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Original article

The impact of pediatric congenital heart disease on primary teeth structure: a histological study

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Abstract. *Background and aim:* Congenital heart disease (CHD) is an abnormality in the structure or function of the cardio-circulatory system present at birth and the ventricular septal defect (VSD) is the most common CHD in children. Previous studies proposed that CHD may affect teeth structure. This study aimed to determine any differences in the histological structure of primary teeth between both healthy children and those children with ventricular septal defects in Erbil City. *Methods:* Children enrolled in this study were divided into two groups. Group I (control) & group II (CHD) aged between 6-10 years old. A total of 44 children were collected, (22 children) in each group. Enamel, dentin, and odontoblast layers were examined histologically. Unpaired t-test used for statistical analysis. *Results:* The histopathological sections showed a significant difference in enamel, dentin, and odontoblast layer thickness (255.8 ± 41.68- 406.4 ± 46.39), (1156 ± 116.0 - 1320 ± 117.4) and (29.74 ± 7.66 -41.38 ± 12.06) respectively, with p values ($P < 0.0001$) for enamel and dentin layer, and $P < 0.0004$ for odontoblast layer. A study of the images in the CHD group showed that the tooth tissue lost its integrity and cohesion in some places, and the thickness of the enamel and dentin layer in this group was significantly reduced compared to group I. Signs of tissue enamel, pulp, and dentin cell loss were observed in the superficial layers. Also, connective tissue layers in the pulp were disrupted. The infiltration of lymphocytes into the pulp tissue also increased in this group. *Conclusions:* CHD can alter the natural structure formation of primary teeth. Histologically, enamel, dentin, and odontoblasts layer thickness reduction are found in primary teeth in children with ventricular septal defects. (www.actabiomedica.it)

Key words: CHD, primary teeth structure, enamel, and dentin abnormality

Introduction

Globally, one of the main heart diseases is known as congenital heart disease (CHD), and it accounts for 8 out of 1000 children at birth (1). In addition, a previous study stated that "one of the most common developmental anomalies is CHD. Children with these defects are at increased risk of developing oral disease and are at increased risk of the systemic effects of oral disease (2). Variations in severity lead to a range in the incidence of CHD that begins at 6/1000 live births for moderate to severe forms and rises to 75/1000 if trivial variants are included (3). Approximately 37% of all cases of CHD in children are caused by isolated VSD. About 0.3% of infants are born with an isolated VSD. The prevalence is much lower in adulthood because up to 90% of them may close on their own. VSDs are completely gender-blind (4).

Despite having similar caries index scores to healthy children, children with CHD who have experienced hypoxia in primary and permanent dentition are more likely to develop enamel abnormalities and periodontal disorders. Pediatric cardiologists, pediatricians, and pediatric dentists must work together in a

multidisciplinary way because of the danger of infective endocarditis caused by preexisting carious lesions and periodontal issues (5).

It has been proposed that CHD children suffer from high caries incidence and hypoplasia. There are suggestions that teeth structure may be altered, which increases the risk of dental caries, increased dissolution, and irregular orientation of enamel prisms, widening, and outline irregularity in the orifices of dentinal tubules have been found (6). A two-way interrelationship between oral health and CHD has been speculated in literature, which causes additional elevation of the tooth-related risk for infective endocarditis (7). In developing countries, children with CHD are subject to sub-optimal oral health (8).

CHD influences the calcium composition of primary teeth, low calcium can cause the start of enamel caries, and hypoxia is another cause of dental caries progression in children with cyanotic heart defects (6,9). A previous study concluded no significant differences in the prevalence of developmental enamel defects in CHD and healthy children (10). However, children and adolescents with CHD had a higher decayed, missed, and filled (DMF) index than healthy children in the same age group (11). This study aimed to find out any histological differences in enamel, dentin, and odontoblast layers of primary teeth between healthy children and children with CHD and to figure out the influence of CHD on primary teeth structure.

