
</tr>
<tr>
<td>0-5 Years</td>
<td>2% (1)</td>
</tr>
</tbody>
</table>

Table 7: Patients per week seen with DDE by Dental Hygienists

<table>
<thead>
<tr>
<th>Number of Patients</th>
<th>Response (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Patients</td>
<td>12% (9)</td>
</tr>
<tr>
<td>1-3 Patients</td>
<td>39% (29)</td>
</tr>
<tr>
<td>3-5 Patients</td>
<td>27% (20)</td>
</tr>
<tr>
<td>5-7 Patients</td>
<td>11% (8)</td>
</tr>
<tr>
<td>More than 7 Patients</td>
<td>12% (9)</td>
</tr>
</tbody>
</table>

Table 8: Treatment options discussed by Dental Hygienists

<table>
<thead>
<tr>
<th>Treatment Options</th>
<th>Response (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sealants</td>
<td>62% (46)</td>
</tr>
<tr>
<td>Amalgam Fillings</td>
<td>23% (17)</td>
</tr>
<tr>
<td>Composite Fillings</td>
<td>89% (66)</td>
</tr>
<tr>
<td>Root Canal Therapy</td>
<td>14% (10)</td>
</tr>
<tr>
<td>Crowns</td>
<td>43% (32)</td>
</tr>
<tr>
<td>Extractions</td>
<td>11% (8)</td>
</tr>
<tr>
<td>No Treatment</td>
<td>42% (31)</td>
</tr>
</tbody>
</table>
Table 9: Recommendations for home care discussed by the dental hygienist

<table>
<thead>
<tr>
<th>Treatment Options</th>
<th>Response (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouth-Rinse</td>
<td>49% (37)</td>
</tr>
<tr>
<td>Flossing</td>
<td>71% (54)</td>
</tr>
<tr>
<td>Limited high sugar intake</td>
<td>83% (63)</td>
</tr>
<tr>
<td>Avoid sticky/gummy</td>
<td>57% (43)</td>
</tr>
<tr>
<td>Fluoride Therapy</td>
<td>88% (67)</td>
</tr>
</tbody>
</table>