Patients and methods

Study design

It is an observational cross-sectional study. This comparative in-vitro study was carried out to find out the structural difference in the composition of primary teeth between both the control group and children with CHD.

Setting

This study was performed from September 1st, 2021 to July 30th, 2022 in Erbil City, Kurdistan region- Iraq, this time interval was chosen because of the time limits of the study and limited resources. The children who were diagnosed with CHD were gathered from the Pediatric Cardiac Center, this center is specific for heart diseases, while the children who were enrolled in the control group were taken from Rapareen Pediatric Hospital, who attended there for reasons other than heart diseases.

Sample size and sampling method

Only a convenience sample was used to collect the data from children who were visiting both hospitals (Rapareen Pediatric Hospital and Erbil Cardiac Center) because most of the parents did not permit tooth extraction. Children who visited both hospitals in the time between September 1 2021 to July 30 2022 were involved in this study without calculating the sample size due to time and resource limits.

Inclusion criteria

Selection of Controls (Group I): The control group consisted of children, who did not have any history of heart disease, and lived in Erbil city. In addition, members of the control group went to a Rapareen pediatric hospital, dental department, who had sound, pre-shedding mobile primary tooth that is bothering the child during eating, or lingual erupted or retaining primary incisors (shark teeth) that are affecting the alignment of newly erupting permanent incisors.

Selection of cases (Group II): The parents of all children diagnosed with CHD were asked to permit their children to take part in the study. The participants in this group had the same age and inclusion criteria as controls.

Clinical examination

A structured questionnaire including the child's biological sex, age, medical history, ultrasonography, medical reports, and types of medicine in use was used. The primary oral examination was performed in Rapareen Hospital for Group I and Erbil Cardiac Center for Group II.

The examination was performed while the child was sitting comfortably on an ordinary chair, under good illumination obtained using a pen light and mouth mirrors to determine any mobile primary tooth or shark teeth needed for dental extraction. A prophylactic antibiotic for CHD patients was discussed with the cardiologist then a perinatal or oral antibiotic (in case it is needed) was given one to two hours earlier to the extraction procedure (12). Extraction was done using topical and infiltration anesthesia. The primary tooth was cleaned with normal saline and kept in 10% neutral buffered formalin at room temperature (13). The samples that were collected from both groups of children were then transferred to the same laboratory for an examination of the data.

Ethical consideration

The principles outlined in the Helsinki Declaration were adhered to throughout the research. On Sep. 28, 2021, the College of Dentistry at Hawler Medical University issued its ethical approval with the reference number (HMU-D-30). Everyone who participated provided their informed oral consent, which was collected. The criteria established by STROCSS 2021 have been accounted for in this study (14). After that, the author had no access to information that could identify individual participants after data collection.

Sample preparation

Tissues were fixed in 10% buffered formalin for 24 hours, decalcified with 10% nitric acid, dehydrated in graded ethanol baths (70% to 100%), cleared in xylene, embedded in paraffin wax, and serially sectioned at 5 μm. The best 5 sections of each specimen were selected and stained with hematoxylin and eosin (H&E) for evaluation by light microscopy. H&E was used to evaluate the cellular structures (13).

The formalin-fixed samples were processed in a tissue processor (Leica TP 1020, Germany) and Tissue Embedding Console System (Didsabz, DS4LM), as shown in Figure 1. Then, they were embedded in paraffin wax and sectioned using the rotary microtome (Leica Jung Multicut 2045, Germany) at 5 μm thick. The mounted tissue sections were stained with Harris' hematoxylin and eosin (HE). The slides were viewed under a light microscope (Labomed LX300, USA) installed with an Image J software analyzer (Image J bundled with Java 1.8.0_172). All evaluations were duplicated and 5 microscopic fields of each slide were randomly selected for data analysis.

After processing the acquired images of the sections, we analyzed them using specialized software(Image Pro analysis software) and made measurements regarding the number of odontoblast cells, enamel, and dentin layer thickness in the 44 examined teeth.

Data analysis

Descriptive statistics were used to analyze the structural differences between the two groups. Graph Pad Prism software (version 8) has been used in statistical analysis. P value (< 0.05) is considered significantly different. An unpaired t-test was used to compare the means of two independent groups.

Figure 1. A) tissue processor (Leica TP 1020, Germany). B) Tissue Embedding Console System (Didsabz, DS4LM).

Results

In the present study, 147 of those parents denied, and only 22 agreed to give permission. The age of included children ranged between 4 to 10 years old. Mean age ± Standard deviation 6.97±1.79.

There were a total of 44 participants, including 22 cases and 22 controls,

This indicates that a total of 44 children were checked to collect samples. The mean age of the participants for both groups was (6.97±1.79), as well as the sex balance was mostly similar. In addition, only 2 (4.4%) of the cases had other diseases other than CHD. Table 1 indicates more information.

Based on the results obtained from group I (without VSD). It was found that the cells of the enamel and dentin layer were observed normally in side-by-side junctions. Also, the thickness of the enamel and dentin layers in group I was higher than in group II. An unpaired t-test was used to compare the mean between two independent groups which was statistically significant (P <0.0001). In addition, no trace of bleeding and tissue infiltration was observed in this group, as shown in Figure 2.

Table 1. Characteristics of the participants (n=44).

Variables	Frequency (%)
Sex	
Male	23 (51.1)
Female	21 (46.7)
Presence of other diseases	
No	42 (93.3)
Yes	2 (4.4)
Total	44

A study of the images in the CHD group showed that the tooth tissue lost its integrity and cohesion in some places, and the thickness of the enamel and dentin layer in this group was significantly reduced compared to group I. On the other hand, signs of tissue enamel, pulp, and dentin cell loss were observed in the superficial layers. Also, connective tissue layers in the pulp were disrupted. The infiltration of lymphocytes into the pulp tissue also increased in this group, as shown in Figure 3.

The mean values of dentin thickness in groups I and II were (1156 µm± 116) and (1320 µm± 117.4) subsequently for both groups and the difference was statistically significant (P <0.0001), as shown in Figure 5.

The mean values of odontoblast layer thickness were (29.74 µm± 7.66) and (41.38 µm ± 12.06) subsequently for both groups. The difference between the two groups was statistically significant (P <0.0004), as shown in Figure 6.

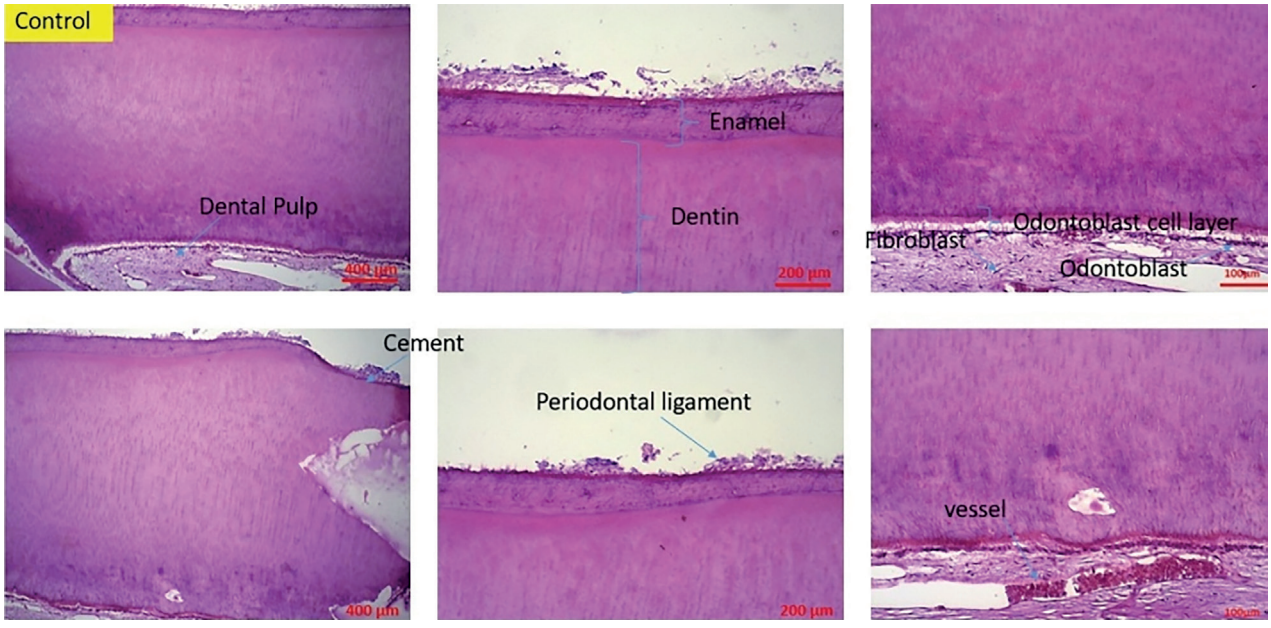

Figure 2. The coronal-sectional images showed human tooth tissue in the control group (I) stained with hematoxylin and eosin dyes.

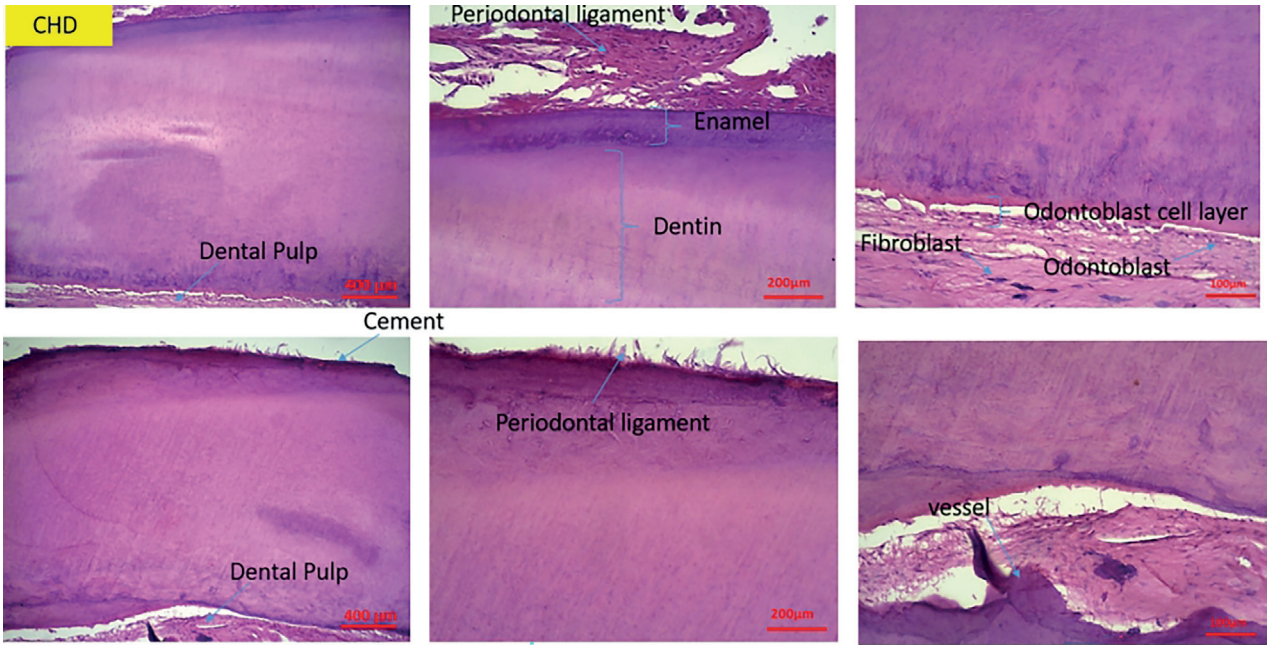

Figure 3. The coronal-sectional images showed human tooth tissue in the congenital heart disease group stained with hematoxylin and eosin dyes. The mean values of enamel thickness in groups I and II were (255.8 µm±41.06), (406.4 µm±46.39), and there were significant differences between both groups (P < 0.0001), as shown in Figure 4.

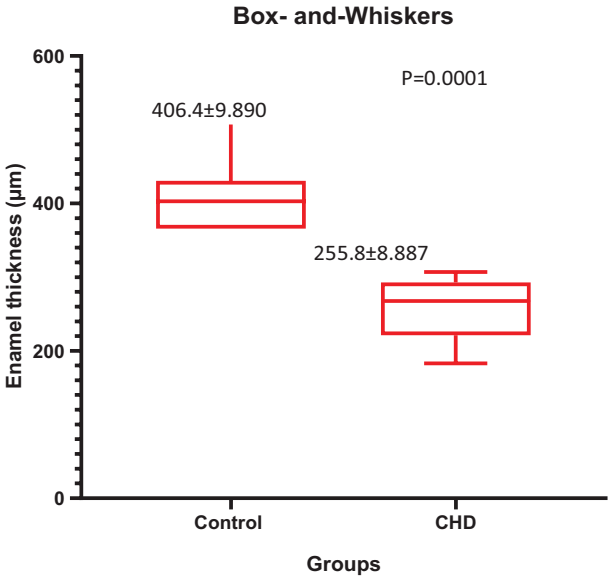

Figure 4. Box plot of e enamel layer thickness in both groups (N=44)

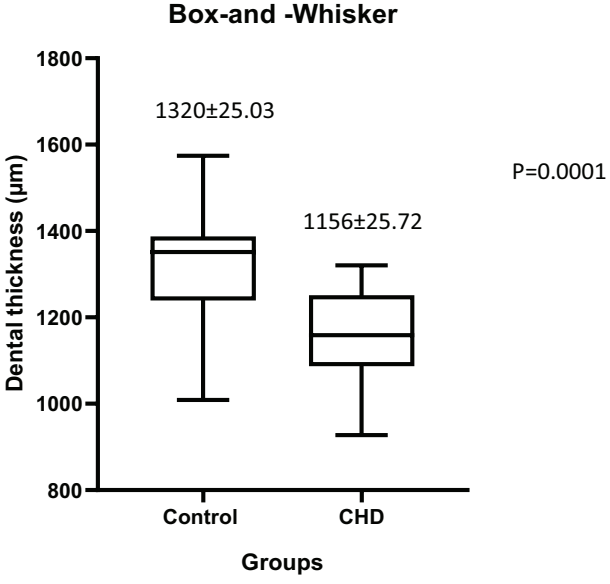

Figure 5. Box plot showing dentin layer thickness in both groups (N=44)

Discussion

There seems to exist a two-way interrelationship between oral health and CHD, that causes additional elevation of the tooth-related risk for infective endocarditis (7).

Hallett *et al.* (1992) concluded that increased dental decay in a pediatric patient may be enhanced

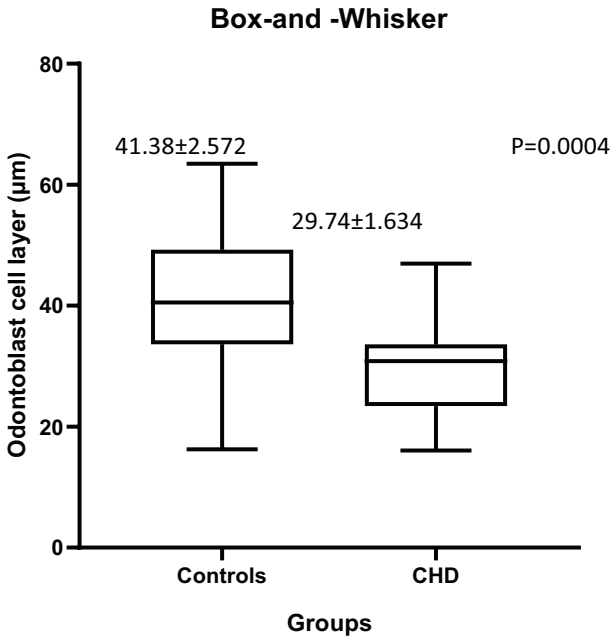

Figure 6. Box plot showing odontoblast layer thickness between groups (N=44)

by systemic diseases since systemic disease stimulates enamel defect and hypo- mineralization, for instance, this type of enamel defect has been found in children with congenital heart disease (15).

The recent result is compatible with a previous study by AL-Etbi and Al-Alousi, in 2011, they concluded that: "A higher rate of development of enamel defects was found in children with ventricular septal defects has been found" (16). In addition, Oliver *et al* performed a study that found that: enamel defect in the primary teeth of CHD children was 29% (17).

Enamel hypoplasia is considered a predisposing factor for early caries (18).

Dental decay is observed more frequently in CHD children than in healthy children (19).

Recent literature has concluded that "children with congenital heart disease (CHD) experience a higher caries prevalence compared to healthy children" (20).

In the present study, the results of the histopathological examination showed that there is a significant reduction in enamel and dentin thickness in children with congenital heart disease (ventricular-septal defect). A study of the images in the CHD group showed that the tooth tissue lost its integrity and cohesion in some places and the thickness of the enamel and dentin layer in this group was significantly reduced compared to the healthy group (I). On the other hand, signs of tissue enamel, dentin, and pulp cell loss were observed in the superficial layers. Also, connective tissue layers in the pulp were disrupted. The infiltration of lymphocytes into the pulp tissue also increased in this group. As a result, one can propose that "congenital heart defect specifically, ventricular septal defect affects the formation of enamel and dentin negatively"

When tooth tissues lose their integrity and cohesion, and the enamel protective layer is thinner and softer than normal, the invasion and spread of cariogenic pulp tissues are easier and faster. In addition, the present study found tissue loss in dentin, and pulp and a decrease in the number of odontoblasts. A decrease in the number of odontoblast layers can impede reparative dentin formation and preservation of pulp tissue from external stimuli. As a consequence, the vitality of the tooth will be lost. Such results may be compatible with the findings of previous studies which found that enamel hypoplasia and risk of dental caries were higher in children with CHD.

In the opposite study performed by Cantekin *et al.*, it was found that there was no significant difference in the development of dental caries or the prevalence of enamel defects between children with CHD and healthy children, the care score was low in children with CHD. Although children with CHD had a higher rate of pulled primary teeth and delayed treatment of decayed teeth (10).

Limitations of the study

The study was limited by, the collection of teeth samples was severely constrained because there was no teeth bank in the study area, most parents or other caregivers were more concerned about heart disease than dental disease, and they lacked adequate dental education regarding the link between dental disease and cardiac health, the risk of infectious endocarditis, and the detrimental effects of VSD on the development of primary teeth. The absence of funds placed restrictions on the examination. As well as the laboratory processing to diagnose teeth histologically

was performed outside the country. Sample size calculation was not performed due to organization issues and time limits.

This study has provided a comprehensive understanding of congenital heart effects on primary dentition tooth structure. This study provided that histologically, enamel, dentin, and odontoblasts layer thickness was found to be decreased in children with congenital heart disease. The tooth structure lost its integrity and cohesion due to the influence of CHD. This study proved that CHD could alter the natural structure formation of primary teeth that may favor early caries formation. The present study results approve the contravention about the prevalence of dental caries between children free of CHD and children with CHD, by giving the conclusion that the VSD has a negative effect on the thickness of Enamel and Dentin that puts the tooth at risk of developing dental caries.

It is recommended that increased sample size, involvement of different congenital cardiac disorders, and a different study methodology be used for generalizability of the result. Additionally, the detrimental effects of dental problems must be understood by the parents.

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Conflict of Interest: The author declares that she has no commercial associations that might pose a conflict of interest in connection with the submitted article.

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